CMR

INSTITUTE OF

TECHNOLOGY

USN

Internal Assesment Test - II

Sub:	Elements of Mechanical Engineering							Code:	21ME25
Date:	08 / 08 / 2022	Duration:	90 mins	Max Marks:	50	Sem:	II	Branch:	CS/CV/IS/ME

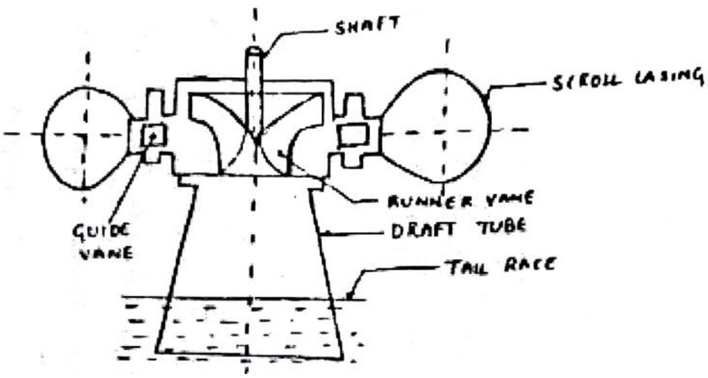
Answer Any FIVE FULL Questions

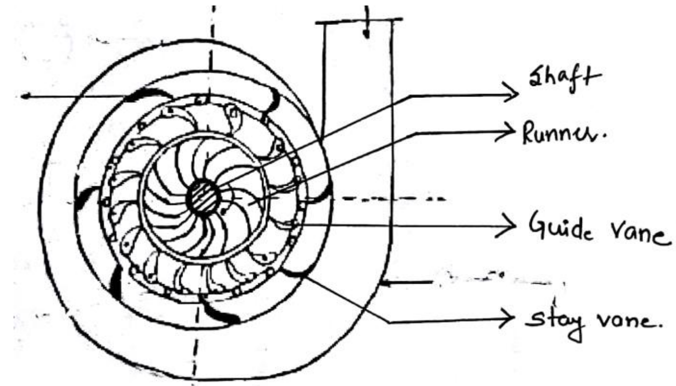
		Marks	OBE	
			CO	RBT
1.	With a neat sketch explain the principle and operation of a mixed flow turbine.	[10]	C3	L1
2.	With a neat sketch explain the working of a centrifugal pump. Explain the concepts of priming and cavitation.	[5+5]	C3	L1
3.	Explain the types of gear trains with suitable diagrams. A simple gear train consists of 3 gears. The number of teeth on driving gear is 60, on the roller gear is 40 and on the driven gear is 80.If the driving gear rotates at 1200 rpm, find the speed of the driven gear and the velocity ratio. Sketch the arrangement of the gear drive.	[10]	C3	L1
4	With neat sketches explain the following operations: Drilling, Reaming, Boring, Countersinking and tapping.	[10]	C5	L1
5.	What is CNC? With the help of a block diagram explain the components of CNC. State few advantages, limitations and applications of a CNC machine.	[10]	C3	L1
6.	What is Mechatronics? With suitable example explain the concept of open and closed loop System.	[10]	C5	L1
7.	Explain the concepts of smart manufacturing and industrial IoT.			

IAT – II Solution

1.

- Francis turbine is a water turbine used for medium head and medium flow rate application.
- Runner, the rotating part of turbine contains set of blades over which the water glides during the flow.
- Runner is connected to the generator via a shaft for electricity production.
- In runner water enters radially and leaves axially, hence also called as a mixed flow turbine.
- The cross-section of blade in the runner has a thin Air-foil shape and a bucket shape towards the outl[et]
- So, when water flows over it, there is a low pressure region on one side and a high pressure region on other side of blade, giving rise to a lift force. (due to air foil shape)
- The bucket shape introduces an impulse force on runne[r]
- Hence Pressure Energy (converts to lift force) and kinetic Energy (used up for impulse force) from the fluid and is used up to do the work on turbin[e]
- Hence both kinetic Energy (K.E) and Pressure Energy (P.[E]) drops down.
- Francis turbine is not a pure reaction turbine, as some portion of force comes from impulse action also.





- Water flows from reservoir through the penstock & enters spiral casing.
- The runner is positioned inside the spiral casing
- The flow rate of water (discharge, m^3/s) decreases along the length of casing, but decreasing area of casing will make sure that the water is entered in the runner region almost at uniform velocity, leading to smooth operation of runner.

$(Q = A_1V_1 = A_2V_2)$
Continuity Equation
A ⇒ Area of cross.
V ⇒ Velocity
Q ⇒ discharge.

- Stay vanes & guide vanes are fitted at the entrance of runner.

- Guide vanes (adjustable), is used to control the flowrate of water towards the runner, depending on electricity demand.

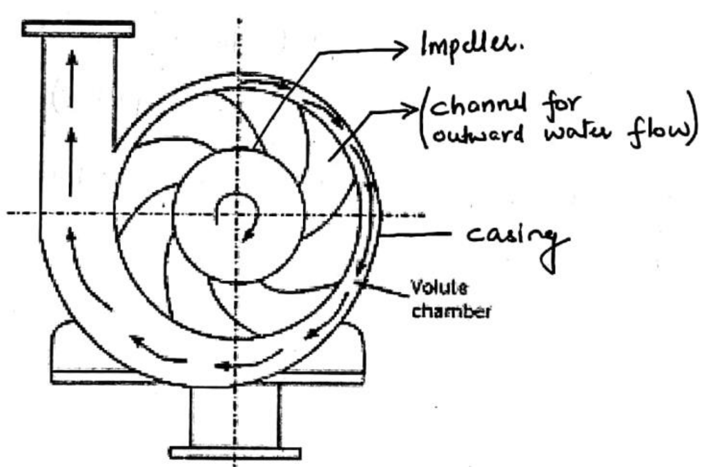
• Draft tube is fitted at the exit side of the turbine, and has increasing cross-sectional area towards the tail race. This increases the pressure of fluid above atmosphere, to maintain continous flow out of the turbine & avoid cavitation (air bubble formation - can lead blade damage).

$$F_{total} = F_{lift} + F_{impulse}$$

2.

→ Centrifugal Pump is a power absorbing turbomachine used to raise liquids from a lower level to a higher level by creating the pressure required, using centrifugal action.

→ It converts mechanical energy into hydraulic energy (in form of pressure energy).



Working :-

- The motor drives the impeller, via a shaft.
- As the impeller rotates, the water enters at the inlet of the impeller due to suction.
- As the impeller rotates, the water entering the inlet of impeller is continously thrown out due to the centrifugal force.
- The water passes through the specially designed channels in the impeller, towards the outer periphery of the impeller.
- The casing space is filled by water continously, and is discharged to the delivery tank continously.
- The pressure head (m of water) developed by centrifugal action is entirely by the velocity imparted to the liquid by the rotating impeller.
- Hence, speed of the shaft is enough to produce necessary centrifugal force for discharging.

Priming :- (in centrifugal pump)

- Process of removing the air present in the suction pipe and the impeller casing.
- To remove the air, the suction pipe, casing of the pump and a portion of delivery pipe are completely filled with water before starting the pump.

→ As density of water is around thousand times more than density of air (i.e. water is 1000 time heavier), the suction created by the impeller when air is present inside the pump, is not sufficient to lift the water up into the impeller inlet.

→ Hence, before starting the centrifugal pump, always ∴ priming has to be done

Cavitation: (in centrifugal pump).

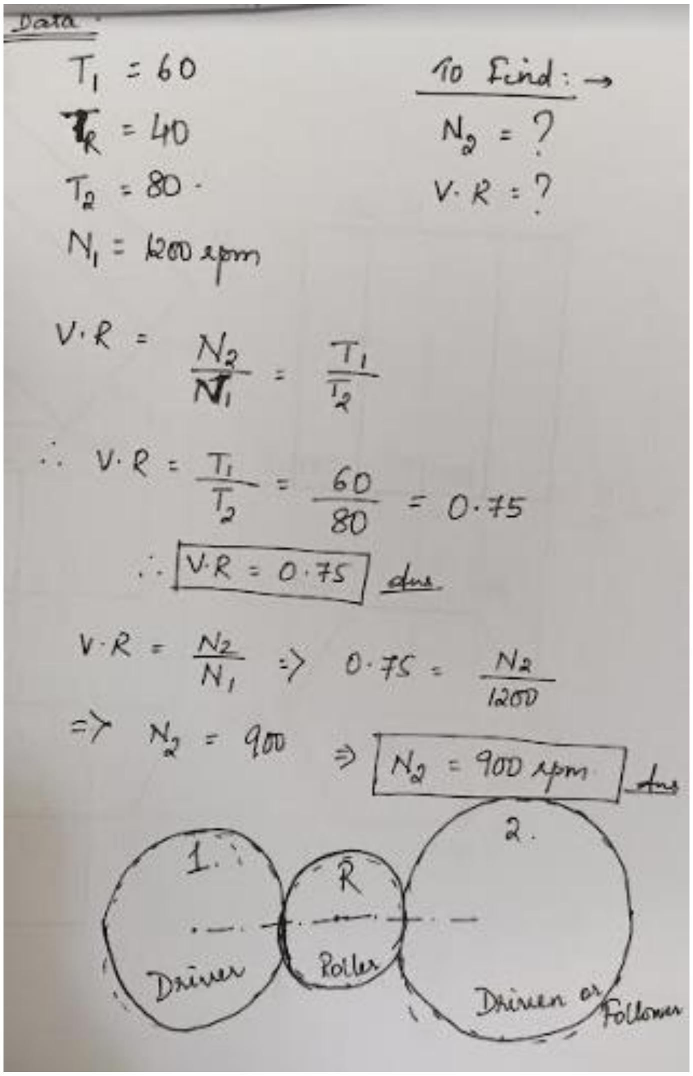
→ If pressure at any point in a suction side of a centrifugal pump falls below the vapour pressure, then the water starts boiling forming saturated vapour bubbles.

→ Thus, the formed bubbles moves at a very high velocity to the more pressure side of the impeller blade, and strikes the surface of the blade and collapses on the surface surface of the blades.

→ This leads to erosion and pitting, forming cavities on the blades.

→ This process takes place many thousand times in a second, and damages the blade of centrifugal pump.

3.



Data:

$T_1 = 60$

$T_R = 40$

$T_2 = 80$

$N_1 = 1200$ rpm

To Find: →

$N_2 = ?$

$V.R = ?$

$V.R = \frac{N_2}{N_1} = \frac{T_1}{T_2}$

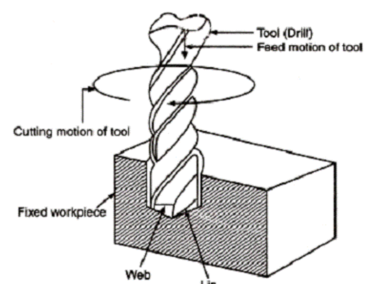
$\therefore V.R = \frac{T_1}{T_2} = \frac{60}{80} = 0.75$

$\therefore \boxed{V.R = 0.75}$ Ans

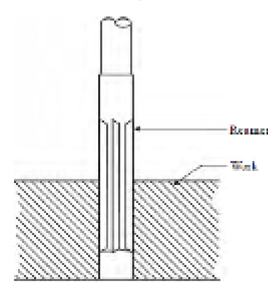
$V.R = \frac{N_2}{N_1} \Rightarrow 0.75 = \frac{N_2}{1200}$

$\Rightarrow N_2 = 900 \Rightarrow \boxed{N_2 = 900 \text{ rpm}}$ Ans

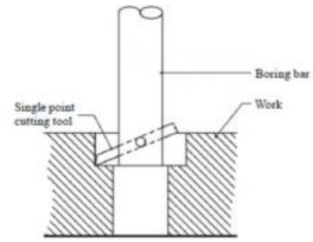
4. **Drilling -** In operation the workpiece is clamped rigidly on the table. A point is marked at the location where the hole is to be drilled with the help of center punch. The machine is started and with the help of hand feed lever the spindle is lowered and fed against the work piece to perform the drilling operation. When tip of the drill bit is touches the center punch work, gradually feed is given so as to produce the hole. When the hole is completed the drill bit is withdrawn slowly by rotating the hand feed lever in the reverse direction.



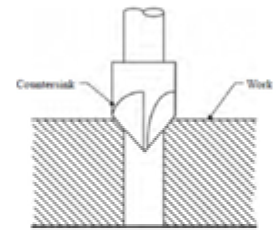
Reaming - It is an accurate way of sizing and finishing a hole which has been previously drilled. The speed of the spindle is made half that of drilling and automatic feed may be employed. The tool used for reaming is known as the reamer which has multiple cutting edges. Reamer cannot originate a hole. It simply follows the path which has been previously drilled and removes a very small amount of metal.



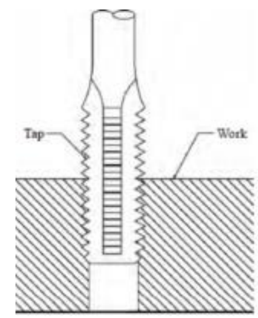
Boring - To enlarge a hole by means of an adjustable cutting tool with only one cutting edge. This is necessary where suitable sized drill is not available or where hole diameter is so large that it cannot be ordinarily drilled. The cutter is held in a boring bar which has a taper shank to fit into the spindle socket. For perfect finishing a hole, the job is drilled slightly undersized.



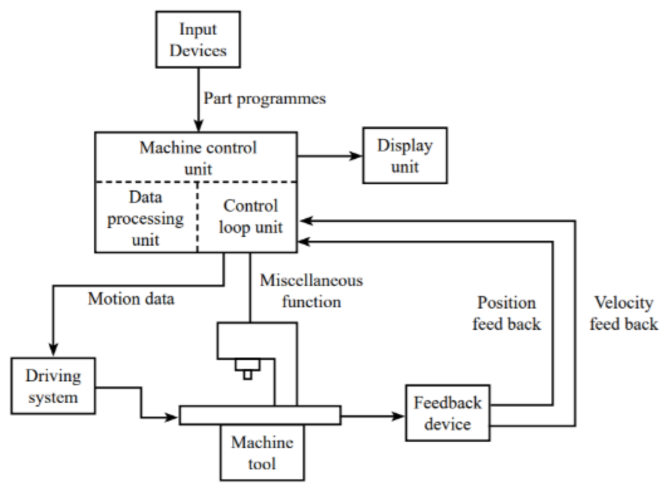
Countersinking - It is the operation of making a cone-shaped enlargement of the end of hole to provide a recess for a flat head screw or countersunk rivet fitted into the hole. The tool used for countersinking is called a countersink. Standard countersunks have 60°, 82° or 90° included angle and the cutting edges of the tool are formed at the conical surface. The cutting speed in countersinking is 25% less than that of drill.



Tapping - It is the operation of cutting internal threads by means of a cutting tool called a tap. A tap may be considered as a bolt with accurate threads on it. The threads act as cutting edges which are hardened and ground. When the tap is screwed into the hole it removes metal and cuts internal threads which fit into external threads of the same size.



5. Computer Numeric Control (CNC) is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium (computer command module, usually located on the device) as opposed to controlled manually by hand wheels or levers, or mechanically automated by cams alone. Computer Numerical Control (CNC) is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data.



The machine control unit (MCU) is a microcomputer that stores the program and executes the commands into actions by the machine tool. The MCU consists of two main units: the data processing unit (DPU) and the control loops unit (CLU). The DPU software includes control system software, calculation algorithms, translation software that converts the part program into a usable format for the MCU, interpolation algorithm to achieve smooth motion of the cutter, editing of part program (in case of errors and changes).
The DPU processes the data from the part program and provides it to the CLU which operates the drives attached to the machine leadscrews and receives feedback signals on the actual position and velocity of each one of the axes. A driver (dc motor) and a feedback device are attached to the

leadscrew. The CLU consists of the circuits for position and velocity control loops, deceleration and backlash take up, function controls such as spindle on/off.

Advantages of CNC

- Increased productivity.
- High accuracy and repeatability.
- Reduced production costs.
- Reduced indirect operating costs.
- Facilitation of complex machining operations.
- Greater flexibility.
- Improved production planning and control.
- Lower operator skill requirement.
- Facilitation of flexible automation

Limitations of CNC

- High initial investment.
- High maintenance requirement.
- Not cost-effective for low production cost.

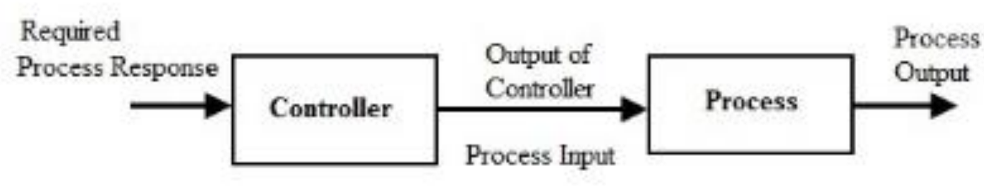
Applications

The applications of CNC include both for machine tool as well as non-machine tool areas. In the machine tool category, CNC is widely used for lathe, drill press, milling machine, grinding unit, laser, sheet-metal press working machine, tube bending machine etc. Highly automated machine tools such as turning centre and machining centre which change the cutting tools automatically under CNC control have been developed. In the non-machine tool category, CNC applications include welding machines (arc and resistance), coordinate measuring machine, electronic assembly, tape laying and filament winding machines for composites etc.

6. **Mechatronics** may be defined as" the complete integration of mechanical system with electronics, electrical and computer system into a single system".

Open Loop Control System

In this kind of control system, the output doesn't change the action of the control system otherwise; the working of the system which depends on time is also called the open-loop control system. It doesn't have any



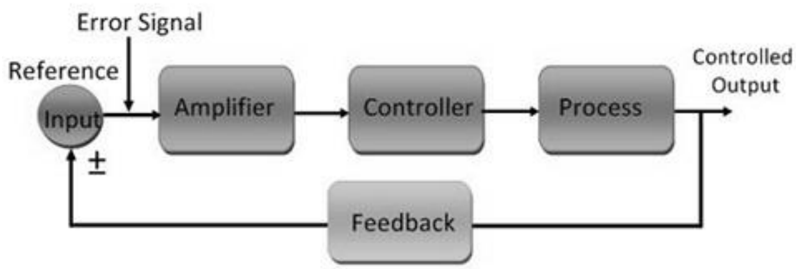
feedback. It is very simple, needs low maintenance, quick operation, and cost-effective. The accuracy of this system is low and less dependable. The example of the open-loop type is shown below. The main advantages of the open-loop control system are easy, needs less protection; operation of this system is fast & inexpensive and the disadvantages are, it is reliable and has less accuracy.

Control the temperature of the room with room heater: the amount of heat generated by a room heater depends on the amount of input power controlled by a regulator.

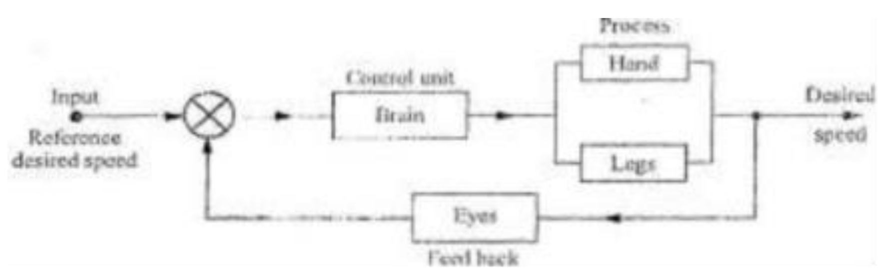
If the power is switch ON, the power supplied to the heater continues and temperature of the room goes on increasing immaterial of whether heat is required in the room or not. Here person is going and OFF the power supply switch and there by cooling the temperature of the room is decreasing.

Closed-Loop Control System

The closed-loop control system can be defined as the output of the system that depends on the input of the system. This control system has one or more feedback loops among its input & output. This system provides the required output by evaluating its input. This kind of system produces the error signal and it is the main disparity between the output and input of the system. The main advantages of the closed-loop control system are accurate, expensive, reliable, and requires high maintenance.



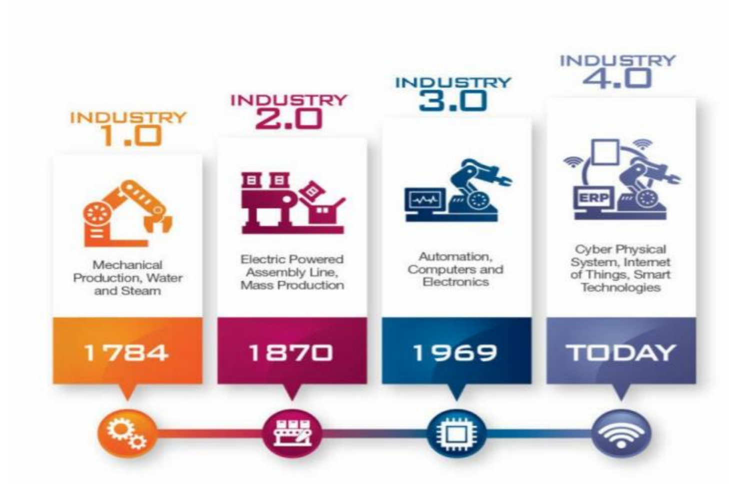
Speed control of an automobile:



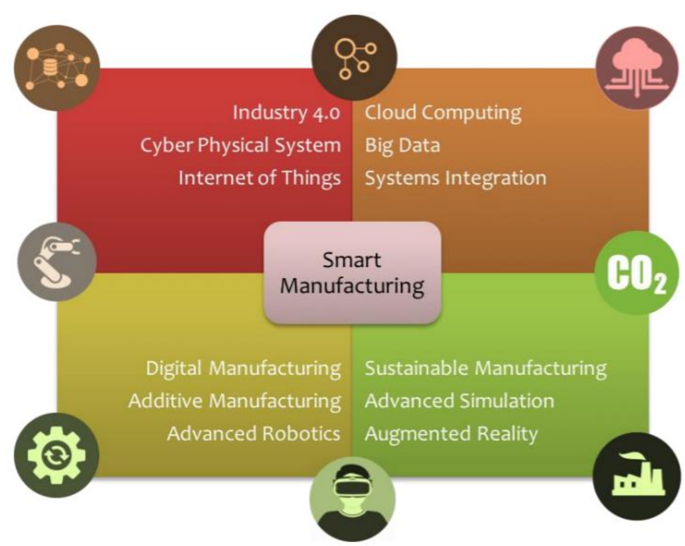
- ➢ The driver observes the speedometer, and based on the speed shown by the speedometer he decides whether the fuel supply should be increased or decreased or gear change is to be made.
- ➢ Here speed shown a speedometer is feedback. A feedback signal from the eye compares the desired speed in the memory of the driver.
- ➢ Error signals are given to brain. Brain manipulates the error signals and gives it ton hand and leg and increase the fuel supply if the speed is less than the desired speed, otherwise decrease the fuel supply.
- ➢ Changing of gear and increase or decrease of fuel supply, depends on whether it an upward or downward gradient respectively.

7. Smart Manufacturing

History/background It's been nearly 260 years since the beginning of the original Industrial Revolution, thought to have started around 1760. In the United States, the latest iteration of this process, the fourth industrial revolution, has been called "smart manufacturing," while in Europe it's known as "Industry 4.0." The first industrial revolution was characterized by steam power and the power loom; the assembly line was introduced during the second industrial revolution; and automation and data enhanced automation came along in the 1970s during the third industrial revolution. This fourth industrial revolution is characterized by a range of interconnected automated systems that are fusing the physical, digital and biological worlds.



Smart manufacturing is a broad category of manufacturing with the goal of optimizing concept generation, production, and product transaction. While manufacturing can be defined as the multi-phase process of creating a product out of raw materials, smart manufacturing is a subset that employs computer control and high levels of adaptability. Smart manufacturing aims to take advantage of advanced information and manufacturing technologies to enable flexibility in physical processes to address a dynamic and global market. There is increased workforce training for such flexibility and use of the technology rather than specific tasks as is customary in traditional manufacturing. The 21st century manufacturing facilities have ushered a new wave of manufacturing with an amalgamation of technologies from advanced robotics to fully integrated production systems. With smart manufacturing or Industry 4.0, manufacturers are moving towards a new level of interconnected and intelligent manufacturing system which incorporates the latest advances in sensors, robotics, big data, and controllers. To keep pace with the evolution of these “smart factories’ requires highly skilled and nimble engineers to manage the increasing complexity and shorter mind-to market product cycles.



Internet of Things (IoT)

Smart Manufacturing is a specific application of the Internet of Things (IoT). Deployments involve embedding sensors in manufacturing machines to collect data on their operational status and performance. In the past, that information typically was kept in local databases on individual devices and used only to assess the cause of equipment failures after they occurred. Now, by analyzing the data streaming off an entire factory's worth of machines, or even across multiple facilities, manufacturing engineers and data analysts can look for signs that particular parts may fail, enabling preventive maintenance to avoid unplanned downtime on devices. Manufacturers can also analyze trends in the data to try to spot steps in their processes where production slows down or is inefficient in their use of materials.

As smart manufacturing becomes more common and more machines become networked through the Internet of Things, they will be better able to communicate with each other, potentially supporting greater levels of automation. For example, smart manufacturing systems might be able to automatically order more raw materials as the supplies, allocate other equipment to production jobs as needed to complete orders and prepare distribution networks once orders are completed. A lack of standards and interoperability are the biggest challenges holding back greater adoption of smart manufacturing.