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Internal Assesment Test – 2

Sub: Computer Integrated Manufacturing				Code: 15ME62
Date: 15/04/2019	Duration: 90 mins	Max Marks: 50	Sem: 6	Branch (sections): ME (A,B)

Answer any FIVE FULL questions.

		Marks	OBE	
			CO	RBT
1	Define Group Technology and explain the types of flexibility in a FMS system.	[10]	CO3	L1
2	Define FMS, list the components and briefly explain the classification of FMS.	[10]	CO3	L1
3	List the functions of industry 4.0 and briefly explain all the components of industry 4.0	[10]	CO5	L1
4	a) What are the challenges in adopting an industry 4.0 b) Briefly explain the applications of industry 4.0.	[3] [7]	CO5	L2
5	Define additive manufacturing and explain the parameters/factors to be considered during additive manufacturing.	[10]	CO5	L3
6	With neat diagrams, explain in detail the process of a) Material extrusion process (FDM 3d printing). b) Powder bed fusion method	[10]	CO5	L2

IAT 2 Solution

Computer Integrated Manufacturing (15ME62) **6^{TH} SEMESTER**

1) **Group technology:** is a manufacturing technique in which parts having similarities in geometry, manufacturing process and/or functions are manufactured in one location using a small number of machines or processes.

The different types of flexibility that are exhibited by manufacturing systems are given:

a). Machine Flexibility. It is the capability to adapt a given machine in the system to a wide range of production operations and part styles. The greater the range of operations and part styles the greater will be the machine flexibility. The various factors on which machine flexibility depends are:

- Setup or changeover time
- Ease with which part-programs can be downloaded to machines
- Tool storage capacity of machines
- Skill and versatility of workers in the systems

b). Production Flexibility. It is the range of part styles that can be produced on the systems. The range of part styles that can be produced by a manufacturing system at moderate cost and time is determined by the process envelope. It depends on following factors:

- Machine flexibility of individual stations
- Range of machine flexibilities of all stations in the system

c). Mix Flexibility. It is defined as the ability to change the product mix while maintaining the same total production quantity that is, producing the same parts only in different proportions. It is also known as process flexibility. Mix flexibility provides protection against market variability by accommodating changes in product mix due to the use of shared resources. However, high mix variations may result in requirements for a greater number of tools, fixtures, and other resources. Mixed flexibility depends on factors such as:

- Similarity of parts in the mix
- Machine flexibility
- Relative work content times of parts produced

d). Product Flexibility. It refers to ability to change over to a new set of products economically and quickly in response to the changing market requirements. The change over time includes the time for designing, planning, tooling, and fixturing of new products introduced in the manufacturing line-up. It depends upon following factors:

- Relatedness of new part design with the existing part family
- Off-line part program preparation

- Machine flexibility

e). Routing Flexibility. It can define as capacity to produce parts on alternative workstation in case of equipment breakdowns, tool failure, and other interruptions at any particular station. It helps in increasing throughput, in the presence of external changes such as product mix, engineering changes, or new product introductions. Following are the factors which decides routing flexibility:

- Similarity of parts in the mix
- Similarity of workstations
- Common tooling

f). Volume Flexibility. It is the ability of the system to vary the production volumes of different products to accommodate changes in demand while remaining profitable. It can also be termed as capacity flexibility. Factors affecting the volume flexibility are:

- Level of manual labor performing production
- Amount invested in capital equipment

g). Expansion Flexibility. It is defined as the ease with which the system can be expanded to foster total production volume. Expansion flexibility depends on following factors:

- Cost incurred in adding new workstations and trained workers
- Easiness in expansion of layout
- Type of part handling system used

2) The components of FMS are:

- Workstation
- Material Handling
- Computer Control System
- Human Resources

Flexible manufacturing systems can be divided into various types depending upon their features.

1. DEPENDING UPON KINDS OF OPERATION-

Flexible manufacturing system can be distinguished depending upon the kinds of operation they perform:

I. Processing operation. Such operation transforms a work material from one state to another moving towards the final desired part or product. It adds value by changing the geometry, properties or appearance of the starting materials.

II. Assembly operation. It involves joining of two or more component to create a new entity which is called an assembly/subassembly. Permanent joining processes include welding, brazing, soldering , adhesive bonding, rivets, press fitting, and expansion fits.

2. DEPENDING UPON NUMBER OF MACHINES –

The following are typical categories of FMS according to the number of machines in the system:
I. single machine cell (SMC). It consist of a fully automated machine capable of unattended operations for a time period longer than one machine cycle. It is capable of processing different part styles, responding to changes in production schedule,
and accepting new part introductions. In this case processing is sequential not simultaneous.

II. Flexible manufacturing cell (FMC). It consists of two or three processing workstation and a part handling system. The part handling system is connected to a load/unload station. It is capable of simultaneous production of different parts.

III. A Flexible Manufacturing System (FMS). It has four or more processing work stations (typically CNC machining centers or turning centers) connected mechanically by a common part handling system and automatically by a distributed computer system. It also includes non-processing work stations that support production but do not directly participate in it. e.g. part / pallet washing stations, co-ordinate measuring machines. These features significantly differentiate it from Flexible manufacturing cell (FMC).

3. DEPENDING UPON LEVEL OF FLEXIBILITY–
Another classification of FMS is made according to the level of flexibility associated with the system. Two categories are distinguished here:
I. Dedicated FMS. It is designed to produce a particular variety of part styles. The product design is considered fixed. So, the system can be designed with a certain amount of process specialization to make the operation more efficient.
II. Random order FMS**.** It is able to handle the substantial variations in part configurations. To accommodate these variations, a random order FMS must be more flexible than the dedicated FMS. A random order FMS is capable of processing parts that have a higher degree of complexity. Thus, to deal with these kinds of complexity, sophisticated computer control system is used for this FMS type.

3) The functions of industry 4.0 are:

- Interoperability
- Information transparency
- Technical assistance
- Decentralized decisions

The components of industry 4.0 are:

1. System Integration

Many systems are highly automated within their own operation, but struggle to communicate with other systems. Standards and open architecture support the easy transfer of information, both to the business and the customer and/or end user. This can involve defining common languages for data exchange such as JDF for job information, CxF for color information, and PDF for content.

2. Big Data and Analytics

As systems become increasingly digitized and connected, there is a great deal of data that can be collected and analyzed. One of the challenges is the quantity of data. Too much data makes it difficult to identify the relevant information and trends that can lead to intelligent and automated decisions. This is where “big” data and analytics come in. Big data and analytics make it possible to identify the performance of an individual component and its operating restrictions in order to prevent future production issues and take preventative action.

3. Simulation and Virtualization

The simulation and virtualization of systems allow for different scenarios to be assessed. Once systems are assessed, cost-effective solutions can be developed, tested, and implemented much faster, ultimately leading to reduced costs and time to market. An example of simulation would be color management and control, where in-line measurements can be used to minimize set up times and optimize subsequent press runs.

4. Internet of Things (IoT)

The IoT is a key functionality in Industry 4.0 driven solutions. The IoT combines physical devices via the network to collect data for the decision making process. This embedded computing enhances the value and functionality of the product being manufactured.

5. The Cloud

The Cloud is being used for applications such as remote service, color management, and performance benchmarking, and its role in other business areas will continue to expand. With continuous advancements in technology, machine data and functionality will only continue to be shifted towards Cloud solutions. The Cloud allows for a much faster roll out of updates, performance models, and delivery options than stand-alone systems. The industry has seen a large shift in utilizing Cloud solutions, and this will continue to grow.

6. Cybersecurity

As we move away from closed systems (with the increased connectivity from the IoT and Cloud), the security of information becomes paramount. Security and reliability enable the successful implementation of a truly modern and digitized production workflow, leveraging all of the benefits of a connected environment.

7. Autonomous Robots

Although robotics is in its early stages in the graphic communications industry, we have seen an increase in use through specific manufacturing systems; for example, activities such as materials movement (as in the Cox Target Media facility) and/or with product inventory control. We expect the level of performance and interaction with humans and systems to improve, and we anticipate increased use of robotics by leading print companies.

8. Augmented Reality

Augmented reality grows in use by providing real-time information in an effective manner to allow humans to better integrate and interact with electronic systems. Examples can include the transmission of information on repairs for a part that can be viewed through different devices or the training of personnel using simulations and 3D views of the facility or equipment.

4a) The challenges in industry 4.0:

- New business models—the definition of a new strategy
- Rethinking your organization and processes to maximise new outcomes
- Understanding your business case
- Conducting successful pilots
- Helping your organization to understand where action is needed
- Change management, something that is too often overlooked
- Examination of company culture
- The genuine interconnection of all departments
- Recruiting and developing new talent

4b) Applications of industry 4.0:

- **Design Engineering**

One of the most important elements of the manufacturing value chain rests in research and development. Design engineers can take full advantage of the catalog of information and related data available to them.

During their preliminary product research, this data can reveal a more specific scope of a product's potential. And it can help designers to focus on efficiency throughout the production process for a better overall product, which will reduce the amount of time it takes to get to market.

- **Planning & Logistics**

From an operational standpoint, the overall function of the middle stage in the value chain will also benefit from Industry 4.0. These technologies offer insight within the nuts-and-bolts of a production process. This data can come together to help manufacturers identify bottlenecks or pain points. From there, they can integrate new and improved solutions to keep their operations well-supported for efficient production and realistic growth.

- **Predictive Maintenance & Service**

Typically, problems within the manufacturing process are addressed reactively – or as they occur. While routine maintenance is a part of the process, Industry 4.0 makes this even easier. Ongoing data reporting can indicate failure rates and notify technicians on where they should prioritize preventative maintenance. This type of predictive reporting ensures fewer interruptions and delays in production.

- **Business Expansion**

When a business focuses on expansion into greater operational capacity or a broader scope of products, data collected through Industry 4.0 serves as an invaluable asset. As the physical-digital-physical cycle presses onward, better or newer products and services can be identified from the data. And this information will give a manufacturing firm more relevant insight on how to remain competitive in their specific market.

- **Connecting to Customers**

Beyond the process itself, Industry 4.0 products and services can also facilitate a better connection with customers. This type of customer information can yield a robust set of data that can be used for learning more about customers' needs, wants, and preferences. And this can allow a manufacturer to produce more marketable products that better address these consumer needs.

5. **Additive Manufacturing:**

Is a process by which digital 3d design data is used to buildup a component in layers by depositing material.

Factors/parameters: to be considered for AM:

1. Layer Height

Think of layer height as the resolution of your print. This setting specifies the height of each filament layer in your print. Prints made with thinner layers will create more detailed print1s with a smoother surface where it's difficult to see the individual filament layers. The downfall of thinner layers is that it takes more time to print something, since there will be more layers that make up your object.

2. Shell Thickness

Shells refers to the number of times the outer walls of the design are traced by the 3D printer before starting the hollow inner sections of your design. This defines the thickness of the side walls and is one of the big1gest factors in the strength of your print. Increasing this number will create thicker walls and improve the strength of the print.

3. Retraction

This feature tells the printer to pull the filament back from the nozzle and stop extruding filament when there are discontinuous surfaces in your print, Retraction is usually always enabled, unless your print doesn't have any discontinuous surfaces in it. This setting can sometimes cause filament to get clogged in your nozzle during a print in which case you probably want to disable it. If you find there is too much filament oozing out of the nozzle, leaving your print with a bunch of strings or clumps on the outer edges, then be sure to turn on retraction.

4. Fill Density

Infill refers to the density of the space inside the outer shell of an object. You'll notice this is measured in % instead of mm like the layer height. If an object is printed with 100% infill, it will be completely solid on the inside. The higher the percentage of infill, the stronger and heavier the object will be, and the more time and filament it will take to print. This can get expensive and time consuming if you're printing with 100% infill every time

5. Print Speed

Print speed refers to the speed at which the extruder travels while it lays down filament. Optimal settings depend on what design you're printing, the filament you're using, the printer, and your layer height. Of course, everyone wants to print their object as quickly as possible, but fast print speeds can cause complications and messy looking prints.2

For complicated prints, a slower speed will give you a higher quality print.

6. Supports

Supports are structures that help hold up 3D objects that don't have enough base material to build off of as they are being printed. Since objects are printed in layers, parts of an object that extend past a 45 degree angle will have nothing for the first layer of filament to build on. These are called overhangs and can create a drooping look without supports.

7. Platform Adhesion Type

These settings will affect how your model sticks to the print bed. Warping at the bottom of a design can be a main culprit for prints not sticking to a print bed, but there are two main settings you can adjust to help with platform adhesion:

- Raft: A horizontal grid that goes under the object that acts as a platform to stick to the bed and build from. They can also be useful when printing models with small parts at the bottom of your print, like animal feet. If you do choose to use a raft, it will leave rough edges on the bottom of your print when you remove it.
- Brim: Like a brim of a hat, brims are lines around the bottom of the object which keep the corners of your model down without leaving marks on the bottom of the object. This is a better option if your main objective is to get your model to stick to the print bed. Brims can also be used to stabilize delicate parts of an object that are isolated from the rest of the model like the legs of a table.

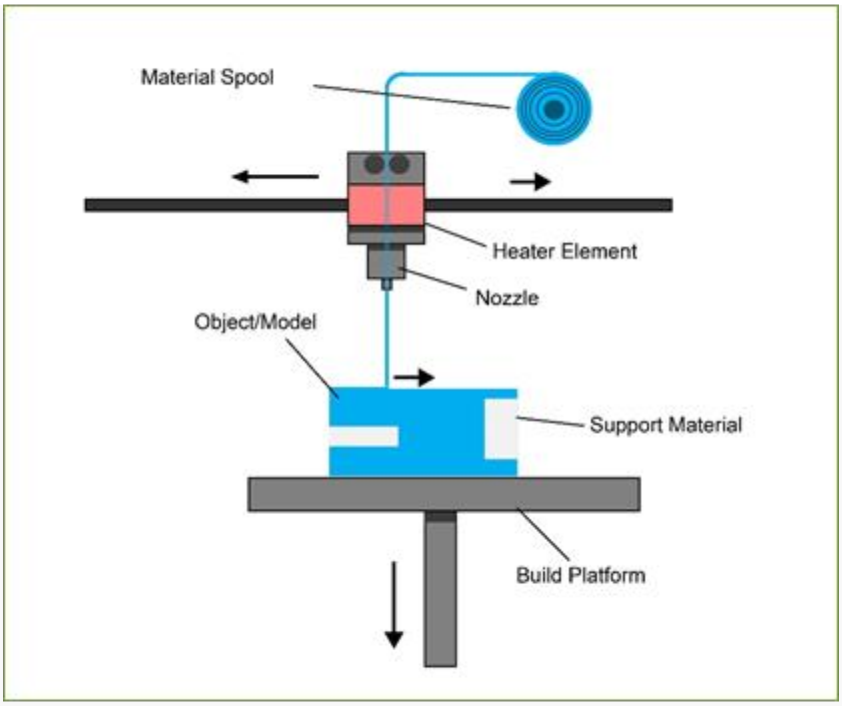
8. Initial layer thickness

This is located in advanced settings in Cura and refers to the thickness of your very first layer on the print bed. If you want a more sturdy base for your print, you can make the initial layer thicker.

6) Material Extrusion

Fuse deposition modelling (FDM) is a common material extrusion process and is trademarked by the company Stratasys. Material is drawn through a nozzle, where it is heated and is then deposited layer by layer. The nozzle can move horizontally and a platform moves up and down vertically after each new layer is deposited. It is a commonly used technique used on many inexpensive, domestic and hobby 3D printers.

The process has many factors that influence the final model quality but has great potential and viability when these factors are controlled successfully. Whilst FDM is similar to all other 3D printing processes, as it builds layer by layer, it varies in the fact that material is added through a nozzle under constant pressure and in a continuous stream. This pressure must be kept steady and at a constant speed to enable accurate results (Gibson et al., 2010). Material layers can be bonded by temperature control or through the use of chemical agents. Material is often added to the machine in spool form as shown in the diagram.



Material Extrusion printing

1. First layer is built as nozzle deposits material where required onto the cross sectional area of first object slice.
2. The following layers are added on top of previous layers.

3. Layers are fused together upon deposition as the material is in a melted state.

Advantages of the material extrusion process include use of readily available ABS plastic, which can produce models with good structural properties, close to a final production model. In low volume cases, this can be a more economical method than using injection moulding. However, the process requires many factors to control in order to achieve a high quality finish. The nozzle which deposits material will always have a radius, as it is not possible to make a perfectly square nozzle and this will affect the final quality of the printed object.

Materials:

- The Material Extrusion process uses polyers and plastics.
- Polymers: ABS, Nylon, PC, PC, AB

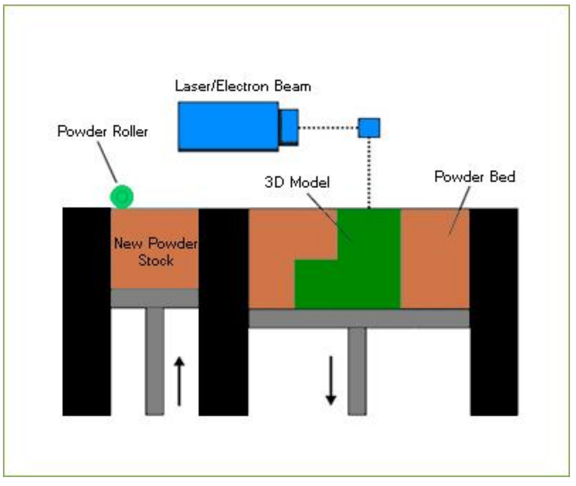
Advantages:

- Widespread and inexpensive process
- ABS plastic can be used, which has good structural properties and is easily accessible

Disadvantages:

- The nozzle radius limits and reduces the final quality
- Accuracy and speed are low when compared to other processes and accuracy of the final model is limited to material nozzle thickness
- Constant pressure of material is required in order to increase quality of finish

Powder bed fusion:



Powder bed fusion

The setup and mechanism of all the PBF techniques is quite same. In a machine for Powder Bed Fusion, there are two chambers where one chamber is filled with powdered building material to feed into the other chamber and the second chamber is used for making the 3D model. The 3D model is built by melting and fusing the particles of powdered building material using a Laser, thermal or electron beam print head. The plastic or metal powder is filled into the storage chamber and feed to the building chamber by rolling sufficient amount for each layer by a levelling roller or blade. The rolled out powder is filled over the building platform which has been lowered to the depth equal to required height of the layer in the beginning of the process. The height of layers is generally kept 0.1 mm or around. Later on either a beam of high power laser or contact thermal print head or high power electron beam is used to melt and fuse material particles while the head moves along the horizontal plane to create the path for the desired layer. After a single layer has been laid out, the platform is lowered to a depth equal to the height of next layer and powder is rolled out or slide out from the storage chamber to the building chamber. Again next layer is built by projecting a laser beam or electron beam or contacting a thermal print head along a computer controlled path. Similarly, all successive layers are built. After the completion of final layer, the 3D model is still is removed from the remaining powder material. The model is left in the machine for some time to cool down and get completely solidified for high quality finish of the 3D model.

The PBF techniques are comparatively less costly and also being a powder based method do not need use of support structures while making the models or parts. A large range of materials including ceramics, glass, plastics, metals and alloys can be used to make 3D objects using PBF techniques. However, the PBF methods have slow operational speeds and models created have size limitations. As the process involves melting of the building material, power consumption of PBF machines is quite high. The quality of the models created depends largely on the size of the powder grain and not all structural characteristics desired for a functional model can be achieved. That is why, the PBF technique is usually limited to prototyping applications.