МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

ЖИТОМИРСЬКИЙ ДЕРЖАВНИЙ ТЕХНОЛОГІЧНИЙ УНІВЕРСИТЕТ

АНГЛІЙСЬКА МОВА

МЕТОДИЧНИЙ ПОСІБНИК ДЛЯ СТУДЕНТІВ ФАКУЛЬТЕТУ КОМП'ЮТЕРНО-ІНТЕГРОВАНИХ ТЕХНОЛОГІЙ, МЕХАТРОНІКИ І РОБОТОТЕХНІКИ (151 " АВТОМАТИЗАЦІЯ ТА КОМП'ЮТЕРНО-ІНТЕГРОВАНІ ТЕХНОЛОГІЇ")

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Методичний посібник з англійської мови для студентів факультету комп’ютерно-інтегрованих технологій, мехатроніки і робототехніки (спеціальність 151 «Автоматизація та комп’ютерно-інтегровані технології»).

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Розробники: І.С. Мельниченко, Л.Л. Отдєльнова, С.В. Суховецька

Рецензенти:

канд. тех. наук., доц., кафедри автоматизації та комп’ютерно-інтегрованих технологій ім. проф. Б.Б. Самотокіна ЖДТУ Ткачук А.Г.,

канд. філ. наук., доц., завідувач кафедри теоретичної та прикладної лінгвістики ЖДТУ Могельницька Л.Ф.

Методичний посібник призначений для студентів факультету комп’ютерно-інтегрованих технологій, мехатроніки і робототехніки. Основна мета посібника – розвиток читання, усного мовлення, анотування та реферування технічної літератури зі спеціальності 151 «Автоматизація та комп’ютерно-інтегровані технології».

Посібник складається з 4 частин. Усі тексти підібрані з оригінальної науково-технічної літератури та містять необхідну термінологію із спеціальності. До текстів подані запитання, вправи на закріплення лексико – граматичного матеріалу. Лексичні та граматичні вправи побудовано на мовному матеріалі, що взятий в основному з текстів даного уроку. Це забезпечує необхідну повторюваність лексичних одиниць і моделей.

Розглянуто і рекомендовано на засідання кафедри теоретичної та прикладної лінгвістики

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CONTENTS

PART I

UNIT 1. GENERAL INFORMATION ON FLEXIBLE MANUFACTURING SYSTEM (FMS)

1. Read the following terms and memorize their meanings:

cart *n* — візок (для перевезення палет між обробними ділянками)
cell *n* — гнучка автоматизована комірка (модуль)
fixture *n* — захват-тримач; захватний пристрій (для орієнтації деталі з координатами різального инструмента верстата)
flexible *a* — гнучкий; **f. manufacturing system** – гнучка автоматизована система; гнучке автоматизоване виробництво (ГАВ)
hardware *n* — апаратні засоби; апаратура
know-how n — уміння; технологія
machine v — обробляти на верстаті
machine tool - верстат; **numerically controlled machine tool** — верстат з числовим програмним управлінням **(ПС),ЧПУ**
manufacture *n* — виробництво; виготовлення; обробка
manufacturing *n* – виробництво; ***a*** – промисловий; виробничий
part *n* – деталь; **p. number (p. type)** – конкретна за конструкцією деталь
process v **-** обробляти
processing *n* – обробка; **distributed data p**. – розподілена система обробки даних
sensor n— датчик
software n – програмне забезпечення; програмні засоби
storage n — збереження; складування; сховище, склад;
s. process — процес накопичення (на автоматизованому складі)
store v — зберігати (на складі); накопичувати (в пам'ять)
workpiece n —деталь (оброблювана); заготівка

2. Read the following word combinations and translate them. Find where in the text is said:

the application of flexible manufacturing system; the definition of a system; the creation of industrial robots; to require advanced technical know-how; to use distributed data processing; to design numerically controlled machine tools; to meet the demands (requirements) of industry; storage process; software and hardware; part flow

3. Translate:

1. When designing an FMS, the basic problem is to create cells from which the system is to be constructed. 2. Flexible manufacturing systems (FMSs) represent a new strategy to increase labour productivity. 3. The FMS is known to provide a direct hardware/software solution to many economic and technical problems. 4. The cart is considered to be a very simple and safe material handling device. 5. Fixtures are used to hold a part. 6. The part is found to be a workpiece processed by a flexible manufacturing system. 7. The FMS is designed to machine more than one part number at low to medium volume levels.

4. Read the text and find FMS system definitions.

Part I

A Flexible Manufacturing System (FMS) is the current level of automation in the field of manufacturing. The application of FMS requires advanced technical know-how.

A Flexible Manufacturing System may be defined as a system dealing with high level distributed data processing and automated material flow using computer-controlled machines, cells, industrial robots, inspection machines and so on, together with computer integrated materials handling and storage systems.

Here manufacturing is considered to be a system, which integrates different processes and requires a properly defined input to create the expected output.

Input may be raw material and/or data, which have to be processed using various auxiliary components of the system, such as tools, fixtures and clamping devices, sensors and their feedback data. The output may also be data and/or material, which can be processed on further units (often called cells) of the manufacturing system.

An FMS can also be defined as a computer-controlled configuration of semi-independent work stations[1] and a material handling system designed to efficiently manufacture more than one kind of part number at low to medium volumes. The definition highlights the three essential physical components of an FMS:

a) standard numerically controlled machine tools;

b) conveyance network to move parts and perhaps tools between machines and fixturing stations;

c) an overall control system that coordinates the machine tools, the parts and the workpieces.

Part II

The number of machines in a system typically ranges from 2 to 20 or more. The conveyance system may consist of carousels, conveyors, carts, robots, automated guided vehicles, etc.

The FMS can be thought of as a distributed management information system linking together intelligent subsystems[2] of machining, welding, painting, flame cutting, sheet metal manufacturing, inspection, assembly, etc. and material handling and storage processes.

Flexible manufacturing systems are regarded by many experts as being the best way to meet the demands of industry. They consider the FMS to be the future of the automated factory, or at least the minimally manned factory. And perhaps most significant that FMS is clearly the most obvious manifestation of computer-integrated manufacturing on the factory floor.

So it is possible to say that the FMS is of interest to manufacturers who produce more than one kind of part number at low to medium volumes. The FMSs provide a direct hardware/software solution to many economical and technical problems. The important aspect of these systems is that the machine tools, conveyance and control devices combine to achieve increased productivity and maximum machine utilization without decreasing flexibility.

Vocabulary notes:

1. **semi-independent work stations** — напівзалежні станції (пости)
2. **intelligent subsystem** — підсистема штучного інтелекту

5. Find in the text English equivalents of the following Ukrainian words and word combinations:

передова технологія; автоматизований потік матеріалу; контрольні машини; автоматизована система переміщення і складування деталей (сервісна система); сировина; інструменти;

захват-тримач; дані зворотнього зв'язку; конкретна за конструкцією деталь; верстати; зварювання; виробництво листового металу; відповідати вимогам промисловості; програмне та апаратне забезпечення; максимальне використання машин.

6. Complete the following sentences from the text:

1. It is necessary to note that the FMS can be defined as ... . 2. Speaking about the input of the system we mean that it ... while the output ... . 3. As a rule the FMS conveyance system includes ... . 4. In fact, there are the three main physical components of an FMS: ... . 5. It should be stressed that there is a hope that the FMS will be widely used in future because ... .

7. Answer the following questions. Try to express your answers in your own words if possible.

In your opinion...

1. Which of the FMS definitions gives more complete characteristics of the system? 2. What is meant by input/output of the FMS? 3. What does the FMS conveyance system include? 4. What do you think about the future of the FMS? Do you agree with the conclusion of the text? Give your reasoning.

8. Make a summary of the text and discuss it.

I'd like to say a few words about; I think; As is known; In my opinion … .

9. Read the text and name the fields of FMS applications.

FLEXIBLE MANUFACTURING - A GROWING INTEREST

The emergence of the flexible manufacturing system represents a significant departure from conventional manufacturing methods. An FMS is a production facility consisting of flexible machines or work stations connected by an automated material handling system, all under the control of one or more computers.

The FMS technology has a relatively brief history. The progress of computing machines has made it possible to introduce a wide-scale automation of all branches of industry which gave rise to[1] independent development of automation processes:

(a) Automated Data Processing (the appearance of Automated Control Systems and Computer-Aided Designing (CAD));

(b) Automation of Production Technology (the appearance of Numerically-Controlled Equipment, Computer-Aided Manufacturing (CAM) and Industrial Robots).

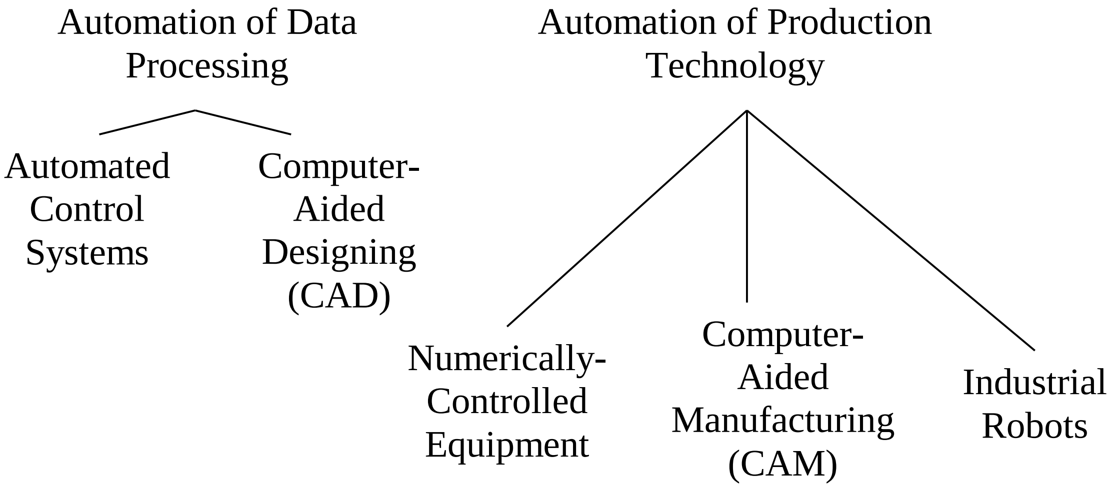


Fig. General trends of automation

The development of Flexible Manufacturing Systems began with the appearance of industrial robots, processing centres, microcomputers, computer-aided designing, etc. followed by the introduction of robotized complexes, flexible modules, automated lines and shops and at last automated factories provided with flexible technology and computer-based artificial intelligence.

It seems almost certain that the main reasons for designing and implementing FMS are the economic benefits of the system. They include first of all greater productivity, which means a greater output and a lower unit cost on a smaller floor space.

It is possible to say that the FMS is the system where the time spent on the machine can be as high as 90% and the time spent on cutting can again be over 90%. Compare this to stand alone numerically-controlled machines (NC), where the part from stock to finished item spends only 5% of its productive time on the machine tool.

Part II

High utilization of capital equipment in the FMS over that of stand alone machines results in fewer machines being needed to carry out the same work.

High product quality is improved because the product is more uniform and consistent. This also leads to greatly reduced costs of rework.

Furthermore, the ability of FMS to produce whatever mix of parts is required on demand, greatly reduces work-in-process time. This reduction may be explained by the variety of causes, which reduce the time a part is waiting for metal-cutting operations, such as:

– The concentration of all the equipment required to produce parts in a small area (within the FMS).

– The reduction in the number of fixtures required and the number of machines a part must travel to because processes are combined on machining centres.

– Efficient computer scheduling of parts batched into and within the FMS.

One other important fact ought to be mentioned. While FMS requires fewer machine operators, or none at all, the remaining staff (i.e. production engineers, computer programmers and maintenance engineers) have to be highly skilled.

With correct planning for available floor space, an FMS can be designed for low production volumes, and as demand increases, new machines can be added easily to provide extra capacity flexibility required.

The main thing is that flexibility is characterized by the system's ability to adapt to change in the composition of the lots and of the machining processes and sequences, which means that it is able to respond to changing market and consumer demands.

Summing it up, it is possible to say that in all countries the introduction of FMS made it possible to greater increase equipment utilization and product quality, reduce the equipment idle time and cut down the number of attending personnel.

10. Make up a short plan of the text.

11. Answer the questions:

1. What information in this text is new for you? 2. What is the advantage of FMS in comparison with the common industrial production? 3. What are the main directions of automation?

12. Exchange your opinion about the read text using the vocabulary of this unit and conversational formulas.

Model: **A**: Can you say a few words about FMS history. The system finds a wide application now and has a lot of benefits.
B: As I know, it has a brief history but ...

I would like to note/emphasize; To my knowledge; First of all; I want to say that and others

Benefits include
- Less work-in-process time
- Greater productivity
- High capital equipment utilization
- Reduced labour costs
- Unmanned operation
- Flexibility
- High product quality

<u>UNIT 2. TOOLING</u>

1. Read the following terms and memorize their meaning:

automated tool delivery system — автоматизована система доставки (подачі) інструмента
breakage *n* — пошкодження; аварія
capacity *n* — продуктивність; потужність; навантаження; пропускна здатність
column *n* — колона, стійка; **gantry c**. — портальна колона
cut v — різати; відрізати; розрізати; **cutter** n — різальний інструмент; фреза; різець; **cutting too1** — різальний інструмент,

gantry crane — портальний кран
overhead transport carrier — підвісний транспортний візок
rack *n* — стійка; стелаж; полиця; **storage r**. — накопичувач;
tool — інструментальна полиця
rail-guided cart - рейковий (перевантажувальний) візок
receiving unit — приверстатний накопичувач
tool changer — механізм заміни інструмента; **tool drum** — інструментальний барабан
wear *n* — знос; зношування

2. Read the following word combinations and translate them:

various machine tool magazines; machine tool magazine capacity, manual/automated tool delivery system; automated tool changing system; portable tool drum; cutting tool; special gantry type crane; large tool storage area; overhead transport carrier; automatic tool transport; tool transfer mechanism; rotary tool station

3. Translate the following sentences, paying attention to the Complex Subject Construction:

1. Tooling seems to have a major effect on FMS performance. 2. Robots are known to give little effect out of flexible production systems. 3. Robots are known to be widely used for compact machining centres and NC lathes. 4. All required cutting tools are known to be stored in the various machine tool magazines. 5. Mounting a portable tool magazine on a movable pallet is considered to be a more common approach to tool transportation. 6. Automatic tool changer (ATC) is said to be a device that can be used in different forms as assembly robots or a number of other machines to increase flexibility. 7. A robot arm located at each machine tool exchanges tools between the overhead transport carrier and the machine tool magazine. 8. It is necessary for the system to operate efficiently and with minimal human interference.

4. Read the text. Tell what importance has delivery and replace of instrument in FMS work. Name the main methods of automated tool delivery system.

AUTOMATING TOOLING IN FMS

Part I

The delivery and changing of cutting tools to the CNC machine tools seems to be a vital requirement in FMS. Typical CNC machine tools consist of permanently attached tool magazines, equipped with automatic tool changers, with capacities of from 30 to 120 cutting tools.

An optimum tooling system would have all required cutting tools stored in the various machine tool magazines. However, tooling requirements generally exceed the machine tool magazine capacities in most practical FMS. Also, due to cutter wear and breakage, tools must inevitably be replaced.

As for tool delivery two approaches should be mentioned — manual and automated. In a manual tool delivery environment, an operator brings the cutters to the machines and manually inserts them into the machine tool magazine. For this system to operate efficiently and with minimal human interference, each machine tool magazine capacity would have to be of the order of 120.

Since the aim of FMS is to strive towards untended manufacturing, an automated tool delivery system is generally preferred. Such an automated tool delivery/changing system includes machine tools along with[1] portable tool drums, each capable of storing up to 30 cutting tools.

A special gantry type crane transports entire tool drums between the tool room and columns located behind the machine tool. The machine's central column travels horizontally enabling the tool drums to be exchanged.

Drawbacks to this system involve redundancy of tool drums, the need for a large tool room to store the tool drums and the requirement of a gantry crane.

Nevertheless, a modified version of this system enables the tool drums to be transported by an automated-guided vehicle (AGV). A shuttle cart exchanges the tool drum, which is stored alongside the machine tool. Although this system is more flexible than the previous one, tool drum redundancy and a large tool storage area are still required.

Part II

A more common approach to tool transport is mounting a portable tool magazine on a movable pallet which can then be transported by an AGV to a total delivery receiving unit located behind each machine tool.

The receiving unit consists of a pallet cylinder capable of unloading and loading the tool magazine pallet from the AGV to the receiving unit. The receiving unit also consists of an interchange arm[2] which exchanges tools between the portable tool magazine and the permanent machine tool magazine.

It should be noted that the major benefit of such a system is that the machine tool can operate while tools are exchanged between the two tool magazines.

Another method for transporting tools consists of using an overhead transport carrier capable of delivering five tools at the same time, all tools being protected by individual plastic cartridges during storage and transport. A robot arm located at each machine tool exchanges tools between the overhead transport carrier and the machine tool magazine. This system allows all machine tools to be automatically linked with the tool room and with each other. And at last it is necessary to mention one more approach to automatic tool transport. Its solution is to store tools on racks behind the machining centres. A rail-guided cart, equipped with a tool transfer mechanism, travels up and down the rail system and transports tools from the storage rack to the individual machine tool magazines. Operators manually load new tools into a rotary tool station, and the rail-guided cart picks up a tool and loads it into the storage rack.

Generally speaking, tooling, essential part of an FMS, is given much attention. It is recognized that tooling can have a major effect on FMS performance. Automation of tooling seems to be a solution to a significant FMS problem and it is a requirement for unmanned FMS operation.

5. Find in the text English equivalents of the following Ukrainian words and word combinations:

основна перевага системи; доставка інструмента в ручну; автоматизована система доставки інструмента; подача та заміна різального інструмента; автоматизований пристрій заміни інструмента; знос і пошкодження інструмента; інструментальний барабан; інструментальний магазин; спеціальний портальний кран; недоліки системи; накопичувач інструмента; рейковий (перевантажувальний) візок; підвісний транспортний візок

6. Make a short report about different methods of automated tool delivery system.

1. What methods of tool delivery and changing of cutting tools are mentioned in the text? 2. What tooling system does a typical CNC machine tool include? 3. What is the capacity of a typical CNC machine tool magazine? 4. What are the main reasons of tool replacement? 5. Why is automated tool delivery system usually preferred? Give your reasoning. 6. What types of tool magazines are described in the text and which of them are the most efficient? 7. What is the importance of tooling in FMS performance?

7. Use the following speech patterns:

I'd like to say a few words about; According to the text; I'd like to draw your attention to the problem; As is known; It is necessary to mention; It is quite obvious that; As for benefits/drawbacks; In addition to that; The conclusion is та інші.

8. Read the text. Define its general idea.

9. What methods find the widest application?

Vocabulary notes:

bar coding — штрихове кодування
memory chip — інтегральна схема пристрою пам'яті
punched card – перфокарта

TOOL IDENTIFICATION AND MONITORING

Since most FMSs require hundreds of cutting tools, an effective tool identification system[1] is a necessity. The machine tool must always know what tools are in its magazine and certain additional information regarding each tool. The following data are usually included in identifying a cutting tool: tool number, magazine slot number[2] and remaining tool life. Several methods for identification exist including bar coding, memory chips, punched cards and vision systems.

The most common tool identification system used is bar coding. Depending upon the type of tool transport system a laser reader can be mounted on the portable tool magazine, the machine tool magazine, or both. The tool is inserted into the magazine and then indexes past the laser reader, which relays the data to the FMS computer.

A new method of tool identification uses memory chips. As is known, there are two types of systems. The first type consists of permanently attaching a read/write chip into the tool holder. All necessary tool data are programmed into the chip. The attendant in the tool room builds the tool assembly and inserts it into a tool presetting machine.

After the necessary tool measurements have been performed, an adaptor engages with the chip and programs it. Equipped with an adaptor, the machine tool magazine indexes around each cutter and reads the programmed information.

Another method of tool identification utilizes specially punched cards which are optically read to identify tools. Cutting tools are delivered by an overhead transport cart, and a robot arm picks up, reads and inserts the cutter into the machine tool magazine.

Since the individual machining centres in an FMS are unmanned, it is essential to monitor cutters for wear and breakage, and to keep a record of remaining cutter life. Most FMSs rely on predetermined cutter lives based on past data to replace worn tools.

The FMS computer monitor cutting time for each tool, and when the present value has been reached, a tool change is performed.

A more efficient method of detecting cutter wear or breakage is by using a fixed probe permanently mounted on the machine tool. The probe is inserted in the chuck at the beginning of the machining sequence,[3] and is brought into contact with the workpiece. These probes are considered to be extremely sensitive and can position the workpiece with great precision. The probe is controlled by the CNC which moves it into position.

Various sensors have been developed to monitor tool wear/breakage. They include sensors which can measure: cutting force, power input, temperatures, vibrations, radioactivity, electrical resistance and acoustic (sound) frequencies.

Vision systems also provide accurate and reliable monitoring of cutter wear. The edge of the cutter is illuminated by light, and the vision system analyzes the reflected pattern. Any change in the pattern indicates tool wear or breakage. A drawback to this system is that it can be used only between cutting cycles and not during the actual cutting operation.

As for adaptive control (AC) systems they not only monitor cutting conditions, but also provide feedback to the machine tool. The most common adaptive control systems utilize sensors that measure lateral cutting force (spindle deflection), spindle horsepower, or both. The AC system compares these values with predetermined values and adjusts the feed rates and/or spindle rpms accordingly. This feedback loop helps extend cutter lives, prevent cutter breakage and reduce machine breakdowns.

Vocabulary notes:

1. tool identification system – система розпізнавання інструмента
2. magazine slot number – номер гнізда магазина
3. machining sequence – послідовність механічної обробки

10. Answer the following questions:

1. What are the main methods of tool identification. 2. What does a robot arm do? 3. What do sences include? 4. What is the function of vision systems? 5. What is the role of adaptive control systems.

UNIT3. MATERIAL HANDLING SYSTEM (MHS)

1. Read the following terms and memorize their meanings:

buffer n – буфер; демпфер **b. storage** – буферний накопичувач
cam n – кулачок
deadman bumper – підпірний бампер; амортизатор
deliver v – поставляти, доставляти, постачати; **delivery** n **-** доставка
drive pin – повідковий палець; замикаючий штифт**;** гвинт який скріплює
encoder n – кодуючий пристрій
jig n – затискний пристрій
pallet assemblies – вузли палет
rock stock – сировина, заготівка
tolerance – допуск
tow chain – буксирний ланцюг
warehouse n – склад

2. Read the text. Name the main transport means, used in FMS.

Part I

Material Handling System (MHS) is used to move and store parts, as well as materials used in processing the parts (e.g., tools, coolant, wastes).

There are two principal forms of part transport: parts must be moved from outside the system into it, and they must be conveyed within the system. Usually it is not convenient to combine these functions because movement into the system involves raw parts while movement within the system involves part, fixture and pallet assemblies.

As is known, an FMS is capable, of simultaneously processing a wide variety of parts at different work stations. Parts are loaded and unloaded at a particular location, and pallets are used to transport parts between machines. Once a part is loaded into the system, it is moved from the station to the other one under the computer control, its path being dependent on its processing requirements, machine loads and other constraints of the system.[1]

Within the system, there are many possible pallet-movement designs. The three principal categories are carts, conveyors, and robots. Guidance and control of carts can take different forms. Carts can move along tracks, energized and controlled externally by the central computer. Sensors located at appropriate points along the track identify the precise location of the cart and can be used to position it to the required tolerance (typically 0.06 in) to transfer pallets to a machine or unload station. Wheel encoders can be used as less precise feedback for the drive system and its programmed speeds. All carts should have dead-man bumpers at each end to help prevent accidents.

Battery-powered carts can be moved along a flat floor, guided by an antenna that detects a wire embedded below the surface.[2] Position sensors still must be used to control pallet transfer.

Another cart design may use a tow chain in a trough under the floor. The chain moves continuously, and cart movement is controlled by extending a drive pin from the cart down into the chain. At specific points along the guideway, computer-operated cam-type stop mechanisms raise the drive pins to cart movement. One advantage of this system is that it can provide some automatic buffering with stationary carts along the track. A variation of this method uses a floor mounted spinning cylinder that imparts motion to the roller drive of individual carts; a computer initiates drive disengagement,[3] and the carts can be stopped at selectable locations.

Powered conveyors can be used for basic transportation between flexible machining cells or for positioning parts to interact with robots or other handling devices. Powered roller conveyors are designed to move pallets from the load stations to pallet exchangers located on the machines. Individual sections can have separate drives to control placement of pallets near machines. Special switches can provide feedback to locate pallets along the conveyor.

Asynchronous conveyors based on the principle of rotating tubes are used to place loads precisely for robots, as well as to move loads at high speeds. In machining centers, specialized conveyors can be designed to handle any type of part from operation to operation. Overhead power-and-free conveyors offer flexibility to a manufacturing operation.

Besides, self-powered monorails independently drive trolleys that can run on the level or uphill. A master controller directs the trolleys in highly flexible configurations.

Various types of cranes can be employed to manoeuvre parts too heavy to lift manually, and this technology includes robots as well.

Part II

It is of importance to note that automated storage and retrieval systems (AS/RS) add more than control and space saving to a manufacturing operation. As flexible manufacturing systems increase their output and the variety of parts that will be produced in small lots, AS/RS fit the needs for[4] buffer storage. Some new FMSs are being designed with raw stock being stored in AS/RS and delivered to machines by automatic guided vehicles. The AS/RS can also provide quick access to the jigs, fixtures and tooling required by the FMS.

Miniload automated storage and retrieval systems, along with horizontal and vertical carousels, bring parts to the worker, often under computer direction.

To sum it up, it is necessary to say that the user today is looking for automatic material handling system. He wants to be sure that a part can be found when it is needed. Such system is automatic guided vehicles (AGVs) which is beginning to take a significant role in material handling. The guided vehicle usually carries the workpiece, on a machine pallet or fixture base, from work cell to work cell. Or it may transport trays of parts that are manually or robotically chucked, fixtured or locked onto machine tables at work stations.

One can say that AGV is not only a transporter of parts and tools, it is also a factory system for delivery, the mode of transportation for the highly flexible systems.

Vocabulary notes:

1. other constraints of the system — інші обмеження системи
2. a wire embedded below the surface – провід, вмонтований під поверхнею підлоги
3. drive disengagement — відключення приводу
4. fit the needs for — відповідати потребам

3. Find in the text English equivalents:

автоматизована складська та розподільна система (система збереження та пошуку інструмента); автоматизовано керовані транспортні засоби; заводська система доставки; заготовки; вузли палет; візки; датчики; необхідний допуск; пристрій що кодує; менш точний зворотній зв'язок; керувати рухом палети; передавати рух роликовому приводу кожного візка; гнучкі комірки, які обробляють; підвісні вільно-приводні транспортери;

4. Answer the following questions:

1. What role does the automatic storage and retrieval system play in the FMS? 2. What are the principal forms of part transport? 3. Why do you think that these forms of part transport cannot be combined? 4. And what pallets are used for? 5. What equipment is used when too heavy parts are to be lifted? 6. What is the difference between carts and battery-powered carts? 7. What is the advantage of the system in which a cart uses a tow chain? 8. Would you say a few words about a roller conveyor system? 9. What is the main function of the material handling system? 10. Are you satisfied with the material handling system used at your plant? 11. What is the advantage of material handling system?

5. Make a summary of the text using the plan:

1. The main transport facilities used outside and within the system.
2. The advantages of materials handling system (MHS).
3. The role of automatic storage and retrieval system.

6. Render the text in English

Матеріали в ГАВ можуть переміщатися за допомогою конвеєрів (транспортерів) різних типів, наприклад: приводних, роликових, ланцюгових, підвісних вільно-приводних та інших. Інші пристрої переміщення включають роботи, навантажувально-розвантажувальні пристрої.

Відомо що, однією з важливих складових частин ГАП є система транспортування сировини, готових виробів, а також інструментів. Транспортні системи в ГАП повинні забезпечувати надійне переміщення усіх типів матеріалів від складів до складів або через накопичувачі на позиції контролю, розвантаження та інші.

Заготовки, як правило, встановлюють на супутниках автоматично, а інколи вручну. Важливим елементом транспортних систем є транспортні пристрої, які передають вироби з транспортера на верстат і навпаки від верстата чи накопичувача на транспортер. До них належать промислові роботи та автоматизовані маніпулятори; візки різних типів, захватні пристрої та інші.

7. Read the text and define its main contents.

APPLICATION OF AUTOMATED GUIDED VEHICLE (AGV)

Part I

1. The AGV is a system in which identical vehicles load, unload and transport loads under computer control, without a human operator on board. Directional control is provided by some type of guidepath,[1] mounted in the floor or transmitted via radio messages. The network and the carts are controlled by base computers, on-board computers and local traffic control devices which also communicate with the overall FMS control system.

2. The major benefits of using AGV systems in FMS are as follows: The route of the AGVs can be easily altered, expanded and modified, simply by changing the guidepath of the carts. This procedure is more effective than modifying fixed conveyor lines or railed carts. It provides a direct access to material handling system for loading and unloading FMS cells and accessing AS/RS (Automated Storage and Retrieval System). In this way new and already existing cells can be linked one-by-one to the overall materials handling system, provided that each cell has the necessary control interface and is mechanically compatible with the AGV system.

3. Because of the computer control, AGVs can be monitored in real-time. If the FMS control system decides to change the schedule, the carts can be rerouted and urgent requests can be served.

Radio control, an alternative to infloor mounted communications lines, permits two way communication between the onboard computer and a remote computer, independent of where the cart is or whether it is in motion. To issue a command to a vehicle the central computer sends a bit stream via its transmitter using frequency shift key[2] methods to address a specific vehicle. The signal transmitted from the base station is, therefore, read by the appropriate vehicle only. Typical commands from the base computer include go from A to B position, stop, load, unload, recharge battery, etc. The cart is also capable of sending signals back to the remote controller, to report the status of the vehicle, vehicle malfunction,[3] battery status, and so on.

4. AGV can travel at a slow speed but typically operate in the range of 10 to 70 m/min. They have on-board microprocessor control to communicate with local zone controllers which direct the traffic and prevent collisions between vehicles. Sometimes AGV manufactures also use sensors for positioning accuracy to avoid collision at the loading stations or during the transport ensuring safety.

AGV can also incorporate warning lights, horns, emergency stop buttons, fire door safety interlocks and door controls for safety in shops which are not entirely unmanned.

Part II

5. The maintenance requirements include the recharging of batteries and the usual checks of the motor, the safety devices (such as horns, bumpers, sensors), the on-board controller, communication links and so on. Most systems are equipped with automatic battery-condition report facility connected to a central computer, which directs vehicles to a battery charging station before power fails. Typically, AGV can work up to eight hours without battery recharge.

6. Environment requirements should also be taken into account, namely: the guidepath is reliable if properly sealed and laid in the floor although expansion joints can cause some problems. The shop floor should be dry during operation because the carts may slip and slide. Lift tracks, if used within the same area, can damage floor control elements of AGVs, so extra attention is required.

7. The load to be considered includes size, weight and stability. If pallets are transported, the maximum part weight is reduced by the weight of the pallet itself which is usually relatively high. The clearance provided for vehicle and its load should be at least 100 mm on each side.

8. During design, the use of simulation can help detect whether there are enough carts to perform the necessary load, unload and transportation tasks and thus optimize the utilization of the AGV system. Because these carts have to work together with highly organized FMS cells as well as with automated warehouses under computer control, their level of performance will effect the entire efficiency of the FMS.

9. The AGV performance also depends on the number and size of buffer stores. Buffers allow cells to maintain a high level of efficiency even if there is a cell failure. In the event of failure buffers decouple the FMS cells from each other as well as from the overall materials handling and storage system.

Vocabulary notes:

1. guidepath – спрямований шлях, маршрут
2. shift key – реєстрова клавіша, клавіша регістра (при натисканні якої відбувається зміна регістра)
3. malfunction – збій; неправильне спрацьовування

8. Answer the following questions:

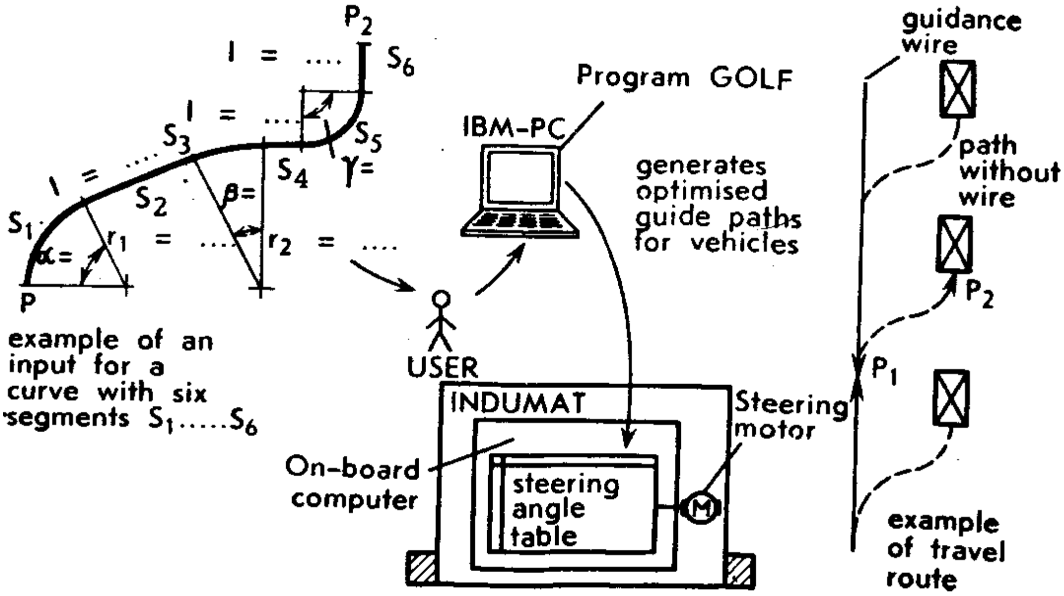
1. What is the role of application of automated guided vehicle?
2. What are the major benefits of using AGV systems in FMS?
3. What is the advantage of radio control?
4. What are most systems equipped with?
5. What does AGV performance depend on?

9. Make up the short plan of the text.

10. Express the main idea of each paragraph using one sentence.

11. Read the description one of the automated guided vehicles which is shown on the exhibition. What is the main peculiarity of this system.

Greater flexibility of materials handling is offered by one of the firms, with its computerized technique for allowing automated guided vehicles to leave the inductive guidepath and travel freely to adjacent areas.



The system described lets a vehicle leave the guidepath and compute its own way to destination. The program which guides the vehicle is prepared by its user on a personal computer running software. The operator defines the angle of travel, the length of straight line elements, and adds curves, destination stations, etc. to suit his requirements.

Transfer of the optimised travel program into the AGVs memory bank completes the procedure. The vehicle then leaves the guidepath and follows the new route under instruction from the master program.

Application of the technique to new installations can save capital outlay[1] on factory and warehouse automation.

Vocabulary note:

capital outlay – капіталовкладення

12. Ask the representative of the firm to explain the principle of automated guide vehicle motion.

13. Generalize the received information about automated guided vehicle (AGV) using the following speech patterns:

I'd like to say a few words ...; I'd like to draw your attention to ...; I think it is necessary to stress that ...; It is quite obvious that ...;
From my point of view ...; I want to start by emphasizing that ... .

14. Read the text and define the main idea of the text

INDUSTRIAL ROBOTS IN FMS

Part I

An industrial robot is a reprogrammable, multi-functional manipulator designed to move materials, parts or tools through variable programmed movement to accept a variety of tasks.

It is important to note that robot applications and programming methods have progressed far beyond merely handling components since their controllers and sensors have developed the capability to communicate with other intelligent devices. Sensors particularly have been the focus of much development in recent years.

Robots are able to provide information not only about their arm position but also about the part being handled and about the gripper or more complex robot tool. They are capable of seeing, hearing, smelting, detecting and analysing force, torque, heat, pressure, colour and other environmental changes or conditions.

Sensors can provide information about the presence of a part in a buffer store, in a robot tool or in the chuck of a lathe, and they can, for example, interact with the robot controller and modify the programmed sequence in real time. More sophisticated sensors such as force and torque sensors, send stress measurement values. Vision systems use special purpose image processors and image data base which are interfaced with the control program of the arm.

Distributed sensory feedback processing makes robots more intelligent, more reliable and more flexible, and these important trends are not to be ignored when designing the FMS.

It is necessary to stress that industrial robots have a very wide range of potential applications in FMS because they are reprogrammable flexible devices themselves. The increasing power of their sensory feedback processing system allows them to work at a high level of intelligence. However, robots are not yet capable of solving most materials handling assembly or inspection tasks in FMS. A relatively low proportion of robots are capable of communicating at a high level with other robots and computers and their sensory systems are usually expensive compared with their performance.

Part II

The major application area of industrial robots include pick and place type of operations.

An example can be given of a robot which ensures smooth product flow in an FMS.

The cell, which includes two drilling machines, was developed to produce 300,000 magnet housings a year on a three-shift operation. It was, therefore, essential to maintain a smooth flow of components into, through and out of the cell. To achieve this product flow the robot was fitted with a pneumatically operated triple gripper to handle raw material, part machined and fully finished components in turn.

Having a repeatability accuracy of 0.25 mm at maximum speed, the robot is able to maintain a handling transfer and location program whereby one magnet housing is picked by the triple gripper and moved to the first twin chuck machine. The empty grippers grasp a component from each chuck of the machine, remove the part and advance one step to load the chucks again.

A finished part is thus removed from the machine, a part-machined component is progressed to the second chuck, and a new component is loaded into chuck one. The robot returns to the unload pallet and deposits the finished part. It then repeats the handling sequence for the second machine, and so on, according to the computer program.

15. Find in the text examples describing the main possibilities of industrial robots. What are the functions of robots in FMS?

16. Give a short summary of the text

UNIT 4. CONTROL SYSTEM. SOFTWARE

1. Read the following terms and memorize their meaning.

chip *n* — кристал; чип; мікросхема; інтегральна схема
computer *n* — комп'ютер; **supercomputer**— супер ЕОМ; **mini-supercomputer** — суперміні ЕОМ; **mainframe computer -** велика ЕОМ
cost savings — зниження витрат (виробництва), економія витрат
data *n p1* от **datum** — (вихідні) дані; факти, інформація; **d. base** — база даних
facility *n* —пристрій; засіб; устаткування
hardware *n* — апаратне устаткування (ЕОМ)
layout *n.* — схема розташування; планування; схема організації робіт; програма
manage *v* — управляти, керувати; **management** n — управління (планування, контроль)
monitor *v* — контролювати; керувати; **monitoring** n – контроль
in real-time — у реальному масштабі часу
simulate v — моделювати; **simulation** *n* — моделювання
software *n* — програмне (математичне) забезпечення

2. Read the following word combinations and translate them.

d) cost savings; equipment utilization; cost estimator; error conditions; production schedule; actual and forecast performances; plant management

e) to rearrange production processes for maximum cost savings; to enable engineers to make changes or corrections; to control the flow of information; to determine the exact physical location in the system; to perform the correct sequence of operations; to forecast system needs at due time; to compare actual and forecast performances

3. Read the text and give a short characteristic of control system software.

CONTROL SYSTEM

Computers have revolutionized manufacturing. They have given manufacturing engineers control over events in the factory. With this information, processes can be reorganized for maximum efficiency and production steps can be rearranged for maximum cost savings. You can know what is occurring on the floor now.

Because of computers tasks are done more quickly and accurately. It enables engineers to make changes or corrections that will utilize equipment and people optimally.

An important quality of computers is that they are flexible. Change the program and you have a "new computer".

Software. Computers cannot run without software; that is, without some instructions on what to do. Software controls the flow of information in a computer system. The software makes a computer a specific device — a calculator, a designer, a programmer, a cost estimator, an expert.

Simulation software is another type of software, which is now becoming quite popular. This type of software lets you see your proposed factory layout at work "on paper".

Simulation software helps in the design and development of automated work cells, manufacturing systems and factories such as FMS.

An FMS without software is not flexible, has little use in manufacturing and is not even a system.

The main problems that FMS software should solve are as follows:

Keep track[1] of the materials being manufactured, determine the exact physical location in the system and perform the correct sequence of operations.

Prevent the different operations from interfering with[2] each other.

Determine error conditions and minimize their impact on the system.

Keep management informed on parts, production, part programming, system status.

Determine the best production schedule to meet due data and maximize machine utilization.

Forecast system needs at due time—fixtures, tools, lubricants and coolants.

Direct in real-time the operations of people in charge of[3] the above facilities. Compare actual and forecast performances.

Inform the plant management with the required data from FMS, for production planning and control, accounting and reporting.

Thus, the FMS control system manages the total combination of devices in the system that contributes to the automatic operation of the production process. This includes the machine-tool controllers, the material handling system, the system monitoring devices, the system communications, and finally the system computer. Computer software supplies all the control management and monitoring functions that enable the system to achieve high utilization.

The control system is easily visualized[4] by considering all the elements of the system in a structured arrangement according to its function. This structure and how each function of the structure relates to the overall system performance will be discussed later.

Vocabulary notes:

1. keep track (of)… — стежити за (перебігом, розвитком чого-н.)
2. interfere with...— заважати, бути перешкодою
3. people in charge of smth... — відповідальні за що-н.
4. visualize — уявляти

4. Find in the text English equivalents of the following Ukrainian words and word combinations.

відбуватися (мати місце); програмне забезпечення; моделювання; вирішувати проблему; виконувати належну послідовність операцій; графік основного виробничого процесу; у свій час (своєчасно);

необхідні дані; звітність; сприяти автоматизації виробничого процесу; автоматизована транспортна система; функції управління та контролю

5. Complete the following sentences from the text:

1. It is necessary to say that one of the important features of computers is that ... . 2. The significance of simulation software is that ... . 3. As is known FMS software should solve a lot of problems, for example ... . 4. Summing it up, one must say that the FMS control system ... . 5. The task of FMS computer software is to ... . 6. It is necessary to say that we can understand the FMS control system easily if we consider ... .

6. Answer the following questions:

1. What is the task of FMS computer software? 2. What problems should FMS software solve? 3. What is the role of computers in FMS? 4. What can you say about simulation software? 5. What does the FMS control system manage?

7. Make a short summary of the text.

UNIT 5. CAD/CAM SYSTEM AND FMS

1. Read the following terms and memorize their meaning.

diemaking — штампування, штамповка
grinding machine — шліфувальний верстат
integrate *v* — інтегрувати, об'єднувати в систему
interactive *a* — інтерактивний; взаємодіючий; **interaction** *n* — взаємодія; взаємозв'язок
set up *v* — встановлювати; утворювати; *n* налагодження, настроювання; установка; **tool s.—** наладка верстата; інструментальне оснащення
sheetmetal *n*— листовий метал
turnkey *a* — готовий до безпосереднього використання;
t. system — система (обчислювальна система або програмний продукт), який не перадбачає жодної доробки чи налаштування користувачем

2. Read and memorize the following word combinations and translate them.

a) computer-aided design; computer-aided manufacturing; flexible manufacturing system; improving productivity of low production volumes in a variety of sizes; the arrangement of production equipment, machines, computers, warehouses and transfer units; the origin of the CAD/CAM system; a small-scale turnkey system; the design of circuits; data flow; CNC cylindrical grinding machine; unmanned carrier; jig and fixture design; cutting tool design; drawing preparation; tool setup data; production schedule data; tool cart; machine tools

b) to integrate data; to act as a production system; to utilize; to advance rapidly; to become ultimately necessary; to give rise to improving productivity; to select machines and tools and prepare NC data; to put into practical use

c) to advance rapidly; to expand rapidly; to be highly correlated with each other; to use computer-aided design; to apply a new technology particularly to the design; to be currently available; to turn out products mainly in low production runs in a variety of sizes; to control machines directly

3. Read the text

CAD/CAM system and FMS

Part I

It should be stressed that now it has become necessary to direct efforts towards the more flexible response of production flow from planning, designing, production engineering to manufacturing.

To solve this problem the Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) and the Flexible Manufacturing System have been developed and put into practical use, the CAD/CAM system to integrate data for the design of production processes and the FMS to act as a production system.

As is known, the development of these systems has become possible due to increasing application of electronics such as the high speed and compact size of computers which advanced rapidly in recent years.

Previously the FMS and the CAD/CAM system progressed from different directions. This is mostly because the CAD/CAM systems developed from the technological side, i.e. with emphasis laid on design, while the FMS developed from the manufacturing side, i.e. with emphasis put on machining.

In point of fact, however, these two systems are highly correlated with each other in basic areas. In other words, the technological integration of the CAD/CAM system and the FMS has become ultimately necessary.

For example, the FMS is a system which aims to unman various types of machining operations, inspection and transferring per plant from the material to the final stages, giving rise to improving productivity of low production volumes in a variety of sizes.

In the design of the FMS, the main objectives are the arrangement of production equipment, machines, computers, warehouses and transfer units.

A definite system of processing a lot of data on plans and design had to be established.

The origin of the CAD/CAM system is generally said to be the interactive computer graphic system. The application of this new computer technology particularly to the design area, i.e. the CAD system, was put into practical use mainly among aircraft builders.

Although CAD/CAM systems were large-scale, based on oversized computers, a small-scale turnkey system was later developed which utilized a minicomputer as a host. This turnkey system rapidly expanded and found its application first in the design of circuits and later machines for diemaking and sheetmetal processing.

The ultimate aim of CAD/CAM systems currently available is common in the design of equipment, including the in-house developed systems and the integration of product design, production design and production control.

If the integration of design and production data is advanced and the combination of the CAD/CAM systems and the FMS which is the desirable production form as a system to turn out products in low production runs in a variety of sizes, is also advanced, automation can be accomplished at a plant level and unmanned operation-oriented FA can be achieved.

Part II

In order to apply the CAD/CAM systems on a full scale to machining operations and also forward the application of FA through the integration with the FMS, the most important aim is to raise the level of automation in processing which is connected with machining and production technologies.

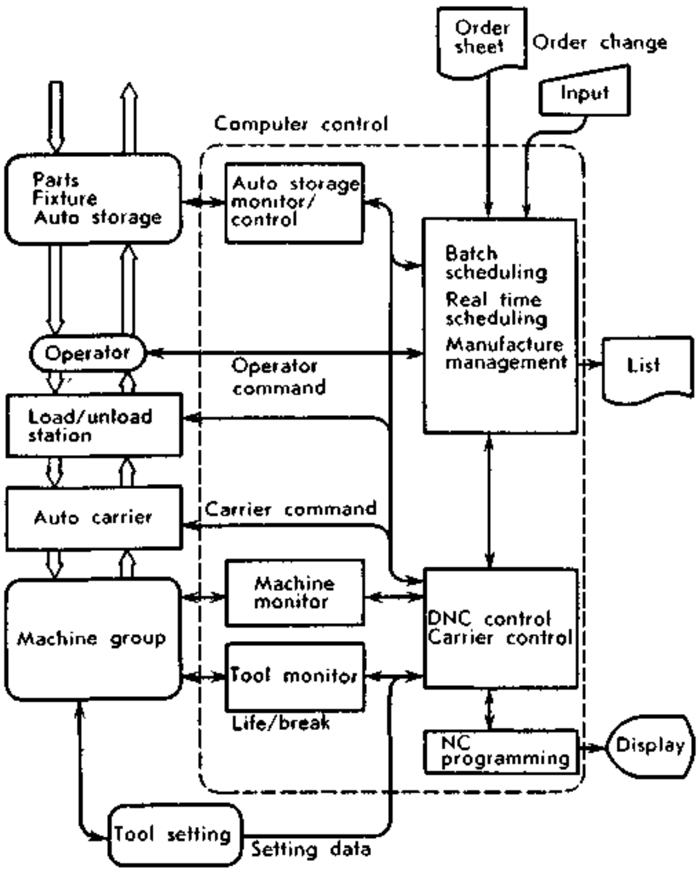
For this purpose the advanced FMS, a production system, has been developed to integrate the CAD/CAM systems and the FMS. In fact, the advanced FMS integrates the conventional FMS and the "data flow" such as design and production engineering data.

Thus a FMS consists of two machining centres and one CNC cylindrical grinding machine connected by an unmanned carrier and a super-minicomputer.

The features of the system are as follows:

The task of CAD function is to perform designs necessary in the production stage such as jig and fixture design, cutting tool design, machining and installation drawing preparation.

CAM function selects machines and tools and prepares NC data in conversation with an operator by using the graphic display and voice.



Operation control function prepares operational instructions concerning tool setup data, pallet and fixture setup data, machining and loading procedure and also production schedule data.

Production control function directly controls physical distribution and machining, such as the control of transfer equipment like a tool cart with robot and a work of transfer cart and the DNC control of NC machine tools.

Production management function collects and shows the progress of operation in the machining system such as the collection of machining results, the operating conditions of machine tools, and the monitor of work flow.

So, one can say that computer-aided design and manufacturing (CAD/CAM) systems which combine computers, software and networks are critical elements in automated manufacturing. They control the design and process aspects of fully automated manufacturing systems or cells. In combination with computer-numerically controlled machine tools, robotics, and automated materials handling equipment CAD/CAM enhances flexibility, efficiency and productivity in manufacturing.

4. Find in the text English equivalents of the following Ukrainian words and word combinations:

спрямовувати зусилля; вирішувати проблему; автоматизоване проектування/автоматизоване виробництво; інтегрувати (об'єднувати) в систему дані; завдяки зростаючому застосуванню електроніки; це головним чином тому, що; іншими словами; автоматизувати різні види операцій, які оброблюють; комп'ютери підвищених габаритів; обчислювальна система, що не припускає ніякої доробки чи налаштування, готова до безпосереднього використання; шліфувальний верстат для циліндричних і конічних поверхонь (для круглого шліфування); проектування затискних пристосувань і палет; дані виробничого планування

5. Situation. You are at the factory, where FMS is used. Talk to the chief designer and industrial engineers ask them some questions about the use of CAD and CAM system and FMS.

1. What industry was the first to use the CAD system? 2. What can you say about CAD/CAM systems and FMS? 3. What is the main task of these systems? And what about the FMS? 4. What systems are used in at

your plants? 5. What new computer technology in the design area is put into practical use? 6. What is the most important aim in production technology of your plant? 7. What is the function of production management?

6. Imagine: you are the representative of the automated factory where CAD/CAM system and FMS are widely used. Tell about these systems, about perspectives of their development. Answer their questions. Use the speech patterns:

I want to draw your attention to; The text deals with; I think; It is quite obvious; I'd like to stress; Could (can) you tell me; In conclusion I should like to say.

PART II

UNIT 1. HISTORY AND DEFINITION OF ROBOTS

1. Read and memorize the following words and word combinations.

hardware — механічна частина, обладнання
handling (manipulative job functions) – маніпулювання, функції маніпулювання, транспортування
to relieve – звільняти
load — вантаж, навантаження
the necessity of handling heavy loads – необхідність транспортування важкого вантажу
to fill the gap – заповнити прогалину
to substitute – заміняти
special-purpose — (вузько) спеціальний
off-the-shelf (commercially available) automation – серійні засоби автоматизації, що випускаються
to be reprogrammed – бути репрограмованим
handling equipment – маніпуляційне обладнання

2. Read text A. Try to understand its contents. See notes given below.

Text A

In the fourth century B.S., Aristotle wrote, "if every instrument could accomplish its own work, obeying or anticipating the will of others... if the shuttle could weave and the pick touch the lyre without a hand to guide them, chief workman would not need servants nor masters slaves".

В четвертому столітті до нашої ери Аристотель писав: "якби будь-який інструмент міг виконувати свою власну роботу підпорядковуючись чи випереджаючи волю інших ..., якби човник міг ткати, а медіатор міг торкатися ліри без руки, яке веде його, то майстру не потрібні були б ні помічники, ні підневільні працівники".

Handling operations occur in practically all production processes. At first they were carried out manually, but then the development of hardware components made it possible to relieve people from the necessity of handling heavy loads.

From this standpoint the industrial robot is not something supernatural. It is only the most perfect form of the technique used in handling processes. Their purpose is not only to substitute or imitate manual actions of human beings, but also to perform production processes more quickly and better than a man.

Robots fill the gap between special-purpose automation and human endeavor. They have demonstrated an ability to perform work that requires simple repetitive motions and, therefore, can relieve human operators from hazardous or monotonous tasks.

Terms like "teachable", and “programme-controlled" often are applied to robots. However, robots are best understood in terms of their real capabilities. Essentially, they are "off-the-shelf" automation. It is the robot's ability to be easily taught or reprogrammed that distinguishes it from other types of automated handling equipment.

Robot is one of the very few Slav words (in this case Czech) borrowed in the different languages. It comes from the Old Slav word "robu", which means a servant. In modern Slav, the word "robotnik" means workman and is linked to the Russian word for work, "rabota".

Notes

in terms of — з точки зору
it is(was)... that — а саме
the very (compare with "very") — саме

3. Characterize the industrial robot choosing the right word.

There are different terms which can be (application, applied) to robots. The robot is called (teacher's, teachable). The robot is also called (program-controlled, program-controlling). The word "robot" means (servant, service). The robot must perform (production, productivity) processes better and faster than a man. The robot's (able, ability) to be retaught and reprogrammed distinguishes it from other types of (automatics, automated) handling equipment. The robot is the most perfect form of (handle, handling) means. Industrial robots are used to (substitute, substitution) manual actions of a human being. The robot must (imitation, imitate) the manual actions of human beings.

4. Combine the sentences in lists A and B into logical units. Complete the sentences with one of the words given below.

A	B
1) Industrial robot is the most perfect engineering means for handling.	a) That's why they differ from other types of automated ... .
2) Robots can be easily taught or reprogrammed.	b) Therefore their aim is to perform ... .
3) The robot performs actions according to a certain programme.	c) Thus we can say it works ... .
4) The term "programme-controlled" is often applied to robots.	d) So it can be called ... .
5) Handling operations can be carried out by hand.	e) Hence they can be called ... .

production processes better than a man, handling equipment, manual operations, automatically, a programmable device

5. Name; a) the possible ways of describing the robot's characteristics — use: "can be called…".

E.g. The robot can be called a programmable device.

Робот може бути названий	програмним пристроєм. автоматичним пристроєм. пристроєм, який навчає. маніпуляційним пристроєм.

b) the functions performed by the robot — use: "the purpose of the robot is...".

E.g. The purpose of the robot is to perform human operations.

Мета робота -	виконувати роботу людини. звільняти людину від маніпулювання важкими вантажами. виконувати виробничі процеси швидше і краще ніж людина. заміняти людину на небезпечних операціях.

6. Speak on the problem of robot's application. The advantages of robot's application are:

a. the operator needs no computer experience, makes no complex calculations;

b. increased productivity and product quality;

c. fast, easy installation;

d. reduced energy consumption.

Text B

Industrial robots are helping to eliminate the hazards involved when workers put their fingers in metalworking presses, are subjected to long exposures of toxic materials, must load and unload parts from processing furnaces, or lift heavy loads. According to GOST 25686-85 the industrial robot is defined as "an automatic machine, stationary or mobile, comprising actuator in the form of a manipulator which has some degrees of motion and a reprogrammable device of program control to perform movement and control functions in the production process".

The industrial robot as considered here, is a general-purpose, programmable, parts-handling machine that will also control and synchronize the equipment or production machinery with which it works. As with a human it can be "taught" a job, can "remember" instructions it has been given, can be "retaught" when the job content changes, and can be transferred to a different job when the first job ends.

Today, more than 100 companies around the world produce industrial robots and several thousand robots have been installed in factories in our country and other countries.

Industrial robots are powerful tools for increasing productivity and profitability and for solving problems of worker safety and poor working conditions and they are available now in a wide variety of shapes, sizes and capabilities.

Notes

to eliminate – усувати

to comprise actuator – містити привід

part — деталь

degree of motion — ступінь рухливості

device — пристрій

general purpose (versatile) — тут широко універсальний

programmable machine — програмувальний пристрій, пристрій, що програмує
production machinery — виробниче устаткування
reteach – перенавчати
productivity – продуктивність
worker safety – безпека робітників
working conditions — умови праці

7. Translate the following definitions and memorize them.

Robot: A mechanical device which can be programmed to perform some task of manipulation or movement under automatic control.
Industrial Robot: An automatic machine, stationary or mobile, comprising actuator in the form of a manipulator which has some degrees of motion and a reprogrammable device of program control to perform movement and control functions in the production process.
Load: The weight (force) applied to the end of the robot arm.
Hazard: A condition or a changing set of circumstances that presents a potential for damage.

8. Make up a summary.

9. Give your opinion on the problem given below.

Industrial robots are available now in a wide variety of shapes, sizes and capabilities.

UNIT 2. CLASSIFICATION OF ROBOTS

1. Read and memorize the following words and word combination.

the type of drive — тип приводу
control system — система управління (керування)
the type of coordinate configuration system – тип конфігураційної системи координат
load capacity (pay load) — вантажопідйомність (корисне навантаження)
PTP control — позиційне управління
CP control – контурне управління
axis – вісь (у роботехніці — ступінь рухливості)
multi-point (MP) – багатоточковий

range — діапазон
compound curve — складна крива
servo-controlled robot — робот з сервоприводами
cartesian coordinate system — декартова (просторова прямокутна) система координат
work envelope (area) — робоча зона

2. See explanation of the following words and translate the sentences.

standpoint ≈ point of view	There are two main types of robots from the standpoint of control
to permit ≈ to allow, to make, possible	The PTP robot permits the control to stop each axis of manipulator at any point.
sophisticated ≈ complex, not simple	The drives of the servo-controlled robots are sophisticated mechanisms.
to include ≈ to contain, to consist of	Industrial robots include PTP robots and CP robots.

3. Read text A. Give the essence of the text.

Text A

The classification of industrial robots is pictured in diagram 1. The typical features of this type of industrial robot are as follows: the type of drive and control system, the type of coordinate configuration system in which the manipulator works; the number of degrees of freedom, load capacity, repeatability, the number of manipulators, etc. From the control standpoint there are two basic types of industrial robots: point-to-point (PTP) and continuous-path (CP).

The simplest case of PTP robots is the “two-point” or cycle robot, where each axis of this robot can generally move to only two positions. The “multi-point” PTP robot permits the control to stop each axis of manipulator at any point within its total range, rather that at only two, or a few, points. CP robots operate, in theory, in an infinite number of points in space, than, when jointed, describe a smooth compound curve. “Multi-point” PTP robots and CP robots are also called “servo-controlled” robots.

Cycle robots are usually either pneumatically or hydraulically driven. The drives of servo-controlled robots are usually sophisticated hydraulic or electric mechanisms.

Industrial robots

Type of coordinate system
- cartesian
- cylindrical
- spherical
- singular

Number of degrees of freedom
- two
- from 2 to 6
- more than 6

Number of manipulators (or arms)
- one
- two
- three
- four

Type of drive
- pneumatic
- hydraulic
- electric

Load capacity
- the lightest (up to 1 kg)
- light (1÷10 kg)
- medium (10÷200 kg)

Type of control system
- nonservo (cycle)
- point-to-point
- continuous-path

Speed of response
- small (V<0.5 m/c)
- medium (V=0.5÷1 m/c)
- high (V>1 m/c)

Robot accuracy (position tolerance Δ)
- small (Δ >1 mm)
- medium (Δ=0.1÷1 mm)
- high (Δ< 0.1 mm)

Degree of versatility
- general-purpose
- special-purpose

Diagram 1

Fig.1 shows “РИТМ-05” robot, working in the cartesian coordinate system. The working area or work is a parallelepiped. The cylindrical coordinated robots include “ЦИКЛОН-3.01”, “РБ-231” types (Fig.2.) the work envelope is a portion of the cylinder. The “ЮНИМЕЙТ” is typical of robots which have a spherical (polar) coordinate system (Fig.3). the work envelope is a portion of a shere. The angular (revolute) coordinate system is used by the “ТУР-10” robot. The work envelope approximates a portion of a sphere (Fig.4).

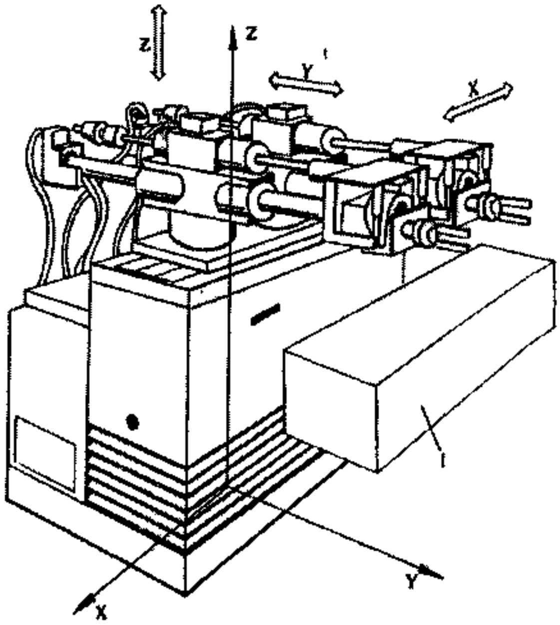


Fig. 1. Cartesian coordinate robot:
1 — work envelope is a parallelepiped

Notes

rather that — швидше
either ... or — або ... або

4. Describe: a) the names of the types of robots; b) the character of operation of the robot's axis; c) the working envelope. Use the substitution table.

A point-to-point robot		is also called	CP robot. PTP robot.
A continuous path robot	can	move stop operate	cycle robot. at any point without its total range.
A two point robot			in theory in an infinite number of points in space.
Each axis of the two-point robot			
Each axis of the multi-point robot			to only two positions.
Each axis of the CP robot			

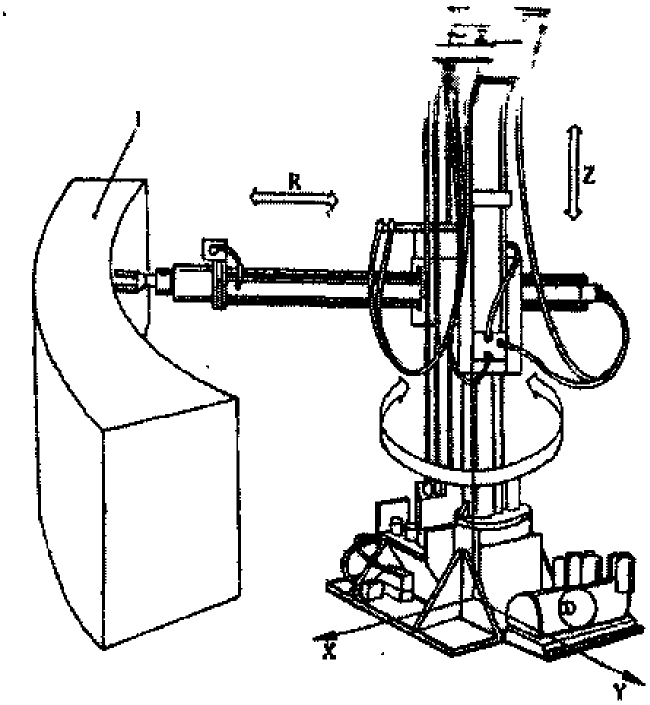


Fig. 2.Cylinderical coordinate robot:
1 – work envelope is a portion of a cylinder

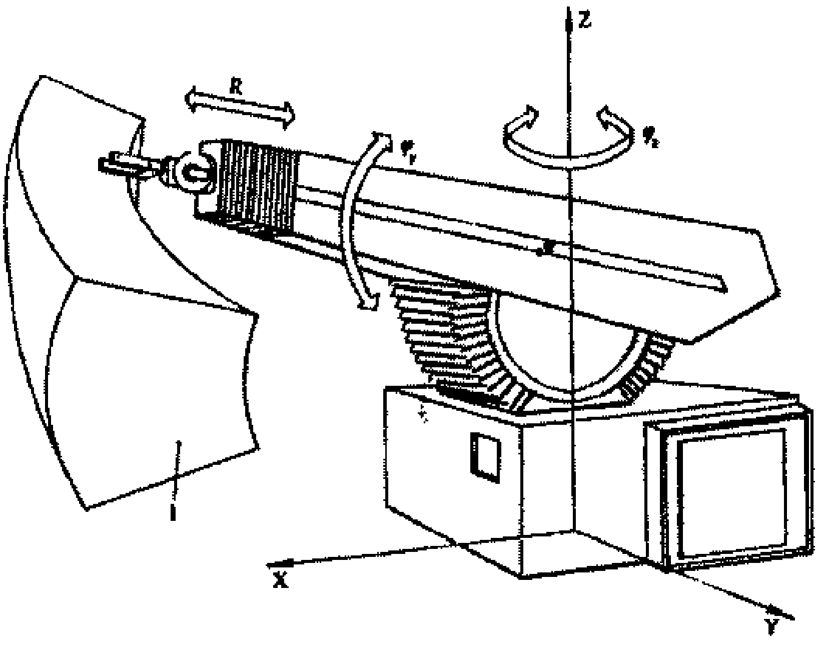


Fig 3. Spherical (polar) coordinate robot:
1 – work envelope is a portion of a sphere

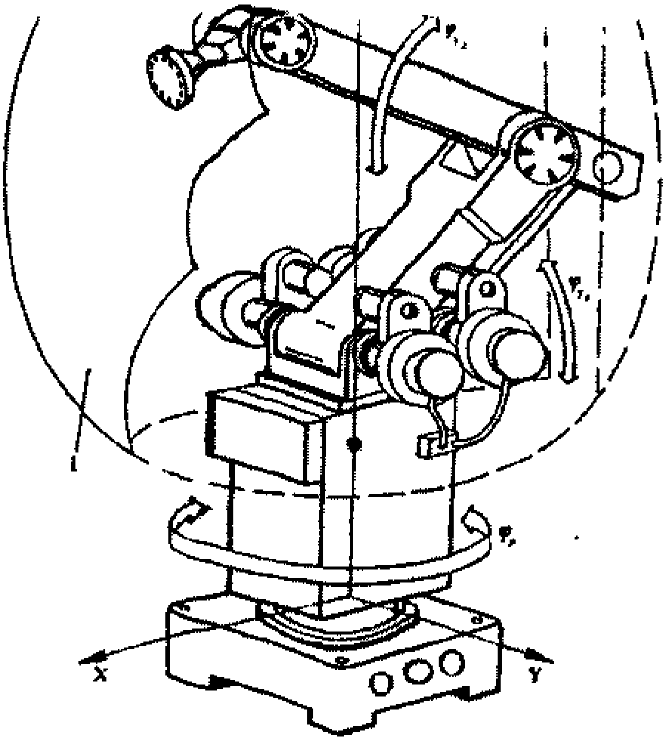


Fig 4. Angular coordinate robot:
1 – work envelope is a portion of a sphere

5. Describe the type of coordinate system and the shape of the work envelope. See e.g. and Figs. 1-4.

E.g. Figure 1 shows the robot working in the cartesian coordinate system. The working area is a parallelepiped.

6. Explain why this or that type of robot is called so. Translate the sentences into English. Use "is called". See e.g.

E.g. If robot is used in industry it is called an industrial robot.

1. Якщо кожна вісь робота може переміщатися в два фіксованих положення, робот називають двохточковим.
2. Якщо кожна вісь може переміщуватись в необмежену кількість точок, робот називають багато точковим.

7. Answer the following questions:

1. What are the typical features of each type of an industrial robot?
2. What is the principle according to which industrial robots are subdivided into PTP and CP robots?

Text B

There are robots with a different number of axes varying from 1 to 7 with load capacities from fractions of a kg to hundreds of kilogrammes. There are also stationary and mobile robots which can be fixed to the floor or to the ceiling, and actuation can be made by pneumatic, hydraulic or electrical actuators, with cycle, point-to-point or continuous-path control from individual special control system.

The simplest of the above mentioned robots are those operated by pneumatics, with fixed cycle control. Most of them have electrical control systems but there are also examples of complete pneumatically controlled models,

Hydraulic robots occupy second place in industrial application. As a rule, these are universal robots with one manipulator, covering the load capacity of 20-40 kg and point-to-point or continuous-path control of operation. They commonly work at cylindrical, spherical or coordinate systems.

The number of types of electromechanical robots is increasing quickly.

Notes

stationary robot — стаціонарний робот
mobile robot — рухливий робот
industrial application — промислове застосування

8. Make up questions to text B.

9.Speaking practice. Discuss the following:

1. There are robots with different numbers of axes.
2. There are different kinds of actuators.
3. There are stationary and mobile robots.
4. The simplest robots are those operated by pneumatics.

10. Write a summary.

Text C

Robots have a wide selection of manipulators: cartesian, cylindrical, polar, revolute, and special ones. They are either pneumatically, hydraulically or electrically driven.

Robots are available with 2 to 6 fully programmable degrees of freedom. They can handle payloads of up to hundreds of kilogrammes. Different control systems from the simplest cycle to the most complex CP systems based on exterior sensors able to correct the relative position are used. The robots may have more than one manipulator.

11. Speak on the topic suggested.

1. Robots have a wide selection of manipulators.
2. Robots are available with 2 to 6 fully programmable degrees of freedom.
3. Robots can have different control systems from the simplest cycle systems to the most sophisticated (complex) CP systems.

12. Speak on the following problem, using Figure 1: "The classification of industrial robots"

UNIT 3. THE ROBOT'S DESIGN

1. Read and memorize the following words and word combinations.

basic components – основні компоненти
the control (controller) — пристрій управління
power supply — підвід енергії (чи електроенергії); енергоживлення
– air supply — підведення повітря
– hydraulic supply — підведення рідини
feedback device — датчик зворотнього зв'язку
joint — зчленування, шарнір (кінематична пара)
actuator — виконавчий орган (механізм)
gripping device — захватний пристрій
memory (programme storage**)** — пристрій пам'яті
sequence – послідовність
to interact with the machines – взаємодіяти з машинами
stepping switches — крокові перемикачі
valve — клапан, розподільник
heat exchanger — теплообмінник
power (supply) unit (- power pack) — енергоблок (живлення)
control cabinet — стійка (пульт) керування
to maintain – підтримувати
filter-regulator — фільтр з регулятором
compressed air system – система стиснутого повітря

2. See explanation of the following words and translate the sentences.

to vary ≈ to be different from, to differ **capability ≈** possibility	Industrial robots vary in shape, size and capability.
to store ≈ to keep **to require ≈** to need	The required motions of the robot are stored by the control.
to interact ≈ to come into contact with	The control system of the robot interacts with the machines with which the robot works.
to maintain ≈ to define, to determine, to fix **to cool ≈** to make colder **fluid ≈** something that can flow	Some robots require cooling water to maintain hydraulic fluid temperature.

3. Translate the two-component and three-component word combinations. Remember that the initial word for translation is the last element of the word combination. See e.g.

E.g. fluid flow — потік рідкого середовища
cabinet temperature regulation — регулювання температури стійки

the manipulator's actuator; power supply; control valve; filter regulation; pneumatically actuated robot; compressed air system; electrically driven pump; power supply unit

4. Read text A. Try to understand as much as possible of its contents.

Text A

What are industrial robots and how do they work? Although they vary widely in shape, size and capability, industrial robots are made up of several basic components: the manipulator, the control and the power supply (Figs. 5,6).

The manipulator is the mechanical device which actually performs the useful functions of the robot. It is a hydraulically, pneumatically or eiectricaly driven jointed mechanism capable of up to seven independent, coordinated motions. Feedback devices on the manipulator's joints or actuators provide information regarding its motions and positions to the robot control. A gripping device or tool, designed for the specific tasks to

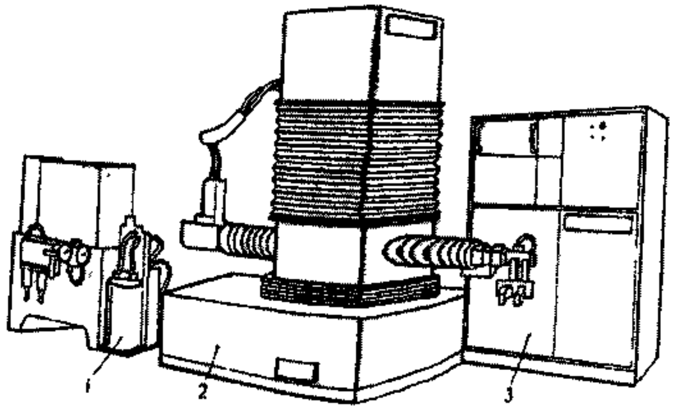


Fig 5. Hydraulically actuated robot:
1 – remote hydraulic power pack; 2 – manipulator; 3 – control cabinet

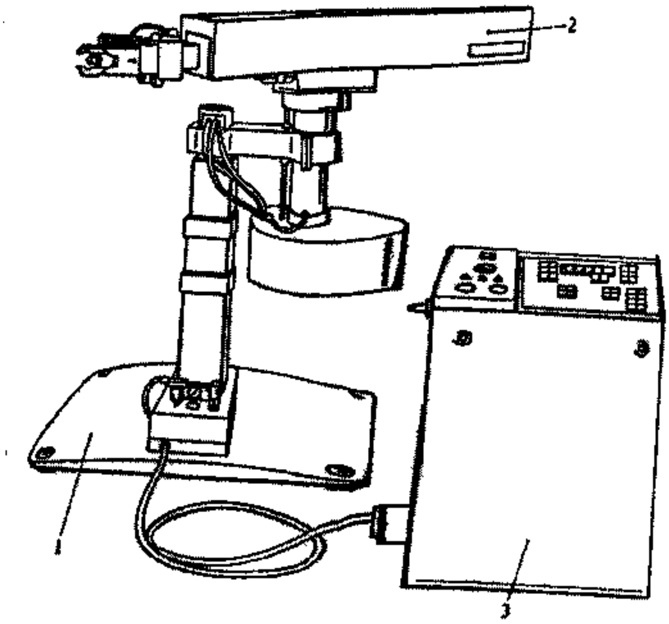


Fig. 6. Pneumatically actuated robot:
1 – base with air supply unit; 2 – manipulator; 3 – control cabinet

be done by the robot, is mounted on the outermost joint of the manipulator. Its function is directed by the robot's control system.

The control stores the desired motions of the robot and their sequence in its memory; directs the manipulator through this sequence or "program" upon command; and interacts with the machines, conveyors and tools with which the robot works. Controls range in complexity from simple stepping switches to minicomputers.

Hydraulically actuated robots also include an electrically driven dump, control valves, reservoir and heat exchanger in a power supply unit which provides fluid flow and pressure to drive the manipulator. Cooling water is also required by some robots to maintain hydraulic fluid temperature or for control cabinet temperature regulation. Pneumatically driven robots are usually connected (through a filter-regulator) to the factory compressed air system.

Notes

regarding — стосовно, що стосується
upon command — згідно команди

5. Read the text over. Name the functions of the robot's components.

	the manipulator		to provide information to the robot control.
	feedback devices		to perform useful functions of the robot.
The function of	the gripping device	is	to store the desired motions of the robot and their sequence in its memory.
	the control		
	the control		to perform specific operations of the robot.
	the power supply		to maintain hydraulic fluid temperature.
	cooling water in hydraulically driven robots		to provide energy to drive the manipulator.

6. Characterize the robot and its basic components, using the word combinations given in Ukrainian.

1. відрізняються за: формою, розміром, можливостями;
2. механізми, що приводяться в дію: гідравлічно, пневматично, електрично;
3. система управління зберігає необхідні рухи, їх послідовність;
4. система управління взаємодіє з: машинами, конвеєрами, інструментами.

Text B

Industrial robots exist in a wide range of capabilities and configurations. However, they commonly consist of several similar major components: the manipulator, the controller, and power supply. The most common manipulator configurations are related to the coordinate systems in which they function: cartesian, cylindrical, polar and revolute.

The drive system may be pneumatic, hydraulic or electromechanic. The controllers initiate the motion of the manipulator, actuate tools or grippers and transmit and receive signals to and from the other equipment with which the robot operates.

The function of the power supply is to provide energy to the manipulator's actuators. In the case of electrically driven robots, the basic function of the power supply is to regulate the incoming electrical energy. Power for pneumatically actuated robots is usually supplied by a remote compressor which may also service other equipment. Hydraulically actuated robots normally include a hydraulic power supply as either an integral part of the manipulator or as a separate unit.

Notes

robot configuration — виконання робота
gripper — захват
integral — вбудований, цілісний
separate — окремо розташований

7. Give a heading to each paragraph of the text.

8. Speak on the topics suggested.

1. Industrial robots exist in a wide range of capabilities and configurations.
2. The function of the power supply is to provide energy to the manipulator’s actuators.

Text C

Industrial robots are made of the following major (basic) components: the manipulator, the control and the power supply. The control is a device by which a person may communicate commands to a machine. The manipulator is a mechanism, usually consisting of a series of segments, jointed or sliding relative to one another for the purpose of grasping and moving objects usually in several degrees of freedom. It may be remotely controlled by computer or by a person. The power supply provides energy to the robot actuators to produce motion. A robot electric power supply unit provides only the DC (direct current) voltages required by the electronic circuits internal to the robot controller.

9. Retell the text.

UNIT 4. MANIPULATORS

1. Read and memorize the following words and word combinations.

a) column, arm, extend-retract, elbow joint, shoulder joint
b) **emulate –** копіювати; моделювати
waist [trunk] — корпус (у робототехніці – опорна колона)
wrist — зап'ястя (у робототехніці — пристрій орієнтації)
rectilinear – прямолінійний
travel [movement] — хід (механізму)
to mount – встановлювати, монтувати
base — основа
carriage — каретка
rotate – обертатися
to pivot – обертатися
upper arm — верхня ланка шарнірної руки
trunk – магістральний кабель (канал)
forearm — нижня ланка шарнірної руки
member [link — ланка
major axes — переносні ступені рухливості
minor axes – орієнтуючі ступені рухливості
jointed arm — шарнірна рука

2. See explanation of the following words and translate the sentences.

to emulate ≈ to try to be better, to complete	The manipulative abilities of the robot emulate the physical capabilities of man.
to be mounted ≈ to be placed to be located	A vertical column of the cylindrical coordinate robot is mounted on a rotating base.
to pivot ≈ to rotate, to revolve	The arm of the spherical coordinate robot pivots in a vertical plane.
to be provide ≈ to be created	In an angular coordinate configuration rotary motion in a horizontal plane is provided at the shoulder joint.
are similar to ≈ are like	The robot's movements are similar to man's movements.

3. Compare the translation of Participle II in - e.g. a) and b).

E.g. a) the designed device

b) the device is designed

Translate the sentences into Ukraine.

1. In Fig. 7 we can see the elbow joint located between the forearm and the upper arm.
2. The elbow joint is located between the forearm and upper arm.
3. The motion provided at the shoulder joint is important.
4. Rotary motion is provided at the shoulder joint.
5. Design variations are pictured in Figs. 7-10.
6. Design variations pictured in Figs. 7-10 illustrate four basic design variations of the robot.
7. The cylindrical coordinate robot has a horizontal arm mounted on a vertical column.
8. The vertical column is mounted on a rotary base.

4. Read and translate text A.

Text A

Robots move according to four basic design variations pictured in Figs. 7-10. The design emulates man's physical capabilities by simulating his movements and activities through "degrees of freedom" or freedom of movement similar to man's waist, wrist, elbow, shoulder and fingers.

The cartesian coordinate robot configuration has three rectilinear movements: a horizontal travel, a vertical travel, and extend-retract. The cylindrical coordinate robot consists of a horizontal arm mounted on a vertical colume which, in turn, is mounted on a rotating base. The horizontal arm moves in and out; its carriage moves up and down on a vertical column and these two members rotate as a unit on the base. Spherical coordinate configuration is similar to the turret of a tank. An arm moves in and out, pivots on a vertical plane and rotates in a horizontal plane about the base.

Angular coordinate configuration consists of a base or trunk and an upper arm and forearm which move in a vertical plane through the trunk. An "elbow" joint is located between the forearm and upper arm, a "shoulder" joint is located between the upper arm and the trunk. Rotary motion in a horizontal plane is also provided at the shoulder joint. These members comprise the major axes of the arm motion.

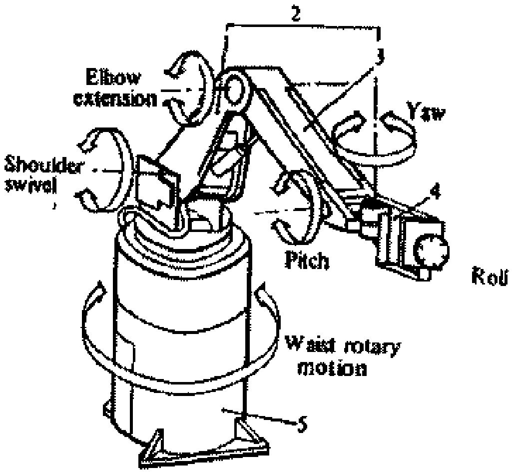


Fig. 7. Angular design variation:
1 – forearm; 2 – jointed arm; 3 – upper arm; 4 – wrist unit; 5 – base (trunk)

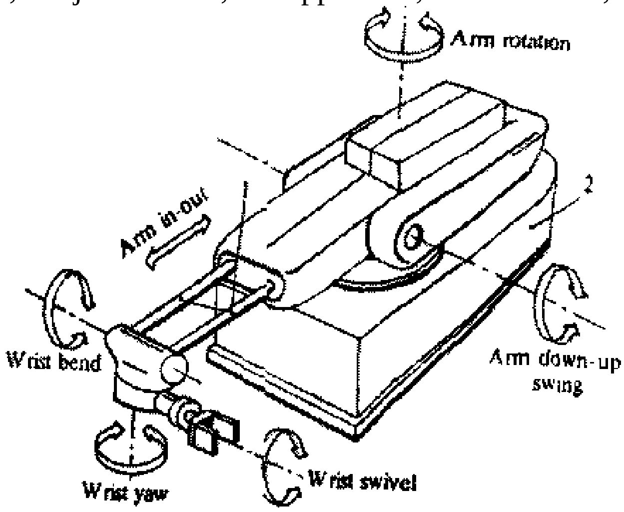


Fig. 8. Spherical design variation:
1 – arm; 2 – base

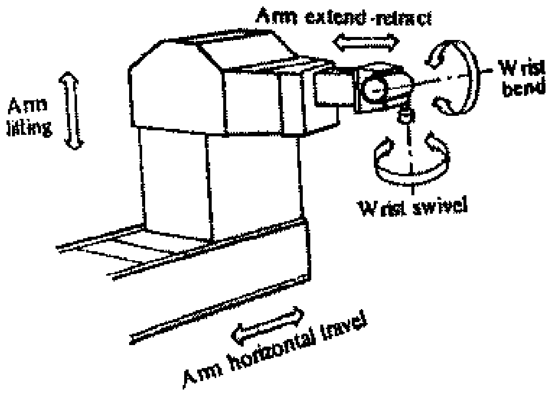


Fig. 9. Cartesian design variation

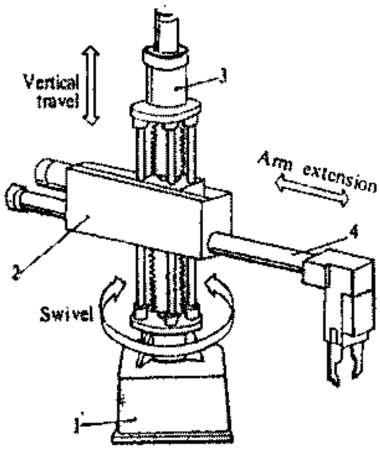


Fig. 10. Cylindrical design variation:
1 – base; 2 – carriage; 3 – electrical motor on the column; 4 – horizontal arm

Notes

according to — згідно
in turn — в свою чергу
the turret of a tank — башта танка

5. Describe the location and way of operation of the robot's parts using the substitution table.

In the cylindrical (spherical, angular) coordinate robots	an arm (forearm) the horizontal arm	is mounted (provided, located)	on the base (on a rotating base, about the base).
	the carriage of the horizontal arm an elbow (shoulder) joint the vertical column rotary motion	moves (pivots, rotates) rotate	on a vertical (horizontal) column (plane). in a vertical plane through the trunk. in and out (up and down). between the upper arm and the trunk (the forearm and upper arm).

6. Fill in the blanks.

1 The design of robots simulates man's movements and activities. These ... and ... are simulated through degrees of freedom. The degrees of ... mean freedom of movement. Freedom of ... is similar to man's waist ad wrist. ... of movement is also ... to man's eibow, shoulder and finger. The cartesian coordinate robot configuration has three rectilinear movements. These ... movements are: a horizontal (ravel, a vertical ... and extend-retract. The cylindrical … … contains a horizontal arm. The ... arm is mounted on a vertical column. The vertical ... is ... on a rotating ... . The horizontal arm moves in and out. The carriage of the … … up and down on a vertical ... . Spherical ... is similar to the turret of a tank. An arm ... up and down. Then it pivots on a vertical plane and rotates about the ... . Angular ... consists of a … or trunk. It incorporates an upper ... and forearm. An ... arm and ... in a vertical ... through the ... . An elbow joint is located between the ... and upper ... . A shoulder joint is ... between the ... arm and the ... .

7. Characterize the structure of robots and their work inserting the words given below.

1. The freedom of movement of a robot... man's waist, wrist and some other parts of his body. 2. One part of the cylindrical coordinate robot moves ... . It is called the horizontal arm. 3. The other part of the cylindrical coordinate robot moves ... . It is called the carriage. 4. The turret of a tank ... spherical configuration. 5. In spherical configuration an arm moves ... . 6. An arm of the spherical coordinate configuration rotates ... the base. 7. The forearm and the upper arm of the angular coordinate configuration move in a vertical plane ... the trunk.

up and down, in and out, is similar to, through, about

8. Complete the answers to the given questions. You may refer back to the text.

1. What is the principle on which the movement of robots is based? The principle on which ... .

2. Could you name the parts of a man's body the movements of which are simulated by the robot? The parts of a man's body ... .

3. Could you name the types of robots the structure of which is pictured in Figs. 7-10?

4. What members comprise the major axis or degrees of freedom of the arm motion? We can name ... .

9. Write a short precis of the text completing the sentences.

The first passage of the text deals with the characteristics of ... .

From the second passage we learn about the types of ..., and the design of ... .

The text also deals with the main principles of …, and the location of ... .

Text B

As many as three additional degrees of freedom are provided at the extremity of the robot arm in a unit commonly called a "wrist". Wrist axes include "roll" (swivel) (rotation in a plane perpendicular to the end of the arm, "pitch" (bend) (rotation in a vertical plane through the arm) and "yaw" (rotation in a horizontal plane through the arm).

Additional motion may be provided by mounting the robot on a two-axis table or on a track on the floor or overhead. Many of the robots available are "modular" in design. That is, the user may select as few as two or as many as seven or eight degrees of freedom, depending upon his need. A mounting surface is provided on the last axis of the wrist for installation of the tool or gripper with which the robot performs its intended task. The total number of degrees of freedom comprises the number of degrees of freedom arm motion, wrist motion and end-effector motion.

Notes

roll (swivel, twist) — обертання (зап'ястя)
pitch (bend) — хитання (зап'ястя)
yaw — вигин (зап'ястя)
track — рейкові направляючі
modular — модульний
mounting surface — монтажна поверхня
end-effector (handtooling) — робочий орган
hand (end-of-arm) — кисть, кінцевий елемент руки

10. Translate the following definitions and memorize them.

Wrist: A set of rotary joints between the arm and end-effector which allow the end-effector to be oriented to the workpiece.

Arm: An interconnected set of links and powered joints comprising a manipulator which supports or moves a wrist and hand or end-effector.

Joint: A rotational or translation degrees-of-freedom in a manipulator system.

Base: The platform or structure to which the shoulder of a robot arm is attached.

Extension: A linear motion in the direction of travel of the sliding motion mechanism, or an equivalent linear motion produced by two or more angular displacements of a linkage mechanism.

Cartesian Coordinate System: A coordinate system whose axes or dimensions are three intersecting perpendicular straight lines and whose origin is the intersection (also described as rectilinear).

11. Write a summary.

Text C

The prevalent types of industrial robot have an articulated mechanical arm to which can be attached a variety of hand-like grippers or a tool.

From two to six programmable robot movements are available. For example, the three arm movements of a typical robot are up-down, extend-retract and rotation (move left or right). The three wrist movements are roll (swivel), bend (pitch) and yaw. For most applications, five movements are sufficient, the yaw movement is rarely required.

12. Render the text in English.

UNIT 5. CONTROL SYSTEMS OF INDUSTRIAL ROBOTS

1. Read and memorize the following words and word combinations.

path (trajectory) – шлях, траєкторія
pick-and-place robot — робот-перекладчик
"teaching" phase (programming) — фаза навчання, програмування
interlocking equipment — зблоковане устаткування

movement — переміщення
resultant arm movement — сумарне переміщення руки
controlled-path type of machine — машина з контурним типом керування
computer control — керування з ЕОМ

2. Read text A. Try to understand its contents.

Text A

From the standpoint of arm motion, control systems may be classified as point-to-point (PTP) and continuous-path types. The simplest version of PTP control systems is a cycle system, usually used for "pick-and-place" robots which move between two preselected points.

In point-to-point only the end point or position is critical. The path the robot arm takes is not important. PTP robots move in discrete steps from one point or location in space to another. During the "teaching" phase of the operation, each of these points has to be recorded in sequence. At any point in space the robot's programme may be interrupted by input signals from interlocking equipment, or it may provide output signals to operate external equipment. Also dynamic characteristics of arm movement are not critical.

A continuous-path system involves a controlled programme for each axis simultaneously involved in resultant arm movement. This smooth trajectory is usually developed during the programming or "teaching" phase which is carried out by an operator. The controlled-path type of machine is less common and utilizes a compute control system with the computational ability to describe a desired path between any preprogrammed points. The computer calculates both the desired path and the acceleration, deceleration and velocity of the robot arm along the path.

Note

both ... **and** — як ... так і

3. Carry out the following tasks:

a. Give the English equivalent of the word combinations given in Russian.

b. Find in text A, read and translate the sentences in which these word combinations are used.

циклова система, позиційна система управління, кінцеві точки, вхідний сигнал, вихідний сигнал, сумарне переміщення руки, машина з контурним управлінням, система управління з ЕОМ

4. Look through text A again. Describe the control systems filling in the blanks.

There are two types of ... systems. They are: point-to-point and continuous-path ... . A cycle ... is the simplest example of the ... control systems. The ... is usually used for pick-and-place ... . These robots have a movement between two points. These ... are preselected. ... robots ... in discrete steps. The robots ... in ... steps from one … in space to another. At any point in space the robot's programme may be ... . It may be ... by input signals. The ... come from interlocking equipment, the robot's ... may provide output … . ...signals are used to operate external ... . Continuous-path ... involve a controlled ... for each axis. The smooth trajectory is developed during the "teaching" phase. The "..." ... is carried out by an operator. The computer of the … systems has an ability to describe a desired path. This … can be … between any … points.

5. Compare PTP and CP systems. Name the parameters (see the word combinations written below) on which the comparison of the systems is based. Working in pairs test each other's ability to characterize the parameters.

PTP systems	**CP systems**
Move from one point to another.	Involve a controlled programme for each axis simultaneously involved in resultant arm movement.
During the "teaching" phase of the operation each of the points has to be recorded in sequence.	During the "teaching" phase the smooth trajectory is usually developed. This trajectory is carried out by an operator.
The robot memorizes on a point-to-point basis, hence it is possible to correct individual teaching points.	The robot learns in terms of continuous-path, hence it is impossible to effect partial correction of the programme.

The essence of the "teaching" phase, character of movement, correction possibilities

6. Guess the answer.

1. What are they?

They move in discrete steps from one point of space to another.
Their programme can be interrupted by input signals.

2. What is it?

It involves a controlled programme for each axis.
Its "teaching" phase is carried out by an operator.
It utilizes a computer control system.

It calculates the desired path and acceleration, deceleration and velocity of the robot arm.

a computer, PTP robots, a continuous-path robot, control systems

7. Suggest the answer to the question: What is essential (not essential) when we deal with the above mentioned robots? Complete the sentence. See e.g.

E.g. When we deal with PTP control systems the path the robot arm takes is not essential.

1. У контурних роботів дві попередньо вибрані точки ... .
2. У позиційних роботів кінцеві точки ... .
3. У позиційних роботах динамічні характеристики руху руки ... .

8. Describe the control systems in English. Use the substitution table.

Циклова система Визначальними позиційної системи Під час фази навчання позиційного робота кожна з точок Програма позиційного робота	є є не є використовується не використовується може бути повинна бути	найпростішим варіантом позиційної системи. кінцеві точки або положення. записана в певній послідовності. перервана вхідним сигналом від заблокованого устаткування

Text B

Cycle systems use simple sequencing controls such as stepping switches or pneumatic logic sequencers capable of executing single program of about 4 consecutive steps, or electronic programmable controllers of greater program capacity.

Multi-point PTP and CP control systems incorporate feedback devices on the joints or actuators of the manipulator which continuously measure the position of each axis. This permits the control to stop each axis of the manipulator at any point within its total range, rather than at only two, or a few, points. Servo-controlled robots thus have much more manipulative capabilily than cycle robots by being able to position a tool or gripper anywhere within the total work envelope.

Multi-point PTP and CP control systems use electronic sequencers, minicomputer- or microprocessor-based systems and magnetic or solid-state electronic memory devices. They are often capable of executing more than one program containing several hundred sequential steps.

Simple point-to-point positioning and trajectory control are both available, in some cases in the same unit.

Notes

sequencer — командоапарат
solid-state — напівпровідниковий
unit — блок

9. Translate the following definitions and memorize them.

Continuous Path Control: A control scheme by means of which the inputs or commands specify every point along a desired path of motion. Point-to-point Control: A control scheme by means of which the inputs or commands specify only a limited number of points along a desired path of motion.

Sequencer: A controller which operates an application through a fixed sequence of events.

Program: A sequence of instructions to be executed by the computer or robot controller to control a machine or a process.

To program: To teach a robot system a specific set of movements and instructions to accomplish a task.

Computer Control: Control involving one or more electronic digital computers.

10. Write a summary of the text.

Text C

There ate two methods of teaching, namely (1) CP (continuous path) control teaching in which the robot is taught to use the tool by operating the teaching handle at the arm end of the robot, and (2) PTP (point-to-point) control teaching in which the robot is slowly taught by approximating the intendent locus of the type of the tool at the arm end of the robot into a member of straight lines and by having the robot aim at the break points connecting these lines.

In the case of CP control teaching, the robot learns in terms of a continuous path, hence it is impossible to effect partial correction of the program. In the case of PTP control teaching, however, the robot memorizes on a point-to-point basis, hence it is possible to correct individual teaching points.

11. Comment on the statements given below.

1. There are two methods of teaching robots.
2. In the case of CP control teaching, the robot learns in terms of a continuous path.
3. In the case of PTP control teaching, the robot memorizes on a point-to-point basis.

12. The main advantages of each method of teaching robots.

UNIT 6. SENSORY FEEDBACK SYSTEMS OF INDUSTRIAL ROBOTS

1. Read and memorize the following words and word combinations.

sensing — чутливість
recognition — розпізнавання
workpiece — заготівка
sensory feedback — сенсорна інформація (зворотній зв'язок)
visual feedback — зорова інформація (зворотній зв'язок)
sensor — сенсорний пристрій, чуттєвий датчик
target designation system — система вказівки мети

computer vision — (технічний) зір на основі ЕОМ
visual servoing — сервоуправління за зоровою інформацією
speed of response — швидкодія
picture — кадр (телевізійний)
image processing — обробка зображення
an error signal — сигнал помилки (неузгодженості)
rest — супорт

2. See explanation of the following words and translate the sentences.

vision ≈ possibility to see **rudimentary** ≈ elementary	Rudimentary vision is very important for a robot.
exciting ≈ remarkable, wonderful, striking	An exciting future of automation is opened by the robots which can interpret what their TV cameras see.
to complete ≈ to finish	It is important to know when a part comes into contact with a workpiece. The robot's task is to operate instinctively and to complete the operation.
unpredictable ≈ nothing could be said about it before	the communication of the vision and manipulative systems with each other is sometimes unpredictable.
are converted into ≈ are transformed into	The error signals are converted into commands to the manipulative system by the control algorithms.
to grasp ≈ to take and hold **to reach down** ≈ to come near	The robot can reach down the object and grasp it.
interaction ≈ communication **data** ≈ information	Physical interaction data is very important when we deal with tactile sensing.
to be aware of something ≈ to know something	When a part comes into contact with a workpiece, we want to be aware of this.

3. Read text A. Try to understand its contents in detail.

Text A

Rudimentary vision and tactile sensing are most important. With regard to vision, we want to know where things are. Ordinarily, those involved in character recognition are interested in identifying objects. This is not the problem with industrial robots. We know that everything is —

we just don't know where everything is. Robots equipped with miniature TV cameras (Fig. 11) and small microcomputers to interpret what the cameras see would open exciting new avenues of automation.

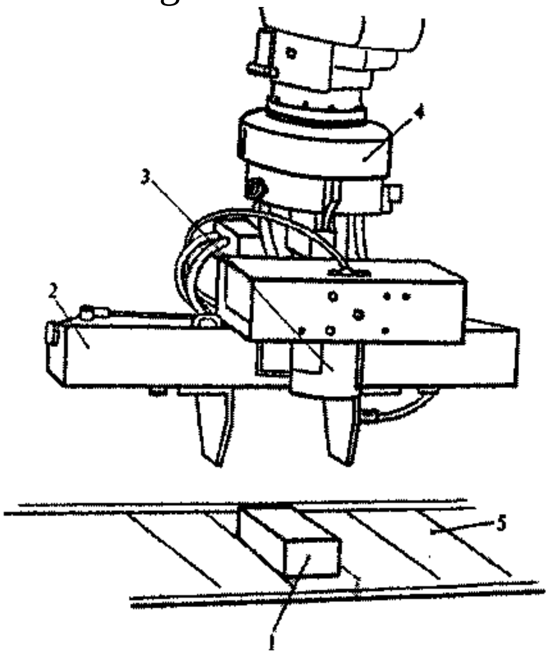


Fig. 11. Robot uses visual servoing to track an object on a moving belt:
1 – object; 2 – tool (gripper); 3 – TV camera; 4 – robot hand; 5 – moving belt

In tactile sensing, the most important quality is physical interaction data. When a part comes into contact with a workpiece, we want to be aware of this and would like the robot to act instinctively to complete the operation.

One of the sensory feedback system applications is the use of visual feedback to control a robot in real time. The robot consists of manipulator with a gripper which has tactile sensors, a target designation system based on a TV camera and a control computer. The function of computer vision in a visual servoing application is to determine the spatial relationships existing between the camera, tool and workpiece. The vision and manipulation subsystems interact with each other in unusual and sometimes unpredictable ways. Stability and speed of response, as well as accuracy, are important.

Visual analysis of a scene is made in two phases: picture taking and image processing. Analysis of the image data produces an "error" signal which then drives the rest of the servo-system. The control algorithms convert the error signals into commands to the manipulation subsystem. When pictures taken by the camera located in hand indicate a position error of 1 mm or less, the robot reaches down and grasps the object.

Notes

with regard to — що стосується
those – замінник раніше згаданого іменника
as **well as** — а також

4. Read and translate the word combinations with Participle II. See Fig 12.

objects involved, in the sphere of research, robots equipped with TV cameras, target designation system based on a TV camera, camera located in hand, pictures taken by a camera

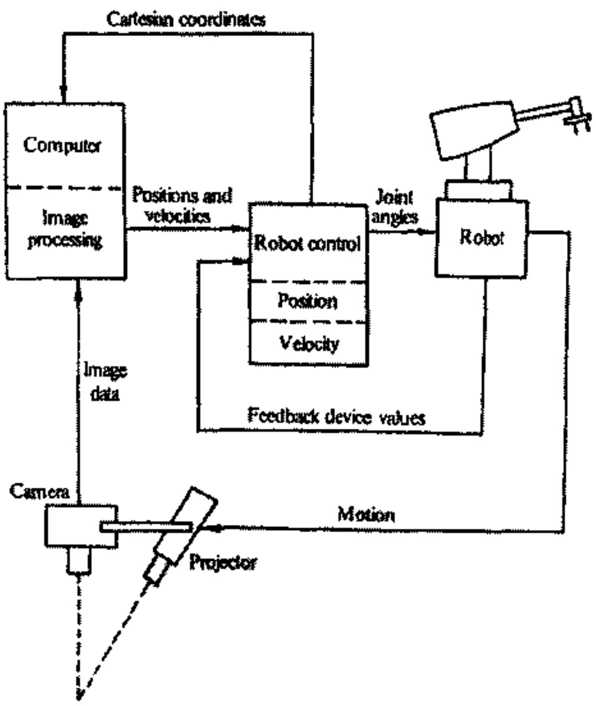


Fig. 12. Block diagram of visual-servo control system show its major elements

5. Name the function of the sensory feedback system combining word combinations of list A and B into a logical unit.

A. The analysis of image data is used ... . Rudimentary vision can be used ... . Robots equipped with TV cameras and small microcomputers can help ... . Tactile sensing can be used ... . Visual feedback of the sensory feedback system is used ... . Computer vision in a visual servoing application is used ... . The control algorithms are used ... . Pictures taken by camera located in hand can be used ... .

B. to know where things are; to produce an "error" signal that drives the rest of the servo-system; to know when a part comes into contact with a workpiece; to interpret what cameras see; to determine the spatial relationships that exist between the camera, tool and workpieces; to control a robot in real time; to indicate a position error of 1 mm or less; to convert the error signal into command to the manipulation subsystems

6. Characterize the sensory feedback systems of robots, Complete the sentences. Use: "One of the system is ...", "The other system is ...", "... deal with", "Thanks to ...".

1. Однією з систем чутливості робота є ... ,
2. Ми маємо справу з цією системою, коли ... ,
3. Іншою системою чутливості робота є ... .
4. Завдяки тактильній системі, робот ... .

7. Give the main points of the text answering the questions.

1. What kind of sensory feedback systems of robots do you know?
2. What is each system used for?
3. What are the most important characteristics of each system?
4. What is the sphere of the sensory feedback system application?

Text B

Existing robot technology is clearly in need of sensory feedback to extend its limited capabilities. Visual feedback can minimize the need for jigs fixtures and ease workpiece tolerance requirements. Visual feedback controlling a manipulator in real time can allow it to work on a moving line without requiring precise control of the line.

The approach has been to place a small solid-state TV camera in the manipulator hand and use its visual feedback to guide the hand to a given target. This method, called “visual servoing” may be applied to a large variety of tasks in material handling, inspection and assembly.

Since control is in real time, a key point in the approach is to make use of binary images to achieve fast and reliable image processing. Special consideration must be given to lighting and contrast in the image but the reward for this is fast operation. The real-time nature of the servo-system requires consideration of the dynamics of mechanical components and leads to questions of stability and speed of response.

Notes

jig – кондуктор (для свердління отворів)
fixture – затискний пристрій
assembly – монтаж

8. Give your opinion on the problems given below.

1. Existing robot technology is in need of sensory feedback to extend its limited capabilities.

2. The method called "visual servoing" may be applied to a large variety of tasks.

3. The real-time nature of the servo-system requires consideration of the dynamics of mechanical components.

9. Translate the following definitions and memorize them.

Sensor: A transducer whose input is a physical phenomen and whose output is a quantitative measure of that physical phenomenon.
Tactile Sensor: A transducer which is sensitive to touch.
Freedback: The signal or data sent to the control system from a controlled machine or process to denote its response to the command signal.
Error Signal: The difference between desired response and actual response.
Search Routine: A robot function by which an axis or axes move in one direction until terminated by an external signal. Used in stacking and unstacking of parts or to located workpieces.

10. Write a summary.

Text C

As with any automated equipment, a robot requires an ordered environment. It performs this task with a fair degree of accuracy and repeatability; however, if the object is not consistently oriented and positioned, the robot will fail in its task. The immediate impact of sensory feedback capabilities will be significant. Sensor-equipped robots will be able to work with mixed, randomly positioned, unoriented parts. Sorting and visual inspection operations will be feasible as robots aquire the ability to apply sensors and rudimentary judgment to their programmed tasks. Sensory feedback will also extend the use of robot in assembly operations.

11. Comment on the statements given below.

1. A robot requires an ordered enviroment.
2. If the object is not consistently oriented and positioned, the robot will fail in its task.
3. Sensory-equipped robots will be able to work with mixed, randomly positioned, unorienled parts.

UNIT 7. END-OF-ARM TOOLING

1. Read and memorize the following words and word combinations.

surface-lift device — пристрій для підйому плоских виробів
lever — важіль
vacuum pickup — вакуумний присос
stud — зварювальний дріт
tubular feeder - трубчастий пристрій, що подає
torch — пальник
routing head — головка для зняття задирок, затуплення кромок
grinder – шліфувальний камінь
sander — абразивна шкірка
primer — ґрунтовка
plating — покриття металом, нікелювання

2. Read and translate text A.

Text A

A general-purpose handtooling (or end-effectors) designed for specific parts or classes of parts includes three general categories: mechanical grippers, surface-lift devices, and tools.

Mechanical grippers employ movable, finger-like levers, which are paired to work in opposition to each other (Fig, 13). A single hand might have one or several sets of opposed fingers. Likewise, a robot might have more than one hand.

Surface-lift devices include vacuum pickups for handling delicate or non-ferrous parts and electromagnets for handling ferrous parts with flat or curved surfaces (Fig. 14).

The spotwelding gun is typical of the tools which can be handled by general-purpose industrial robots. Many industrial robots with six-axis positioning control are employed to manoeuvre spotwelding guns through complex welding programs (Fig. 15). An industrial robot which is equipped with a stud-welding head is also practical. Studs are fed to the

Fig. 13. Mechanical gripper with finger-like levers

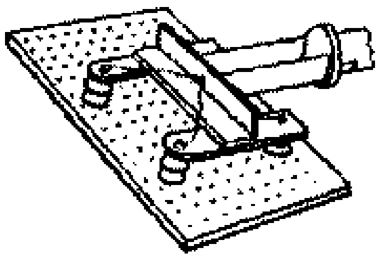


Fig. 14. Surface-lift device

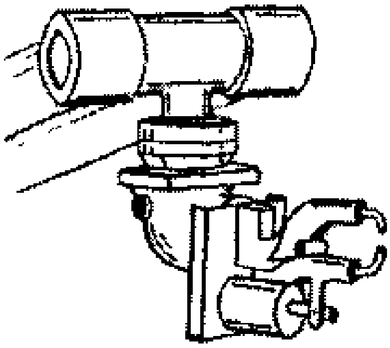


Fig. 15. Spotwelding gun

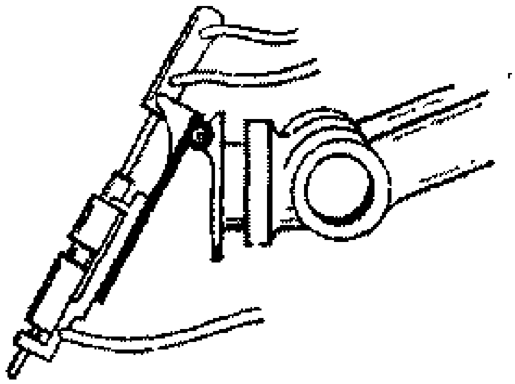


Fig. 16. Stud-welding head

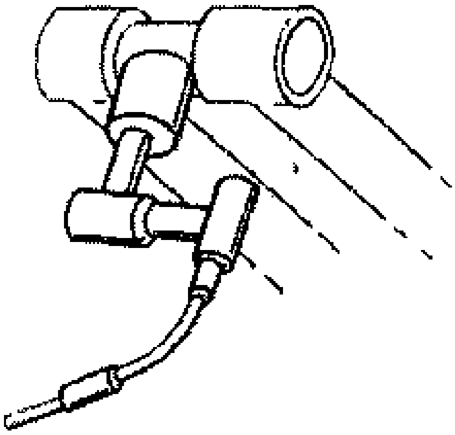


Fig. 17. Arc welding torch

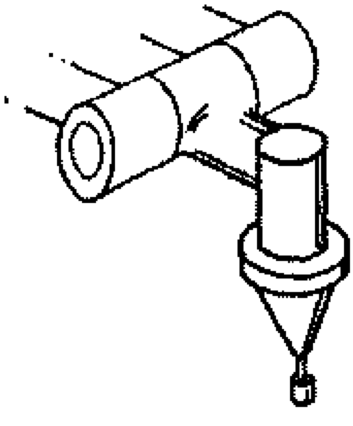


Fig. 18. Routing head

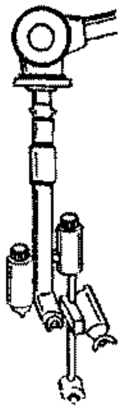


Fig. 19. Spray gun

head from a tubular feeder suspended from overhead (Fig. 16). Arc welding with a robot-held torch is another application which can be performed by an industrial robot instead of man (Fig. 17). A routing head, grinder, belt sander, or disk sander can be mounted readily on the wrist of an industrial robot (Fig. 18). The industrial robot's capacity to perform multipass spraying at controlled velocity makes it suitable for automatically applying primers, as well as applying masking agents which are used before plating (Fig, 19).

Notes

likewise — аналогічним чином
instead of — замість

3. Talk about the general-purpose handtooling. Choose the required word.

A general-purpose handtooling is designed for (specify, specific) parts. There are three (generally, general) categories of general-purpose handtooling or end-effectors. They are (mechanical, mechanically) grippers, (surface, service) lift devices and tools. Mechanical grippers employ (movement, movable) levers which can work in (opposite, opposition). Surface-lift devices contain vacuum pickups. The pickups can handle (delicately, delicate) parts. The spotwelding gun is a (type, typical) tool that can be handled by general-purpose industrial robots.

4. Read and translate the sentences which contain Participle II.

1. сконструйовані для конкретних деталей, пальцеві захвати; 2. криволінійні поверхні; 3. підвішений зверху; 4. нанесення покриття з керованою швидкістю

5. Describe the gripping devices. Use the substitution table.

Mechanical grippers	have	finger like	levers
			sets
A single hand	has	movable	of opposed fingers.
Ferrous parts		one or several more than	one hand surfaces.
		flat	
		curved	

6. Topics for discussion:

- a genenl-purpose handtooling (aim, design)
- mechanical grippers
- surface-lift devices (design, function)
- induslrial robots' capacity

7. Describe Figs, 15, 16, 17, 18, 19. Insert the properword.

Fig. 15 – It is a … … . The … … can be handled by general-purpose industrial robots. Many … … having six-axis positioning control are employed. They … … to manoeuvre ... … through complex welding programs.

Fig. 16 — An … … is equipped with a stud-welding head. ... are fed to the ... from a tubular feeder. The … … is suspended from overhead.

Fig. 17 — Arc welding with a robot … … is another application in which an ... robot can take over from a man.

Fig. 18 — An industrial robot has a routing head, grinder, belt sander which can be mounted on the ... of an … … .

Fig. 19 – An industrial robot has an ability to do multipass spraying. The … … is done with controlled velocity. The ... of the industrial robot to do spraying with controled ... fits it for automated application of primers, paints. Before plating masking agents are ... .

8. Answer the following questions.

1. What is the subject of the text the author deals with?
2. What questions does the author touch upon describing the end-of-arm tooling?
3. How does the author present each part of the end-effectors?
(Use: shows, describes, illustrates, explains why.)
4. What is your opinion of the text?
(Use: In my opinion ..., As far as I think ... .)

Text B

Industrial robots are provided with different kinds of end-effectors: gripping devices for grasping and holding parts and tools by which means the main technological operations are carried out.

End-effectors for material handling operations include vacuum and magnetic devices and a wide variety of pneumatically or electrically actuated mechanical grippers, usually designed especially for the parts being handled.

Robots don't just handle things — they do things too. Jobs such as welding, for which a tactile sense might at first be thought essential, prove to be suitable for industrial robots. A general-purpose industrial robot can manoeuvre and operate a spotwelding gun to place a series of spot welds on simple-curved or compound-curved surfaces. Stud-welding heads or arc-welding guns are used where the angle at which the tool is held must change continuously.

A single industrial robot can also handle several tools sequentially, with an automatic tool-changing operation programmed into the robot's memory.

9. Dispute the following problems.

1. Industrial robots are provided with different kinds of tools.
2. End-of-arm tooling for material handling operations includes vacuum and magnetic devices.
3. End-of-arm tooling for material handling operations includes a wide variety of grippers.

10. Translate the following definitions and memorize them.

End-effector: An actuator, gripper or mechanical device attached to the wrist of the manipulator by which objects can be grasped or otherwise acted upon.

Mud of Axis Control: Controlling the delivery of tooling through a part or to a point by driving each axis of a robot in sequence. The joints arrive at their preprogrammed positions in a given axis before the next joint sequence is actuated.

Robotics: The science of designing, building, and applying robots.

Feeding: The process of placing or removing material within or from the point of operation

UNIT 8. APPLICATIONS AREAS OF INDUSTRY

1. Read and memorize the following words and word combinations.

die – пресформа
die casting – лиття металів під тиском пластмас
injection moulding – лиття під тиском пластмас
gage (gauge) – вимірювальний прилад
forging – кування
billet – ковальська заготівка
trimming – обрізка
clean-up – очистка (виливків)
cut-off wheel – відрізний круг
gate – живильник (в ливарній формі)
riser – прибуток (виливки)
grinding – шліфування
flash – заусенец, грат
drilling – свердління

2. See explanation of the following words and translate the sentences.

to tend ≈ to try, to attempt	The robot may tend more than one machine loading.
dimension ≈ size **to check ≈** to control, to test	The robot may place parts in gages for dimensional checking.
succesive ≈ following one after another	Robots may be used to transfer parts from die in succesive forming operations.

3. Read and translate text A

Text A

Industrial robots are being used for a wide variety of tasks in factories, shops and foundries around the world. Robots unload parts from die casting machines and plastic injection moulding machines. They load and unload parts at machine tools and stamping presses; transfer parts from die to die or from press to press. In die casting and plastic injection moulding operations, a robot may unload a single machine or as many as three machines. In machine tool loading and unloading, the robot may also tend more than one machine – loading and unloading each in turn, or on demand and transferring parts from machine to machine, as well as placing parts in gages for dimensional checking.

In forging operations, robots are used to transfer hot billets from furnaces to forging presses, to transfer parts from die to die in succesive forming operations and to handle hot and cold parts in trimming operations. Robots are also used in casting clean-up operations, handling cutting torches or abrasive cut-off wheels to remote gates and risers and for grinding flash from parting lines.

Continuous-path servo-controlled robots are used for spraying a wide variety of parts and materials; for spot and arc welding. Robots are used for drilling and grinding, handling either the parts or a power tool.

In assembly operations, the microprocessor-controlled robot with sensory feedback capability performs the complex part and tool-handling tasks.

Notes

in turn – у свою чергу
as well as – а також як і

4. Read the sentences from the text which illustrate the following statements.

1. Robots are used in different places.
2. Robots are used for various operations.
3. Robots may perform different numbers of operations.
4. Robots are widely used in forging operations.
5. There are some types of robots which are used for spraying and assembly operations.

5. Complete the sentences choosing the required words or word combinations from list B. read the sentences.

A. 1.The places where robots can be used are …
2. Job functions performed by the robot are … .
3. There are various types of operations in which the robot performs different functions. They are … .

B. shops, to unload parts, machine tools, grind, factories, to load parts, foundry, to transfer parts, to handle parts, trimming, to spray parts, stamping presses, to place parts in gages, forming, forging, casting clean-up, to drill, to weld, assembly

6. Perform two tasks: 1. Working in pairs test each other's ability to answer the questions. 2. Write a summary of the text.

1. What is the robot's application sphere? Are there any limitations with regard to the robot's application in industry?
2. What kind of operations are robots used for at your institute?
3. What are the main job functions performed by the robot?
4. What are the most characteristic features of loading and unloading performed by the robot/

Text B

Industrial robots are being employed to load parts into and then unload parts from production equipment, stack and palletize parts, assemble parts in sequence, transfer parts from one machine to another, and spotwelding assembles.

Spray painting of auto parts or other products exposes workers to solvent vapors and aerosols. Robots were developed to eliminate the need for a man to spend prolonged periods in this kind of environment for a number of years, auto manufacturers had industrial robots doing press-loading work, so that a man never had to put his hands anywhere near of a press. An industrial robot loads and unloads a rotary-hearth furnace for firing ceramic coating on interiors of valve bodies. Formerly, a man was stationed in front of the 1800 F furnace. Industrial robots are in use at die casting plants where they extract die castings from between the open plates of the casting machines. Industrial robots are transferring projectiles from conveyors to one of several positions in storage carts at an ammunitions plants. This particular palletizing task is not very hazardous, but explosives are present elsewhere in the plant.

7. Speak on the following problems.

1. Industrial robots are being employed to load parts into and then unload parts from production equipment.
2. Spray painting of auto parts or other products exposes workers to solvent vapors and aerosols.
3. For a number of years in car manufacturing industrial robots performed press-loading work, so that a man never had to have his hands anywhere near a press.

8. Discuss the advantages and disadvantages of different types of robots.

PART III

ADDITIONAL TEXTS FOR READING AND DISCUSSION

REASONS FOR USING ROBOTS

The first commercial application of an industrial robot took place in 1961, when a robot was installed to load and unload a die-casting machine. This was a particularly unpleasant task for human operators. In fact, many early robot applications were in areas where a high degree of hazard or discomfort to humans existed, such as in welding, painting, and foundry operations.

In recent years, robots have been used more in applications where they offer clear economic advantage over human workers. Although human labor rates have continued to escalate, the hourly operating and depreciation costs for robots have remained relatively constant. Thus, in many instances robots can perform tasks at considerably less cost than humans. Savings of 50-75% in direct labor costs is not uncommon.

Another closely related reason for using industrial robots is increased productivity. Robots are not only cheaper than manual labor, but frequently have higher rates of output.

In addition to their economy and their ability to eliminate dangerous and unsocial tasks and increase productivity, robots are also used in many applications where repeatability is important. Although today's robots do not possess the judgmental capability, flexibility, or dexterity of humans, they do have the distinct advantage of being able to perform repetitive tasks with a high degree of consistency, which in turn leads to improved product quality.

These four benefits—reduced costs, improved productivity, better quality and elimination of unsocial and hazardous tasks—represent the primary reasons for using industrial robots in today's factories.

Vocabulary:

die-casting machine	машина для лиття під тиском
depreciation costs	амортизаційні витрати
repeatability	повторюваність
judgmental capability	здатність мислити; міркувати
dexterity	вправність; гарні здібності
consistency	послідовність; логічність
hazardous	небезпечний
in turn	по черзі

ROBOT CAPABILITIES

In general, robots possess three important capabilities that make them useful in manufacturing operations:

1.Transport

One of the basic operations performed on an object as it passes through the manufacturing process is material handling or physical displacement. The object is transported from one location to another to be stored, machined, assembled, or packaged.

The robot's ability to acquire an object, move it through space, and release it makes it an ideal candidate for transport operations. Simple material-handling tasks, such as part transfer from one conveyor to another, may only require one-or two-dimensional movements. These types of operations are often performed by nonservo robots. Other parts-handling operations may be more complicated and require varying degrees of manipulative capability in addition to transport capability. Examples of these more complex tasks include machine loading and unloading, palletizing, part sorting, and packaging. These operations are typically performed by servo-controlled, point-to-point robots.

2. Manipulation

Another basic operation performed on an object as it is transformed from raw material to a finished product is processing, which generally requires some type of manipulation. That is, work- pieces are inserted, oriented, or twisted in order to be in the proper position for machining, assembly, or some other operation.

A robot's capability to manipulate both parts and tooling makes it very suitable for processing applications. Examples in this regard include robot-assisted machining, spot and arc welding, and spray painting.

3. Sensing

A robot's ability to react to its environment by means of sensory feedback is also important, particularly in sophisticated applications such as assembly and inspection. These sensory inputs may come from a variety of sensor types, including proximity switches, force sensors, and machine vision systems.

State-of-the-art robots have relatively limited sensing capabilities. This is due primarily to the difficulty with which today's robots can be effectively interfaced with sensors and, to a lesser extent, to the availability of suitable low-cost sensing devices. As control capabilities continue to improve and sensor costs decline, the use of sensory feedback in robotics applications will grow dramatically.

Vocabulary:

material handling	транспортування
to machine	обробляти
servo robots	робот з сервоуправлінням
part-handling	частково механізована
palletizing	складування
servo-controlled robot	робот з сервоуправлінням
point-to-point robots	робот з позиційним управлінням
workpieces	оброблювальні деталі
twist	скручувати
tooling	інструмент, обладнання, інструментарій

WHAT IS AUTOMATION?

In its modern usage, automation can he defined as a technology that uses programmed commands to operate a given process, combined with feedback of information to determine that the commands have been properly executed. Automation is often used for processes that were previously operated by humans. When automated, the process can operate without human assistance or interference. In fact, most automated systems are capable of performing their functions with greater accuracy and precision, and in less time, than humans are able to do.

The process in an automated system is one that requires power to actuate or drive it from one physical condition to another. The physical condition can be defined in terms of mechanical, electrical, or chemical states. For example, there are many manufacturing processes in which the shape of the product is produced by transforming it from one mechanical state to a more desirable state. Other products are made by changing their chemical or electrical properties. In each case, power in some form is required to accomplish the process. Accordingly, one of the conditions that must be satisfied in order for a system to be classified as an automated system is that the controlled process uses power (energy) which results in a change in physical state.

The technology of automation has become strongly associated with and dependent on computer technology. Today, computers provide the principal means for programming and controlling an automated system. As computer technology has become more and more sophisticated, the automated processes which depend on it have become more sophisticated. Modern automated systems are able to control physical processes with accuracies measured in millionths of an inch, detect and identify problems related to their operations, make decisions, report their own performance, and interact with humans if that becomes necessary.

The terms "automated system" and "computer system" are often used interchangeably. A computer system is sometimes referred to as an automated system, and vice versa. Although the two terms are closely associated, as suggested above, it is appropriate to recognize a principal distinction between them. The distinction is that an automated system causes some physical action or process to occur whereas a computer system results in the generation of data, information, and/or calculations. A computer system can be utilized as a component in an automated system to store programs of processing commands, perform control calculations, make decisions, etc, but these various functions are then converted into actions by other components of the automated system. Computers are also used in applications that have little or no association with automation. These applications include data processing and engineering analysis. Similarly, automated systems can be implemented without digital computers. Mechanical or electrical devices can be used to define and store the control programs for the automated system.

Vocabulary:

feedback	зворотній зв'язок; зворотне живлення
to determine	вимірювати; обчислювати; розв'язувати
interference	втручання; перешкода
to accomplish	виконувати; доводити до кінця; досягати
sophisticated	складний; ускладнений
accuracy	точність; правильність
whereas	де; тоді як; у той час як; незважаючи на те, що
to implement	виконувати; здійснювати; забезпечувати виконання

ROBOTICS

Robotics is a technology closely associated, with automation. Industrial robotics can be defined as a particular field of automation in which the automated machine (i.e., the robot) is designed to substitute for human labor. To do this, robots possess certain human-like characteristics. Today, the most common human-like characteristic is a mechanical manipulator that is patterned somewhat after the human arm and wrist. The robot's manipulator can be programmed to move through a series of positions to perform some useful task, such as loading and unloading a machine tool, spray painting a metal part, or spot welding an automobile car body. The motion sequence will be repeated until the robot is reprogrammed to accomplish some alternative task. In the future, industrial robots will have other human-like characteristics in addition to the manipulator. These characteristics might include: two arms instead of one, vision and other advanced sensors, greater intelligence to perform more complicated tasks, and the ability to move around the factory.

Industrial robots are related to computer technology. Indeed, robotics has been described as a combination of machine tool technology and computer science. The reason is that virtually any robot designed today uses a computer (either a microcomputer or programmable logic controller) as its controller or "brain". The controller stores the programs that define the tasks performed by the robot. The computer is also an important component in the feedback control system used to correctly position the manipulator in the workspace.

Automation is a technology that has been applied widely to a variety of fields including household appliances, control of automobile engines, automatic bank teller machines, industrial manufacturing processes, and robotics.

Voabulary:

robotics	робототехніка
to substitute	заміняти, підміняти
pattern	зразок; форма; виготовляти за зразком; копіювати
wrist	палець
household appliances	побутові прилади

TYPES OF PRODUCTION AUTOMATION

As the term is applied in production, automation, can be defined as a technology that involves the application of mechanical, electronic, and computer-based systems to operate, control, and manage manufacturing systems. Automated production systems can generally be classified into three basic types:

1. Fixed automation.
2. Programmable automation.
3. Flexible automation.

These three types correlate to a large extent with the kind of production that is accomplished. Fixed automation is limited to large volumes of product being made where the variations in product are limited. Programmable automation is usually applied to low and medium volumes of production and is equipped to deal with relatively large variations in product configuration. Flexible automation is a relatively new form of automation and has thus far been applied in the mid-volume production range.

Vocabulary:

to involve	включати; містити в собі
to correlate	установлювати співвідношення, співвідноситись
to a large extent	значною мірою

FIXED AUTOMATION

In fixed automation, the sequence of the production process is fixed by the configuration of the equipment. This type of automation is also sometimes referred to as "hard" automation to emphasize the hardened configuration of the production machinery. The individual processing (or assembly) operations performed in a fixed automated system are generally uncomplicated. However, the coordination and control required to integrate multiple operations into a single system is what makes fixed automation complicated. Some of the features associated with fixed automation are

Used for continuous production of identical or nearly identical parts (or products) in high volumes.

High production rates.

Specialized equipment designed to perform a specific sequence of processing operations with a high level of efficiency.

Vocabulary:

fixed	постійний; незмінний; призначений
to refer to	посилати; звертатися; відносити
hardened	твердий; незмінний; загартований
rate	норма; частка; відсоток; оцінювати; темп

PROGRAMMABLE AUTOMATION

As its name suggests, programmable automation is represented by a production system that can be programmed and reprogrammed with relative convenience. The capability to be programmed means that the sequence of processing operations can be changed to accommodate variations in product style. Programmable automated systems are therefore used in industries that make varieties of products in low to medium volumes. The majority of products made throughout the world fall into this category.

The features that characterize programmable automation can be summarized as follows:

Used for low-to-medium volume products. The products are usually made in batches.

Lower production rates than fixed automation.

Equipment designed to accommodate variety of product configurations.

Readily reprogrammed to change over from one product configuration to another.

Vocabulary:

reprogram	перепрограмувати
convenience	зручність; pl.-вигоди; перевага; користь
batch	купа; дозування; порція; партія

FLEXIBLE AUTOMATION

Part I

The trouble with programmable automation, the way it has been defined above, is that there are interruptions in the flow of production as a result of the programming and setup requirement between each batch. Flexible automation represents a means of addressing this deficiency. Flexible automation is an extension of programmable automation because the production system must be programmed for each different part made. However, there are certain differences in operation that distinguish flexible automation from programmable automation.

A flexible automated system is capable of producing a mix of different product with virtually no time lost for physical changeovers from one product to the next. The system is able to produce the various products without the downtime for setup and reprogramming that is characteristic of programmable automation. As a consequence, the system can efficiently make the products in varying combinations and schedules to meet changing demand requirements without the need to operate in a batch production mode. At the present state of the technology, the product variety that can be accommodated in flexible automation is not as great as in programmable automation. However, flexible automated production systems are a relatively recent innovation, and their capabilities are likely to expand in the future. The first significant example of flexible automation was the flexible manufacturing system (FMS), introduced in the late 1960s. These flexible manufacturing systems consisted of a group of machining stations (NC machine tools) connected together by a material handling system, all operating under computer control.

The two technological requirements that make flexible automation possible are (1) the capacity to reprogram the equipment for different products with no lost production time, and (2) the capability to change over the physical setup of the equipment, again with no lost production time. If both of these requirements can be accomplished, then the automated production system can manufacture the various products continuously rather than in batches.

Part II

Off-line programming is what makes the first requirement, reprogramming without downtime, possible. Instead of interrupting the operation of the production system to change the program, the programs for new parts are prepared at a separate site, generally using computer-assisted methods of programming. This permits the system to continue its production of parts under previously prepared programs. New programs prepared at the remote computer site are electronically downloaded to the equipment to make new parts introduced onto the production system. In the future, computer systems with graphics modeling capabilities (called CAD/CAM systems, for computer-aided design and computer-aided manufacturing) will be used to automatically prepare part programs based on part geometry data entered by the product designer.

The second requirement for flexible automation, changing the physical setup with no lost production time, is generally accomplished on an FMS by means of pallet fixtures that are loaded off-line with new parts while the system is engaged in the production of the previous parts. The material handling system, operating under computer control, transfers the pallet fixture from the loading station to the machine tool scheduled to make the particular part. The machine tool has a variety of different cutting tools available in a tool storage drum for use on the part. Some parts require machining by more than one machine tool in the system. The material-handling system is programmed to make the corresponding transfers. When the machining sequence is completed, the part is transferred to an unloading station. The loading and unloading stations are manned by human operators and represent the interface between the FMS and the other systems in the factory.

The important features of flexible automation, as illustrated by an FMS, include

Considerable preplanning required to identify the parts (or products) that will be made on the system and to specify the most appropriate equipment to make these parts.

Continuous production of variable mixtures of parts (or products).

Medium production rates, typically between those of fixed automation and programmable automation.

Flexibility to deal with a limited range of variations in product design.

Vocabulary:

interruption	затримка; втручання; перешкода; розрив
extension	збільшення; розширення
requirement	вимога; потреба
permit	дозвіл; ліцензія; дозволяти; допускати
to download	завантажувати; перекачувати
pallet	піддон; плита(конвеєра); заціпка храпового колеса
drum	барабан; циліндр; колектор
off line	автономний, вимкнений

AUTOMATION STRATEGIES

The design of an automated production system involves the implementation of various principles or strategies whose purpose is to improve process productivity and product quality. Ten of these basic strategies are listed here:

Specialization of Operations

This principle involves the use of production equipment that is designed to perform one operation or task with the greatest possible efficiency. It is analogous to the principle of specialization of labor (also called division of labor which has been used for many years to increase labor productivity.

Combined Operations

The usual method of producing a product involves a sequence of individual operations that are performed at separate workstations. The product must be moved from one station to the next. The purpose of the combined operations strategy is to combine several of the individual operations in sequence at a single workstation, thereby saving handling time and expense.

Simultaneous Operations

This principle extends the previous strategy by not only combining the processing steps at a single workstation, but also performing the operations at the same time rather than in sequence.

Integration of Operations

The term "integration of operations" refers to a production system in which the individual workstations, each performing a particular processing step on the product, are physically connected together by means of a handling mechanism that transfers the parts from station to station. This type of integration represents an alternative to the second strategy (combined operations), and usually results in higher production rates since several products can be processed simultaneously (one product at each workstation).

Vocabulary:

to involve	містити в собі
thereby	таким чином; за допомогою цього
to extend	розширяти; подовжувати; поширювати
to permit	дозволяти; давати можливість
buffer	буфер; амортизатор; демпфер
approach	підхід; наближення; подача
overall	повний; загальний

INCREASED FLEXIBILITY

The objective of this principle is to design the production system so that it can be used for more than a single product. This permits the equipment to be used for a variety of products, making the system adaptable to changes in demand patterns and production schedules. Programmable automation and flexible automation make use of this strategy.

Improved Material Handling and Storage

This strategy involves a number of principles in the applied field of material handling. These principles include minimizing distances that materials must be moved, and sometimes including temporary storage zones between workstations to act us buffers against irregularities in production rates.

On-line Inspection

The traditional approach to inspection in industry is to perform the inspection process after processing has been completed. This principle involves the use of automatic on-line inspection in which the product is inspected during processing so that the information can be used to correct the process immediately. This means that processing errors and variations can be corrected either on the current unit of product or on the following product.

Process Control and Optimization

This principle involves the use of a variety of control schemes and optimization methods to operate the individual process more efficiently. A well-developed theory of process control exists for this purpose.

Plant Operations Control

This strategy involves the overall factory operations rather than the individual processes. It is concerned with optimum production scheduling algorithms, shop floor control, material-handling system management (if applicable), and other approaches that can be applied in the individual factory.

Computer Integrated Manufacturing

This strategy extends the previous strategy to the corporate level. It is concerned with integration of the design function with manufacturing through the use of CAD/CAM, corporate management information systems and data bases, computer networking, and other techniques to improve corporate operations.

Vocabulary:

permit	допускати; дозволяти
adaptable	тут - які пристосовані; придатний
demand	вимога; попит
on-line	оперативний режим; неавтономний; включений
shop floor control	управління цехом

Early Machine Tools

The evolution of mechanization and automation in the manufacturing industries is based largely on developments in machine tool technology. One early example of machine tool automation was the automatic screw machine, an invention credited to Brown & Sharpe around 1800. Although early versions of the automated screw machine do not possess all of the four automation building blocks described above, it nevertheless stands as a remarkable achievement for its time.

The automatic screw machine (another machine that is very similar is called an automatic bar machine) is a highly mechanized lathe used for repetitive machining of small turned parts. An important early application involved the manufacture of screws and similar threaded hardware items; hence, the name screw machine. The program for the machine tool is contained in a series of mechanical stops and cams that regulate the cycle of machining operations. The stop settings and the cams must be designed specifically for the part that is made on the machine. Because of the time and expense involved in preparing the program (setting the stops and making the cams), automatic screw machines are usually employed for medium-to-high production jobs. Automatic screw machines are technically classified as belonging to the programmable automation class, although they are often employed as fixed automated systems for very high production.

Some automatic screw machines have multiple spindles (eg, a six-spindle automatic bar machine). These machines are capable of performing six machining operations simultaneously on six different workbars. This mode of operation increases the production rate and reduces the unit cost of the product.

Vocabulary:

tool	інструмент, ріжучий інструмент, різець; верстат (pl.)
the automatic screw machine	токарно-гвинтовий верстат
lathe	токарний верстат
threaded	нитяний; нарізаний, з різьбою
hence	з цього часу; з тих пір; віднині
cam	кулак; кулачковий диск; вал
spindle	стержень; шпулька; шпиндель

TRANSFER LINE

Part I

A transfer line is an automated production system consisting of a series of automatic workstations with a parts handling mechanism for transferring parts from one station to the next. It is another example of automation whose roots are in the machine tool industry. The processing or assembly operations performed on a transfer line are done progressively, each station contributing work to the part as it moves through the sequence. A raw workpart begins at one end of the line and is processed through each workstation until it is completed at the final station. The transfer line illustrates several of the automation strategies, including specialization of operations and integration of operations. The significant advantage of the transfer line is that many parts (the number is theoretically equal to the number of workstations on the line) are being processed simultaneously at any moment, each at a different station.

The term transfer line derives from the fact that the configuration of the system is a production line and that the parts are transferred between workstations. The generic form of the transfer line involves a straight-line flow of work. Other transfer line work flows include L-shapes, U-shapes, and loops. The same principle of progressive processing of the work at stations can also be accomplished using a circular configuration. This type of system is called a dial-indexing machine because the work is transferred from station to station using a rotating circular table called a dial.

One of the problems in the operation of transfer lines, especially lines with many workstations, is downtime. When one workstation on the line malfunctions or breaks down, the upstream and downstream stations are affected. Parts at upstream stations cannot be transferred to the broken-down station, and the broken station is not producing parts to supply the downstream stations. The entire line must be temporarily stopped while the broken-down station is repaired. This causes a high proportion of nonproductive time on the production line. To alleviate this problem, transfer lines are sometimes designed with parts storage buffers located between certain workstations along the line. The purpose of these buffers is to separate the line into groups of workstations that can operate somewhat independently of each other.

Part II

In addition to storage buffers, transfer lines can also be designed with manually operated workstations, and automatic inspection stations. The manual stations are included for operations that are difficult to automate. Assembly operations that require adjustments or calibration procedures are examples of these kinds of operations. Automatic inspection stations are included to monitor certain quality characteristics of the products made on the line. These inspections are generally performed on a 100% basis in which every part is inspected, rather than on a statistical sampling basis in which only a small portion of the parts are checked, usually by human inspectors.

Transfer systems (transfer lines and dial indexing machines) are examples of fixed automation. The parts or products made on these systems are almost always made in large quantities at high production rates, and there is no real deviation in product design. When changes are made in the product design, either a substantial changeover of the production line is required, or a new production line must be built thus rendering the previous system obsolete.

There is no need to alter the programmed commands which regulate and coordinate the basic operation of a transfer system. The same work cycle is repeated at each workstation for every part made without variation. Before computer control was used in production systems, the program for a transfer line was contained in the form of control circuits consisting of electromechanical relays. Since there was little or no need to change the programs (except to work out, the initial bugs in the logic that might be present), these hard-wired controls were sufficient for early transfer lines. As the need for more sophisticated controls increased (eg, process optimization, error detection, decision-making for repair diagnosis), relay controls were replaced by programmable logic controllers and similar controls. These computer-based systems permit the programming of more complex logic and allow for easier program debugging.

Vocabulary

transfer line	автоматична верстатна лінія
generic form	генетична форма
to derive	відводити; визначати походження
straight line flow	пряма лінія деформації; циркуляції

loop	петля; пучність; вантажний хомут; гак; скоба
dial-indexing	диск з поділками
downtime	простій; вимушена бездіяльність
upstream and downstream	угору та вниз за течією
to alleviate	полегшувати; зменшувати
adjustment	регулювання; пристосування
sampling	вибірковий контроль; вибіркове управління

FLEXIBLE MANUFACTURING SYSTEMS

A flexible manufacturing system (FMS) is a highly sophisticated example of automation. An FMS is an integrated production system consisting of a group of processing stations (usually NC machine tools) connected together by an automated material-handling system, all operating under computer control. As its name suggests, an FMS is a form of flexible automation. It is capable of processing a variety of part configurations although they are limits to the amount of variation that an FMS can accommodate. It can also tolerate variation in the mix of parts made on the system, so that if requirements change over time, the production schedule can be adjusted accordingly. In the ideal operation of an FMS, these changes in production can be made without the need to shut the system down for reprogramming of changeovers in the physical setup.

The most common application of flexible manufacturing systems have thus far been in the machining area. There are several hundred machining type FMS installations in operation throughout the world. Additional applications are in other metalworking processes, inspection, and assembly. It is anticipated that future flexible systems will have the capability to extend the range of economic production. both in the direction of higher as well as lower production volumes

The three components of an FMS are the processing workstation, the material-handling systems, and the computer controls. For machining-type FMSs, the processing stations are predominantly CNC machine tools. Parts are delivered to the machines using automated guided vehicles, conveyors, or other forms of material-handling devices. Industrial robots are used in some systems to handle parts between workstations. The overall control of the systems is accomplished by the computer control unit.

Vocabulary:

to accommodate	пристосовувати; допомагати
to tolerate	дозволяти; допускати; витримувати
assembly	комплект; агрегат; монтаж
predominant	переважний; переважаючий

INDUSTRIAL ROBOTS

Strictly speaking, an industrial robot is an example of programmable automation. As defined previously, an industrial robot is a programmable machine that possesses certain humanlike features. Although the robot itself is an example of programmable automation, robots are often used production systems that represent either fixed automation or an approximation of flexible automation. An illustration of these two cases is in robotic spot-welding lines used to assemble car bodies in the automobile industry. Some of these assembly lines weld the same body styles in a dedicated, continuous fashion. There is absolutely no variation in the product made on these kinds of production lines. Accordingly, although the robots capable of being reprogrammed, the applications involve the repetition of the same motion patterns for each car body that moves long the line. In effect, the robots are being used as components in a fixed automated production system.

Other robot welding lines are designed to perform welding cycles on body styles that are not the same. The difference might be between sedans and station wagons of same basic model, or the models themselves might be different. In these applications, the robots must use different motion and spot welding cycles to deal with the variations in body style. A sensor (usually an optical sensor) is utilized to identify with body style is next in the line, and the central control computer or programmable logic controller indicates the corresponding program for the robot to use. To a significant degree, such a production line is flexible in the sense that the mixture of body styles can vary from day to day, corresponding to changes in demand for the different types of cars. This type of automated line does not completely satisfy our definition of flexible automation because the line cannot be reprogrammed for a new body style, which has not been produced before on the line, without shutting it down to introduce the new program.

Vocabulary:

approximation	наближення; приблизна точність; зближення
spot-welding	точкове зварювання
weld	зварний шов; зварюватися
station wagon	автомобіль універсал; автомобіль з кузовом "універсал"
from day to day	щоденно

REASONS FOR AUTOMATING

There are a number of economic and technical reasons for installing an automated production system. These reasons for automating include the following:

1. **Higher productivity and lower cost**. Automation reduces the labor content of the production operation and usually increases the rate at which parts are made. Both of these factors tend to increase labor productivity and reduce the cost per unit produced.

2. **Increased safety**. By removing human operators from active participation in potentially dangerous production jobs, safety is improved.

3. **Improved uniformity and quality of product**. Automated production tasks are typically performed with a higher degree of precision and consistency than tasks accomplished by manual labor. This precision and consistency usually mean greater uniformity and qualify of product.

4. **Reduced work-in-process and manufacturing lead time**. Work-in-process inventory represents unfinished product. The producer has invested money in raw materials, labor, and equipment to make the product but cannot receive payment until it has been completed. Automation tends to reduce the amount of unfinished product held in the factory, and it also reduces the time required to complete the associated production processes.

5. **Better corporate image**. Finally, by automating its factories and maintaining a technological advantage over its competitors, a company tends to improve its corporate image. This translates into higher employee morale and better customer acceptance of its products.

Vocabulary:

to reduce	знижувати; зменшувати
uniformity	однорідність

precision точність; чіткість
corporate спільний; корпоративний
to tend мати тенденцію; приділяти увагу; схилятися (до чогось)

WELDING

To date, the predominant use of robots in the United State has been in the automotive industry; the majority of these applications have been to spot weld structures to assemble automobiles. Robots offer substantial advantages over human operators in welding applications. Humans are subjected to an unpleasant, if not hostile, environment while welding and must deal with heavy equipment and protective clothing. Robots are not subject to these limiting factors and can make dramatic improvements in "arc-on" time weld quality, and product uniformity.

Robots offer a number of advantages in spot-welding applications, including speed and more accurate positioning of welds, resulting in better appearance and more uniform quality. In automotive spot-welding applications, robots may be stationed on opposite sides along the line, allowing one supervisory computer to control all robots. This arrangement permits large numbers of welding programs to be stored and used to process different products and reallocate tasks as necessary. Robots also offer advantages in arc welding, an application that requires the robot to track the weld seam.

Data required to complete the analysis include (1} parts to be assembled, (2) geometrical conformation of parts and the number of stations required, (3) distribution of spot welds and the number of robots required to complete them, (4) production rate and the number of lines required to achieve the rate, desired degree of flexibility, (6) basic principles for transferring and positioning the assembly, (7) final selection of the robot and its equipment and installation, and (8) the environment and the available space. This approach is applied to auto-body assembly, pointing out the importance of maintaining product orientation throughout assembly, assuring high utilization of robots through the use of buffer stocks, minimizing the number of robots, balancing work load among stations, redistributing tasks in case of robot downtime, and providing flexibility to handle new product designs in the future.

Vocabulary:

“arc-on” time	робочий час пальника
supervisory	спостережний; контролюючий
to track	прокладати шлях; подолати; рухатись
welded seam	зварний шов
redistribution	перерозподілення
gantry	рама; портал(крана); радіолокаційна антена
traverse	поперечка; перетинати

SPRAY PAINTING

Robots make excellent spray painters because they do not require the extensive protective devices that humans do. Once taught, a robot can repeat its skill, tracking product shape with a consistency that humans cannot duplicate.

This consistency allows robots to reduce the amount of coating material used as well as the energy consumed while improving overall quality. Current applications include automotive exterior top coat and underbody primer, stains on wood furniture, sound deadeners on appliances, porcelain coating of kitchen and bathroom fixtures, and exterior coating on the space shuttle booster rockets

In spray-painting applications, robots may be made mobile in a variety of ways (eg, mount on a turntable, lift table, or traverse table) and parts may be presented through a variety of motions (eg, rotate or index, convey continuously or intermittently). Close attention must be directed to the interface between the robot and the conveyor to assure synchronized speeds, maintaining the correct gun-to-target position for high quality results.

Some types of errors may be corrected at touch-up stations downstream from the automatic spray line, but robotic lines are especially vulnerable to malfunctions that may force the entire line to shut down. In particular, malfunctions caused by robot-product interaction or by failure to shut off the spray may cripple the line.

The John Deere Company has developed an extensive application of line tracking to spray-paint tractor chassis. The system achieves an efficiency in excess of 90% on 2-shift-a-day operation and can automatically handle 8 different chassis models that require over 30 paint programs.

At the Toyo Kogyo factory in Japan, 2 robots are used to apply weld sealer to the underside of 20,000 Mazda 626 cars monthly; photoelectric sensing is used to allow the robot to track the seam. Two additional robots apply weld sealer inside the car, 2 more apply PVC, 4 others apply underseal, 6 apply primer/surfacer, and 4 apply color coats. In the primer/ surfacer booth, robots are used to open the car doors before painting and to close them afterward. In the color booth, the line splits and parallel stations employ 2 robots to select the appropriate color from among 27 colors and spray the car; 5 men are used to do the complicated areas.

Vocabulary

sound deadeners	звукові глушителі
touch-up	ретушування
weld seal	зварювальне ущільнення; з’єднування
to shut off	відключати; вимикати; ізолювати
vulnerable	уразливий
to track the seam	прокладати шов (спай)
underseal	антикорозійне покриття
the line splits	роз’єднання; розрізи
the line tracking	лінійні слідкування

ROBOT GEOMETRY

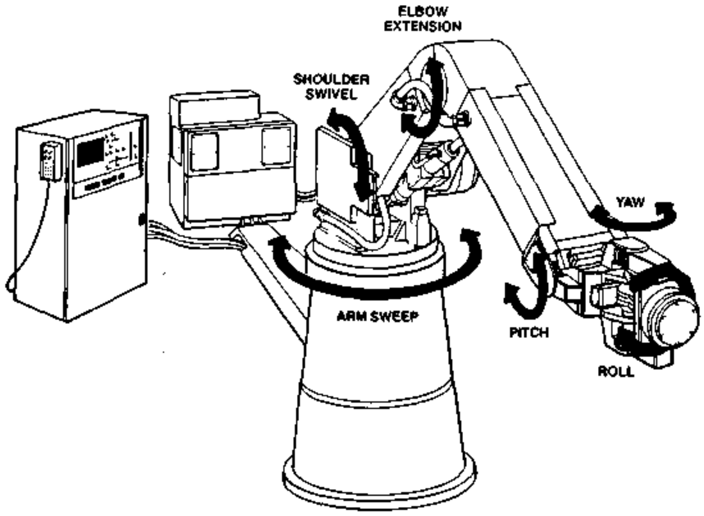
Since robot configurations vary greatly, some classification of robot geometries is useful before going any further. The industry has settled upon the term *degrees of freedom* to describe the number of ways a robot can move. The form of these movements and the way they are assembled make up the robot *configuration.*

Degrees of Freedom

Every mechanical point on a robot, except in the gripper or tool, at which some form of drive induces motion in a robot part is called a degree of freedom. The motion can be of a pivoting nature or a reciprocal motion as is produced by a pneumatic or hydraulic cylinder. Figure displays a robot with six degrees of freedom:

1. Base rotation
2. Shoulder flex
3. Elbow flex

4. Wrist pitch
5. Wrist yaw
6. Wrist roll



Industrial robot with six degrees of freedom. (Reprinted by permission of Cincianati Milacron, Lebanon, Ohio.)

Although there are exceptions, in most robots the degrees of freedom are in series. Thus, the first degree of freedom in the robot of Figure, base rotation, imparts motion to all of the parts of the robot affected by subsequent degrees of freedom. Conversely, the third degree of freedom (elbow flex), for example, has no effect upon the base movement. It follows that the most sophisticated motion in the entire robot is that of the member driven by the highest degree of freedom. Generally speaking, the robot with the most degrees of freedom can produce the most complex movement, but there are other important factors to consider, such as range and quality of motion within a given degree of freedom.

The sequence of the various degrees of freedom and their types of motion determine the physical configuration of the robot. Theoretically, there could be a large number of configurations for a robot with six degrees of freedom. From a practical standpoint, however, almost all robots fall into a few popular configuration categories.

Vocabulary:

configuration	форма; конфігурація
gripper	захват
to induce	викликати
pivot	цапфа
flex	угинатися, згин
pitch	крок(нарізки); качнути; висота звука

yaw відхилення
standpoint точка зору

ROBOT DRIVES

The most distinguishing feature used to describe an industrial robot is its power source. The power source usually determines the range of the robot's performance characteristics and in turn the feasibility of various applications, although there is considerable overlap between types. The four principal power sources are now compared.

Hydraulic

From a physical standpoint, the most powerful robots are generally the hydraulic models. Hydraulic robots are able to deliver large forces directly to the robot joints and to the gripper or tool center point. Offsetting this advantage is cost, which is usually higher for hydraulic models than for electric or pneumatic models of equivalent capability. Hydraulic models also require a pump and reservoir for the hydraulic fluid in addition to fittings and valves, all designed for high pressure.

An important application of hydraulic robots is in spray-paint operations. Due to flammability considerations, it may be necessary to employ an explosion-proof robot in paint-spray areas, which require equipment to meet National Fire Protection Association (NFPA) standards for Class I, Division 1 flammable atmospheres. Such standards are almost impossible to meet except by hydraulic- or pneumatic-powered robots.

Popular in the early years, the hydraulic drives are declining in importance among the major robot drives. Most early robots were used in the automobile industry, and the primary application area was spot welding. Many of the spot welding robots are hydraulic. Also, the handling of heavy forgings and die castings called for hydraulic models, typified by Unimation's "first family of robots."

Vocabulary:

overlap перекривати; перекриватися
off setting зміщення
fitting and valves пригонка (монтаж), клапани, задвижка, заслонка
die casting лиття під тиском

flammable займистий; вогненебезпечний
forging кування; ковка; кувати
decline знижуватись, зменшуватись

PNEUMATIC

Some of the least expensive and most practical robots for ordinary pick-and-place operations or for machine loading and unloading are the pneumatic models. The availability of shop air at approximately 90 psi is an obvious advantage. Most factories have compressed air piped throughout their production areas, and this can be conveniently tapped to power a pneumatic robot.

Pneumatic robots usually operate at mechanically fixed endpoints for each axis. The pneumatic robot is really an assembly of several such cylinders, each one representing an axis of motion.

With motion in each axis controlled only at the end points, the reader may be wondering what can be programmable about a pneumatic robot. But remember that timing and sequence are also important, resulting in an infinite variation of possible programmed setups for the pneumatic robot, even without touching a wrench. By further adjustment of the mechanical stops, even more variety can be achieved. Still, a carefully controlled, continuously varying path is impossible to achieve with the typical pneumatic robot.

It should be mentioned here that there is one type of pneumatic robot, certainly atypical in design, which achieves a continuous, controlled motion through the use of a concept known as *differential dithering.* Differential dithering applies a series of short pulses of compressed air that can act upon the robot member in either direction, causing it to follow a continuous path under control.

One of the principal advantages of pneumatic robots is their modular construction and their use of standard, commercially available components. This is true of other robots but is especially true of the pneumatic models. This feature opens up the possibility of a firm deciding to build its own robots, sometimes at considerable cost savings. Some component suppliers emphasize the “build your own” concept in marketing their products. Any firm that decides to embark upon a “build your own” strategy to save hardware costs should also remember to add in the engineering and component procurement costs in addition to the hardware costs.

Vocabulary

to tap	випускати
end points	гранична енергія
to reveal	відкривати, знаходити
to actuate	привести в дію
wrench	гайковий ключ
differential dithering	підмішування

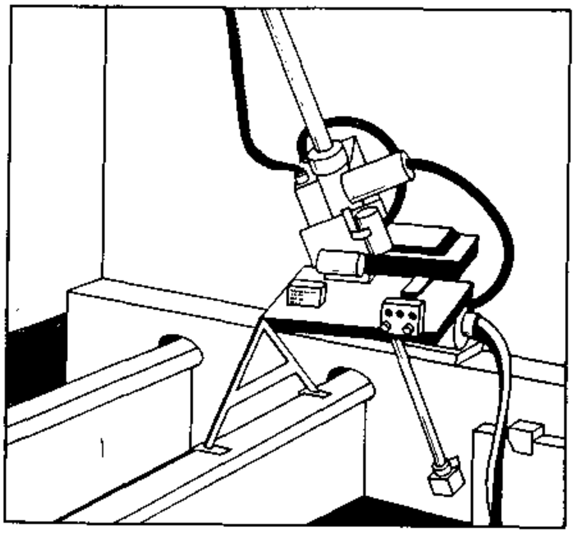
WELDING

Welding is the first application addressed, because welding is the number-one application of industrial robots as of the early 1990s. The majority of these applications are in *spot* welding in such heavy assembly-line industries as automobile and truck manufacturing, but arc-welding robots are on the increase.

When performed manually, both spot welding and arc welding are subject to personnel safety hazards. In addition, welding is undesirable to workers because of the protective equipment that must be worn, especially for arc welding. When robots are not used, heavy loads, especially heavy-duty spot-welding equipment, may be handled by personnel. Not the least important motivation to use robots in welding operations is the quality and product uniformity attainable, for both spot welding and arc welding.

Figure illustrates the key application of spot welding on an automobile body line. Since the line moves continuously, automatic line-tracking capability is usually required for spot-welding robots on assembly lines.

One example of an arc-welding application is in the welding of structural members of ship hulls. Arc welding inside a ship's hull is often extremely cramped and can be very dangerous because of toxic fumes and gases liberated in the confined space. Add to this danger the sheer discomfort of attempting to weld in a tiny space. Figure illustrates the use of an arc-welding robot for this ideal application.



An arc welding robot welds the inner bottoms of ship hulls. (Reprinted by permission of Unimation-Westinghouse, Inc., Danbury, Conn.)

Vocabulary:

ship hull корпус корабля
cramp затиск, скоба, зв'язувати, скріплювати
fumes вихлопні гази (дим)
liberate виділяти
sheer повний, явний

MACHINE LOADING

Machine loading and unloading by industrial robots offer some of the same key advantages as does robot welding: safety and relief from handling heavy loads. The job of punch press operator historically has been one of the most dangerous factory jobs because of the risk of amputations while feeding the press by hand. The risk has been greatly reduced in recent years due to:

1. Increased use of robots and automated press feeding equipment.
2. Increased attention to industrial safety standards, especially OSHA standards for safeguarding the point of operation of presses and other dangerous machines.

Both influences have implications for the field of robotics, the first directly and the second indirectly, in that serious attention to machine safety standards is driving the movement toward machine-loading automation. One example of robots loading and unloading ma-A large determinant of the success of a robot arc-welding operation over a manual operation is the improvement in "arc-on-time." Manual-welding operations often have very low arc-on time percentages (20-30 percent) because the remaining 70-80 percent of the time is consumed in adjusting helmet, respirator, or other personal protective equipment that would not be needed if a robot were used instead. Sometimes one skilled human welder can operate and control several robot arc welding systems, making possible production levels two to four times that of a single welder working without the benefit of robots.

Vocabulary:

relief	чіткість, контраст
manual-welding operations	операції ручного зварювання

PART IV

THE LIST OF ABBREVIATIONS

AC (adaptive control) адаптивне управління; **AC-assisted machine tool** верстат з адаптивно-програмним керуванням

AFS (automated factory subsystem) гнучкий виробничий модуль

AGV (automated guided vehicles) автоматично керовані транспортні засоби

AI (artificial intelligence) штучний інтелект

AMT (advanced manufacturing technology) прогресивна техніка, передові методи виробництва, перспективна технологія

APC (automatic pallet changer) автоматичний пристрій зміни палет

AS/RS (automatic storage and retrieval system) система збереження та пошуку

ATC (automated tool-carrier) візок для транспортування інструмента

ATC (automated tool changer) автоматичний пристрій зміни інструмента

AWC (automatic workpiece changer) автоматичний пристрій зміни оброблюваної деталі (заготовки)

CAD (computer-aided design) система автоматизованого проектування (САПР)

CADD (computer-aided design and drafting) система автоматизованого проектування та виготовлення креслень

CAE (computer automated engineering, computer-aided engineering) автоматизована інженерія (з **ЕОМ**)

CAM (computer-aided manufacturing) система автоматизованого керування технологічним процесом (АСКТП)

CAPP (computer-aided process-planning) автоматизоване планування виробничого процесу

CHS (chip handling system) система відводу стружки

CHS (coolant handling system) система подачі, забору, переміщення та збереження охолодної рідини

CIM (computer integrated manufacturing) автоматизована виробнича система з ЕОМ

CMM (coordinate measuring machine) координатно-вимірювальна

машина
CMPN (computer managed parts manufacture) керування виробництвом деталей за допомогою ЕОМ
CNC milling machine фрезерний верстат з ЧПУ (від комп'ютера)
CNC (computerized numerical control) числове програмне управління з використанням ЕОМ (ЧПУ)
CPC (computerized part changer) автоматизована зміна деталей
CPU (central processing unit) центральний процесор (ЦП)
DNC (direct numerical control) пряме числове керування
DSS (decision support system) система забезпечення прийняття рішень
FA (factory automation) автоматизація виробничих процесів; гнучка автоматизація заводу; завод-автомат
FAS (flexible assembly system) гнучка складальна система
FBG (feedback gauging) автоматичний вимір зі зворотнім зв'язком (наприклад, в системі керування верстатом)
FFC (flexible fabrication cell) гнучка виробнича комірка
FFS (flexible fabrication system) гнучка виробнича система
FFT (floor-to-floor time for one component) час транспортування деталі із цеху в цех
FMC (flexible machining cell) гнучка автоматизована ділянка (модуль)
FMS (flexible manufacturing system) гнучке автоматизоване виробництво (ГАВ), гнучка автоматизована система (ГАС)
FTL (flexible transfer line) гнучка лінія транспортування (транспортна лінія)
ICAM (integrated computer-aided manufacturing) інтегроване автоматизоване виробництво (на ЕОМ)
IR (industrial robot) промисловий робот
LAN (local area network) локальна обчислювальна мережа
MAP (manufacturing automation protocol) протокол автоматизації виробництва, протокол вводу ГАВ
MC (machining centre) обробний центр (виробничий модуль, верстат з ЧПУ, виконуючий різні операції: свердління, фрезерування, розточення та т.п.)
MHS (material handling system) автоматизована сервісна система (переміщення та складування деталей, інструмента, відходів, охолодної рідини та т.п.)

MIS (management information system) управлінська інформаційна система (УІС)

MFC (manufacturing part cost) заводська собівартість деталі

MRP (material requirements planning) планування забезпечення виробництва необхідними матеріалами

NC (numerical control) числове управління (одним чи декількома модулями прямим введенням числової програми)

PCR (process-control robot) робот-контролер

PHS (part handling system) сервісна система з деталей (шляхи подачі, конвеєри, ланцюги, склади деталей, захвати, палети, візки)

PLC (programmable logic controller) програмно-логічний контролер; програмний контролер

SAC (stand alone computer) автономний комп'ютер, окремо працюючий комп'ютер

THS (tool handling system) сервісна система з інструменту

VTL (vertical table lathe) вертикальний токарно-револьверний верстат

WHS (waste handling system) сервісна система з відходів

XYZ осі координат *(див. також* **interpolation**)

ZL (XYZ) див. **interpolation**