Unit-1

Automation

- ✓ Definition of automation
- ✓ Advantages & disadvantages of automation
- ✓ Types of automation
- ✓ Elements of automation
- ✓ Need of automation

Definition

- The word 'Automation' is derived from greek words "Auto"(self) and "Matos" (moving). Automation therefore is the mechanism for systems that "move by itself"
- Automation can generally be defined as the process of following predetermined sequence of operation with little or no human labour.

ADVANTAGES OF AUTOMATION

- **Reduction in production time** - having a machine that is automated definitely speeds up the production time since no thinking is needed by the machine, there is better repeatability, and less human error.
- **Increase in accuracy and repeatability** - when an automated machine is programmed to perform a task over and over again, the accuracy and repeatability compared to an employee is far greater.
- **Less human error** - no one is perfect, and we are all prone to making mistakes. Which is why a machine that performs repeated tasks is less likely to make mistakes than an employee.
- **Less employee costs** - by adding automated machines to an operation, means less employees are needed to get the job done. It also indicates less safety issues, which leads to financial savings. With having less employees, there am numerous costs that are diminished or reduced such as payroll, benefits, sick days, etcetera.
- **Increased safety**,- having automated machines means having less employees who perform tasks that can be dangerous and prone to injury, which can make the work environment safer.
- **Higher volume production** - investing in automated equipment creates a valuable resource for large production volumes, which in turn, will increase profitability.

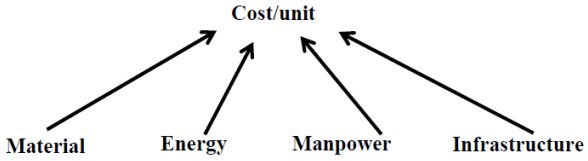

Fig. 1.2 The Components of per unit Manufacturing Cost

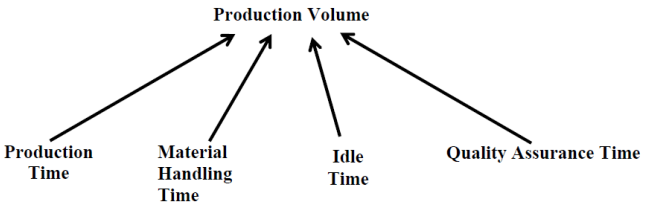

Fig. 1.4 The major factors that contribute to Overall Production Time

DISADVANTAGES OF AUTOMATION

- **Less versatility** — by having a machine that can perform a certain task limits to the flexibility and variety of tasks that an employee could do.
- **More pollution** — different types of machines operate using motor which may require gases or chemicals in order to operate. This can cause an increase in pollution in the workplace.
- **Large initial investment** — automated machines can be one of the most costly operating costs for a company. With automated machines running anywhere between thousands and millions of dollars depending on the type and degree of automation.
- **Increase in unemployment** — by increasing the amount of automation, there are less employees required causing high unemployment rates.
- **Unpredictable costs** —there can be several unpredictable costs that may exceed the actual cost saved by the automation itself. Some of these costs could include research and development costs of automating a process, preventative maintenance costs, and the cost of training employees to operate automated machines.

Automated manufacturing systems can be classified into three basic types:

a. Fixed automation. (Hard automation)
b. Programmable automation (soft automation)
c. Flexible automation. (Integrated automation)

Fixed Automation: Fixed automation is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. Each of the operations in the sequence is usually simple, involving perhaps a plain linear or rotational motion or an uncomplicated combination of the two; for example, the feeding of a rotating spindle. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex.

Typical features of fixed automation are:

- High initial investment for custom-engineered equipment
- High production rates
- Relatively inflexible in accommodating product variety

Advantages:

1. Low unit cost
2. Automated material handling
3. High production rate.

Disadvantages:

1. High initial Investment
2. Relatively inflexible in accommodating product changes.

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Programmable Automation: In programmable automation the production equipment is designed with the capability to change the sequence of operations to accommodate different product configuration. The operation sequence is controlled by a program, which is a set of instructions coded so that they can be read and interpreted by the system. New programs can be prepared and entered into the equipment to produce new products.

Some of the features that characterize programmable automation include:

- High investment in general purpose equipment
- Lower production rates than fixed automation
- Flexibility to deal with variations and changes in product configuration
- Most suitable for batch production.

Advantages:

1. Flexible to deal with design variations.
2. Suitable for batch production.

Disadvantages:

1. High investment in general purpose equipment
2. Lower production rate than fixed automation.

Flexible Automation: Flexible automation is an extension of programmable automation. A flexible automated system is capable of producing a variety of parts (or products) with virtually no time lost for changeovers from one part style to the next. There is no lost production time while reprogramming the system and altering the physical setup (tooting, fixtures, machine settings). Consequently, the system can produce various combinations and schedules of parts or products instead of requiring that they be made in batches.

What makes flexible automation possible is that the differences between parts processed by the system arc not significant. It is a case of soft variety. So that the amount of changeover required between styles is minimal.

The features of flexible automation can be summarized as follows:

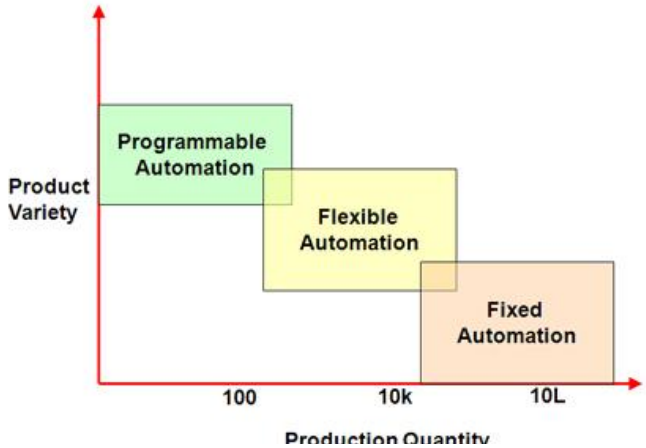
- High investment for a custom-engineered system
- Continuous production of variable mixtures of products
- Medium production rate
- Flexibility to deal with product design variations

Advantages:

1. Continuous production of variable mixtures of product.
2. Flexible to deal with product design variation.

Disadvantages:

1. Medium production rate
2. High investment.
3. High unit cost relative to fixed automation.



REASONS FOR AUTOMATION

1. Shortage of labour
2. High cost of labour
3. Increased productivity: Higher production output per hour of labour input is possible with automation than with manual operations. Productivity is the single most important factor in determining a nation's standard of living. If the value of output/hour goes up, the overall income levels go up.
4. Competition: The ultimate goal of a company is to increase profits. However, there are other measures that are harder to measure. Automation may result in lower prices, superior products, better labor relations, and a better company image.
5. Safety: Automation allows the employee to assume a supervisory role instead of being directly involved in the manufacturing task. For example, die casting is hot and dangerous and the work pieces are often very heavy. Welding, spray painting and other operations can be a health hazard. Machines can also do these jobs more precisely and achieve better quality products.
6. Reducing manufacturing lead-time: Automation allows the manufacturer to respond quickly to the consumers needs. Second, flexible automation also allows companies to handle frequent design modifications.
7. Lower costs: In addition to cutting labor costs, automation may decrease the scrap rate and thus reduce the cost of raw materials. It also enables just-in-time manufacturing which in turn allows the manufacturer to reduce the in-process inventory. It is possible to improve the quality of the product at lower cost.

REASONS FOR NOT AUTOMATION

1. **Labour resistance:** People look at robots and manufacturing automation as a cause of unemployment. In reality, the use of robots increases productivity, makes the firm more competitive and preserves jobs. But some jobs are lost. For example, Fiat reduced its work force from 138,000 to 72,000 in nine years by investing in robots. GM's highly automated plant built in collaboration with Toyota in Fremont,

California employs 3100 workers in contrast to 5100 at a comparable older GM plant.

2. **Cost of upgraded labour:** The routine monotonous tasks are the easiest to automate. The tasks that are difficult to automate are ones that require skill. Thus manufacturing labour must be upgraded.
3. **Initial investment:** Cash flow considerations may make an investment in automation difficult even if the estimated rate of return is high.

The Functional Elements of Industrial Automation

Basic elements of an automated system:

1. Power to accomplish the process and operate the system.
2. A program of instructions to direct the process.
3. A control system to actuate the instructions.

Elements of Automated system

1. Power source: An automated system is used to operate some process and power is required to drive the process as well as controls. There are many sources of power available, but the most commonly used power is electricity. The actions performed by automated systems are generally of two types:

(a)Processing

(b)Transfer and positioning

In the first case, energy is applied to accomplish some processing operation on some entity. The process may involve shaping, moulding or Loading and unloading. All these actions need power to transfer the entity from one state or condition into more valuable state or condition.

The second type of actions-transfer and positioning. In these cases, the product must generally be moved from one location to another during the series of processing steps.

2. Program of instructions: The actions performed by an automated process are defined by a set of instructions known as process. The programmed instructions determine the set of actions that is to be done automatically by the system. The program specifies what automated system should do and how its various components must function in order to accomplish the desired results.

3. Control system: The control element of the automated system executes the program of instructions.

The controls in an automated system can be

(a)Closed loop

(b)Open loop.

(b) **Closed loop control system**: It is also known as a feedback control system. In this system the output variable is compared with an input parameter and any difference between the two is used to drive the output into agreement with input.

1. Input parameter: as set point, represents the desired value of output.

2. Output variables: actual value of parameter.

3. Sensors: A sensor is used to measure the output variable and close the loop

4. Between input and output: It performs feedback function.

5. Controller: The controller compares the output with the input and makes the required adjustment in the process to reduce the difference between them.

6. Actuator: The adjustment being done with one or more actuator which are the hardware devices that physically carry out the control actions such. electric motor, cylinder etc.

Open loop control system

Open loop control system: It is without the feedback loop. In this case the controls operates without measuring the output variables, so no comparison is made between the actual value of the output and desired input parameters There is always risk that the actuator will not have intended effect on the process.

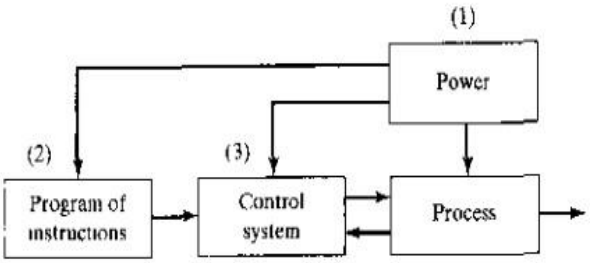


Figure 3.2 Elements of an automated system: (1) power, (2) program of instructions, and (3) control systems.

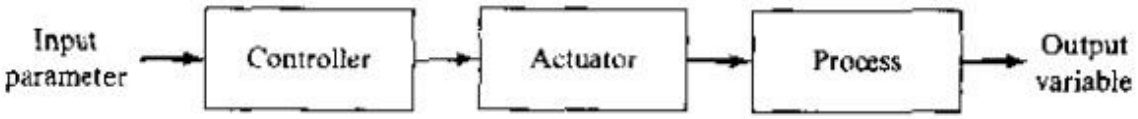


Figure 3.4 An open loop control system.

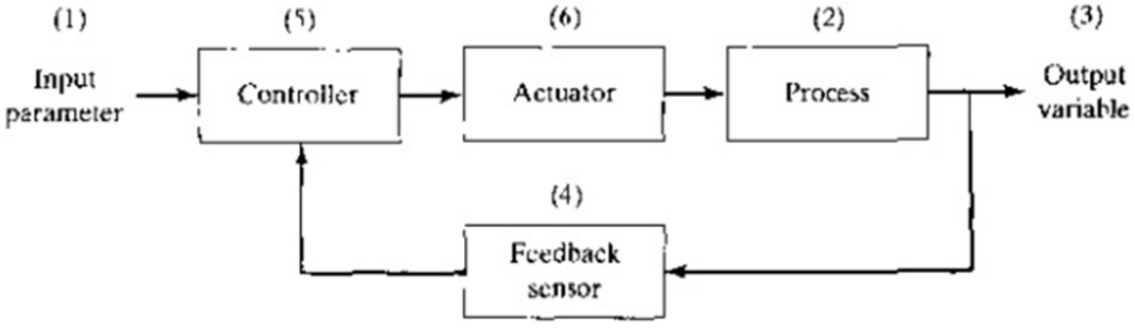


Figure 3.3 A feedback control system.

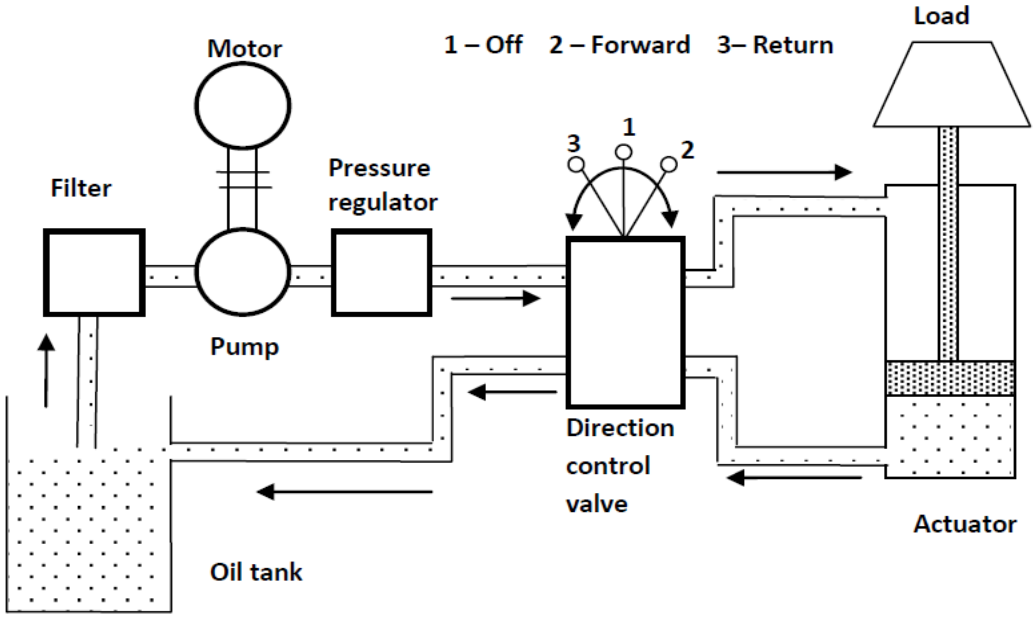
Fluid power & Pneumatic System

- ✓ Fluid power and its elements,
- ✓ Application of fluid power
- ✓ Pneumatics vs. Hydraulics,
- ✓ Benefit and limitations of pneumatics and hydraulics systems
- ✓ Role of Robotics in Industrial Automation.

INTRODUCTION TO FLUID POWER

- In the industry we use three methods for transmitting power from one point to another. Mechanical transmission is through shafts, gears, chains, belts, etc. Electrical transmission is through wires, transformers, etc. Fluid power is through liquids or gas in a confined space.
- **Fluid power** is the use of fluids under pressure to generate, control, and transmit power. Fluid power is subdivided into hydraulics using a liquid such as mineral oil or water, and pneumatics using a gas such as air or other gases.
- A fluid power system is the one that transmits and control energy through the use of pressurized fluid.
- The term fluid power applies to both hydraulics and pneumatics. With hydraulics, that fluid is a liquid such as oil or water. With pneumatics, the fluid is typically compressed air or inert gas.

Basic Components of a Hydraulic System



Functions of the components shown in Fig. are as follows:

1. The hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work. The actuator may be of the linear type (e.g., hydraulic cylinder) or rotary type(e.g., hydraulic motor) to provide linear or rotary motion, respectively.

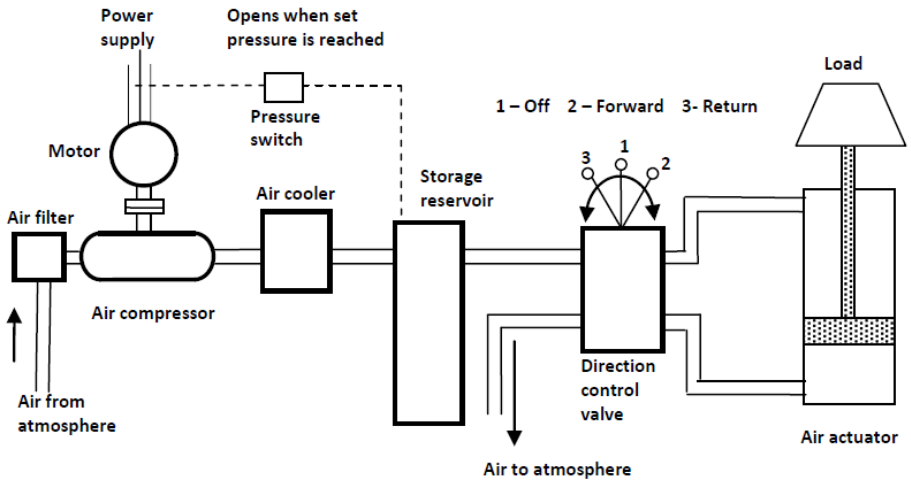
2. The hydraulic pump is used to force the fluid from the reservoir to rest of the hydraulic circuit by converting mechanical energy into hydraulic energy.

3. Valves are used to control the direction, pressure and flow rate of a fluid flowing through the circuit.

4. External power supply (motor) is required to drive the pump.

5. Reservoir is used to hold the hydraulic liquid, usually hydraulic oil.
6. Piping system carries the hydraulic oil from one place to another.
7. Filters are used to remove any foreign particles so as keep the fluid system clean and efficient, as well as avoid damage to the actuator and valves.
8. Pressure regulator regulates (i.e., maintains) the required level of pressure in the hydraulic fluid.

Basic Components of a Pneumatic System



The functions of various components shown in Fig. 1.3 are as follows:
1. The pneumatic actuator converts the fluid power into mechanical power to perform useful work.
2. The compressor is used to compress the fresh air drawn from the atmosphere.
3. The storage reservoir is used to store a given volume of compressed air.
4. The valves are used to control the direction, flow rate and pressure of compressed air.
5. External power supply (motor) is used to drive the compressor.
6. The piping system carries the pressurized air from one location to another.

ADVANTAGES AND DISADVANTAGES OF FLUID POWER

Advantages

There are few advantages, which make fluid power so popular. These are listed below:

- **No need of intermediate equipment:** they eliminate the need for complicated systems of gears, cams, and levers. Motion can be transmitted without the slack inherent in the use of solid machine parts.
- **Less wear and tear:** The fluids used are not subject to breakage as are mechanical parts, and the mechanisms are not subjected to great wear.
- **Multi-function control:** A single hydraulic pump or air compressor can provide power and control for numerous machines or machine functions when combined with fluid power manifolds and valves.
- **Constant force or torque:** This is a unique fluid power attribute.

- **Flexibility:** Hydraulic components can be located with considerable flexibility. Pipes and hoses instead of mechanical elements virtually eliminate location problems
- **Comparatively small pressure losses:** The different parts of a fluid power system can be conveniently located at widely separated points, since the forces generated are rapidly transmitted over considerable distances with small loss. These forces can be conveyed up and down or around corners with small loss in efficiency and without complicated mechanisms.
- **Multiplication and variation of force:** Very large forces can be controlled by much smaller ones and can be transmitted through comparatively small lines and orifices. Linear or rotary force can be multiplied from a fraction of an ounce to several hundred tons of output.
- **Accurate and easy to control:** We can start, stop, accelerate, decelerate, reverse or position large forces with great accuracy.
- **High horsepower and low weight:** Pneumatic components are compact and lightweight.
- **Smoothness:** Fluid systems are smooth in operation. Vibration is kept to a minimum.
- **Overload protection:** In case of an overload, an automatic release of pressure can be guaranteed; automatic valves guard the system against a breakdown from overloading so that the system is protected against breakdown or strain.
- **Wide variety of motions:** Fluid power systems can provide widely variable motions in both rotary and straight-line transmission of power.
- **Low speed torque:** Unlike electric motors, air or hydraulic motors can produce large amounts of torque (twisting force) while operating at low speeds. Some hydraulic and air motors can even maintain torque at zero speed without overheating.
- **Less Human intervention:** The need for control by hand can be minimized.
- **Low operating costs:** Fluid power systems are economical to operate their high efficiency with minimum friction loss keeps the cost of a power transmission at a minimum.
- **Safety in hazardous environments:** Fluid power can be used in mines, chemical plants, near explosives and in paint applications because it is inherently spark-free and can tolerate high temperatures.
- **Better force control:** Force control is much easier with fluid systems than for electric motors. Fluid actuators, either hydraulic or pneumatic, are well suited to walking robots because they are high force, low speed actuators. They provide much higher force densities than electric systems.

- **Simpler design.** In most cases, a few pre-engineered components will replace complicated mechanical linkages.

Disadvantages

The main disadvantage of a Fluid system is maintaining the precision parts when they are exposed to bad climates and dirty atmospheres. Protection against rust, corrosion, dirt, oil deterioration, and other adverse environmental conditions is very important.

APPLICATIONS OF FLUID POWER

1. Mobile Fluid power is used to transport, excavate and lift materials, as well as control or power mobile equipment. End use industries include construction, agriculture, marine and the military. Applications include backhoes, graders, tractors, truck brakes and suspensions, spreaders, and highway maintenance vehicles.
2. Industrial Fluid power is used to provide power transmission and motion control for the machines of industry. End use industries range from plastics to paper production. Applications include metal working equipment, controllers, automated manipulators, material handling and assembly equipment.
3. Aerospace Fluid power is used for both commercial and military aircraft, spacecraft and related support equipment. Applications include landing gear, brakes, flight controls, motor controls and cargo loading equipment.

PNEUMATICS VS. HYDRAULICS

The fluid power can be broadly divided into two fields: pneumatics and hydraulics. Both pneumatics and hydraulics are applications of fluid power.

	Pneumatics	Hydraulics
Pressure level	5-10 bar	Upto 200 bar
Actuating forces	Pneumatic actuators can produce only low or medium size forces	Hydraulic actuators are suitable for very high loads.
Element cost	Pneumatic elements such as cylinders and valves are less costly as compared to hydraulic elements	Hydraulic elements can cost from 5 to 10 times more than similar size of pneumatic elements
Transmission lines	Transmission lines in pneumatics are made up of inexpensive flexible plastic tubing. Only single line is needed in pneumatics to simply exhaust the air into atmosphere	Transmission lines in hydraulics are made up of metal tubing with expensive fittings to with stand high working pressure and to avoid leaks. Also return lines are needed in hydraulics to return the oil form each cylinder back to reservoir.
Stability	Low stability because air is compressible	High stability because oil is incompressible
Speed Control	Difficult to control the speed of pneumatic cylinders or motors.	Easy to control the speed.

ADVANTAGES AND DISADVANTAGES OF PNEUMATICS

Advantages

- Pneumatic systems are clean because they use compressed air. If a pneumatic system develops a leak, it will be air that escapes and not oil.
- Pneumatic systems are cheaper to run than other systems.
- Inherently modulating actuators and sensors.
- Explosion proof components.

• High efficiency, for example a relatively small compressor can fill a large storage tank to meet intermittent high demands for compressed air.
• Ease of design and implementation.
• High reliability, mainly because of fewer moving parts.
• Compressed gas can be stored, allowing the use of machines when electrical power is lost.
• Easy installation and maintenance.

Disadvantages

• Low accuracy and control limitation because of compressibility.
• Noise pollution.
• Leakage of air can be of concern.
• Need for a compressor producing clean and dry air.
• Cost of air piping.
• Need of regular component calibration

Advantages and disadvantages of hydraulics

Advantages

Through the use of simple devices, an operator can readily start, stop, speed up , slow down and control large forces with very close and precise tolerance.

• High power output from a compact actuator.
• Hydraulic power systems can multiply forces simply and efficiently from a fraction of an ounce to several hundred tons of output.
• Force can be transmitted over distances and around corners with small losses of efficiency.
• There is no need for complex systems of gears, cams, or levers to obtain a large mechanical advantage.
• Extreme flexibility of approach and control. Control of a wide range of speed and forces is easily possible.
• Safety and reliability.
• Hydraulic systems are smooth and quiet in operation. Vibration is kept to a minimum.

Disadvantages

• Hydraulic systems are expensive.
• System components must be engineered to minimize or preclude fluid leakage.
• Protection against rust, corrosion, dirt, oil deterioration, and other adverse environment is very important.
• Maintenance of precision parts when they are exposed to bad climates and dirty atmospheres. • Fire hazard if leak occurs.
• Adequate oil filtration must be maintained.

APPLICATIONS OF PNEUMATICS

• Operation of heavy or hot doors.

- Lifting and moving in slab moulding machines.
- Spray painting.
- Bottling and filling machines.
- Component and material conveyor transfer.
- Unloading of hoppers in building, mining and chemical industry.
- Air separation and vacuum lifting of thin sheets. • Dental drills.

APPLICATIONS OF HYDRAULICS

- Machine tool industry.
- Plastic processing machines.
- Hydraulic presses.
- Construction machinery.
- Lifting and transporting
- Agriculture machinery

Future of Fluid Power Industry in India

- The automation market in India is estimated to be $1/10^{th}$ that of China. If India has to become one of the leading economies in the world, based on manufacturing, it will have to attain higher technological standards and higher level of automation in manufacturing.
- In the past 30 years, fluid power technology rose as an important industry. With increasing emphasis on automation, quality control, safety and more efficient and green energy systems, fluid power technology should continue to expand in India.
- Fluid power industry is gaining a lot of importance in Indian industry. According to a recent survey, it has shown a growth of 20% over the last 10 years and the size of market is estimated to be close to 5000 crores per annum. This makes it a sizable industry segment in India. The growth rate of this industry in India is typically about twice the growth of economy.

The reasons for this are three-fold:

1. As the economy grows, this industry grows.
2. There is a lot of automation and conversion into more sophisticated manufacturing methods which increases the rate.
3. One of the interesting things happening in this industry is that India is becoming an attractive destination for manufacturing and outsourcing of some of the products.

So these three aspects together create a situation where the growth of this industry is twice the growth of GDP in India.

The fluid power sector in India consists of many sophisticated Indian industries and partnership with number of global fluid power technology leaders that include Festo, Rexroth, Vickers, Eaton, Parker Hannifin, Norgen, , Saucer Donfos, Yuken, Siemens, Shamban, Pall and Gates, , Rotex, , Janatics, Maxwell, Wipro Dynamatic Technologies and many more.

One of the major segments for hydraulic industry in India is mobile hydraulics. Because of massive programs on road construction, there is a major expansion of construction machinery

industry as well. In addition to this, a trend toward the usage of more sophisticated hydraulics in tractors and farm equipment is witnessed. The manufacturing industry in India is working toward higher automation and quality of output. As Indian industry moves toward modernization to meet the productivity and to compete in the global market, an excellent potential for the pneumatic industry is expected in India.
Another area of interest for fluid power industry would be the opportunities in defense equipment. Defense is a major market segment in Indian fluid power industry and contributes to over 40% of the market demand. There is also a move toward products with miniature pneumatics, process valves, servo drives, hydraulic power steering with new controls and sophisticated PLC, microprocessor controls.

However, the key input required for the effective utilization of fluid power is education and training of users. So there is a big need for education and training in design application and maintenance of fluid power systems. Rexroth recently opened many competence centers in India to train the manpower and to create awareness about the use of fluid power in Indian industry.

REASONS TO USE ROBOTICS IN MANUFACTURING

Robots are valued in the manufacturing industry for a number of attributes: reliability, predictability, precision, repeatability, and imperviousness to hazardous environments. Robots come with certain limitations when we compare them with humans. Unlike humans, robots lack the ability to respond to unexpected circumstances and improve performance based on previous experience. Robots have a broad range of potential applications in manufacturing because they are flexible and programmable. Sensor technology enables robots to hear, see, and feel the environment. These abilities are essential in quality control and measurement process.

Since the introduction of industrial robots in the 1960s, technology has improved immensely and continuously.

Following are some of the benefits of robotics in terms of productivity:

- Robots are capable of producing precise and high-quality work.
- They can produce larger quantities of products in short period of time.
- They improve the safety conditions in a facility.
- They can perform in harsh environments where humans cannot operate.
- They can be reprogrammed and used for producing varying products.