



CAPITAL UNIVERSITY - KODERMA

BASIC MANUFACTURING PROCESS ASSIGNMENT

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### Q1

Manufacturing Process is one of the main parts of the production process. It is that process which involves the changes of sizes/dimensions or shape of the part. Transportation or material storage is not a part of the manufacturing process. Manufacturing process classified into following processes.

1. Primary shaping process.
2. Secondary shaping process or machine process.
3. Metal forming process.
4. Joining process.
5. Surface finishing.
6. Processes that involve the changes in the material properties.

### Q3

Primary shaping process is used to give the amorphous material a well-defined shape. Some of the primary shaping processes produce final products and other needs additional machining works. Primary shaping process involves casting process, plastic forming technology, powder metallurgy, bending of the metals, forging and gas cutting and many more. For example, in casting technology, the molten metal is needed to be poured on the moulds and it needs to cool down. Afterwards, the cooled metal object may need some extra machining through grinding or lathe machine or some milling operation.

### Q4:

Machining process

Machining is one of the processes of making the primary shapes into finished goods. The components or parts are subjected to machine shops for finishing. It is used to give desired shape and size to the cylindrical and flat objects. The process to remove unwanted materials from the jobs using cutting tools is known as machining. The purpose is to give perfect

dimension and desired shape. Machines used for these operations include lathe, milling, drilling, shaper, planner etc. The materials subjected to machining operations include the shapes of a bar, rod, tubes and flat surfaces. For greater dimensional accuracy and surface finish the machining processes are important. They also provide the good surface finish. At the time of machining different multi-point cutting tools, jigs and fixtures and measuring devices are used. Machining produces a lot of waste metals in the form of chips. These days CNC machining is used for better accuracy and quick machining. Turning, knurling, parting, facing, boring, reaming, slotting, punching, threading, milling, gear cutting are some of the metal removing processes.

## Q5

Joining is a process we are using in our everyday life frequently. Different sub-assemblies are joined together to get a completely assembled product. In fabrication process joining is used frequently. In manufacturing or fabrication, two or more metal parts are put together and joined by means of fusion, riveting, screwing, applying pressure and rubbing. These joining processes are needed to make air-tight joints and semi-permanent and permanent fasteners. These joining techniques are very important in making bigger assemblies. For example, an aeroplane is assembled by putting together more than a thousand subassemblies. The joining process includes different types of welding, soldering and brazing, riveting and screwing, pressing, nut and bolt joints etc.

Surface finishing is a process which is applied to get the desired levelling of the surface and also to obtain the desired smoothness. Very negligible amount of the materials is removed from the surface by this process and does not involve any effective change in the dimensions. It is not an effective metal removing process and should not be confused with the machining process. Putting some kind of coating over the metal is also a surface finishing process. Various surface finishing processes include honing, lapping, super finishing, sanding, debarring, electroplating, buffing, painting, anodizing, galvanizing etc. Sherardizing, Parkerizing, plastic coating or metal spraying is also known as one kind of surface-finishing process. Surface finishing provides excellent finishing of the metal surface and at the same time gives good protection from the environmental contaminants.

Different properties of the same metal are desired for different applications. So metal property is needed to be changed in those cases. Material property change may include improved hardness, greater ductility, durability etc. For some particular uses or operations, suitable properties are needed to be incorporated. Some operations need softer material, some need harder. The properties of the materials change when the total grain size of the materials are regrouped or reorganized. Different grain conditions provide different properties. The grain sizes are changed by the application of different heat treatments. By heat treatments, the internal structure of the material is changed. And they achieve different improved properties. common heat treatment methods include –annealing, hardening, case hardening, normalizing, grain refining, tempering and age hardening etc.

### **Q9:**

Manufacturing processes are assembled together to form a manufacturing system (MS) to produce a desired set of goods. The manufacturing system takes specific inputs, adds value and transforms the inputs into products for the customer. It is important to distinguish between the production system which includes the manufacturing system and services it.

The production system services the manufacturing system using all the other functional areas of the plant for information, design, analysis, and control. These subsystems are connected to each other to produce either goods or services or both.

The use of computers in the manufacturing sector has increased in recent years due to various reasons. One of the main reasons for this is the high demand for manufactured products and the requirement of on time delivery of quality product. Most of the manufacturers have turned to computer integrated (CIM) or computer aided manufacturing (CAM) to improve efficiency, quality and reduce cost , lead time and process time of the product. Computers are today applied in all the aspects of manufacturing operations including, planning, control, scheduling, designing, distribution, processing, marketing, production etc.

In a CIM system functional areas such as design, analysis, planning, purchasing, cost accounting, inventory control, and distribution are linked through the computer with factory floor functions such as materials

handling and management, providing direct control and monitoring of all the operation. CIM is an example of application of Information and Communication Technology (ICT) in the Manufacturing process.

**Q10:**

1. Computer-aided design (CAD) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. Designs made through CAD software are helpful in protecting products and inventions when used in patent applications. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.
2. Computer-aided manufacturing (CAM) also known as Computer-aided Modelling or Computer-aided Machining is the use of software to control machine tools and related ones in the manufacturing of work pieces. This is not the only definition for CAM, but it is the most common; CAM may also refer to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation and storage. Its primary purpose is to create a faster production process and components and tooling with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material (thus minimizing waste), while simultaneously reducing energy consumption. CAM is now a system used in schools and lower educational purposes.
3. A flexible manufacturing system (FMS) is a manufacturing system in which there is some amount of flexibility that allows the system to react in case of changes, whether predicted or unpredicted. This flexibility is generally considered to fall into two categories, which both contain numerous subcategories. The first category is called as Routing Flexibility which covers the system's ability to be changed to produce new product types, and ability to change the order of operations executed on a part. The second category is called Machine Flexibility which consists of the ability to use multiple machines to perform the same operation on a part, as well as the system's ability to absorb large-scale changes, such as in volume, capacity, or capability.

4. Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control entire production process. This integration allows individual processes to exchange information with each part. Manufacturing can be faster and less error-prone by the integration of computers. Typically CIM relies on closed-loop control processes based on real-time input from sensors. It is also known as flexible design and manufacturing.

5. Numerical control (also computer numerical control, and commonly called CNC) is the automated control of machining tools (such as drills, lathes, mills and 3D printers) by means of a computer. A CNC machine processes a piece of material (metal, plastic, wood, ceramic, or composite) to meet specifications by following a coded programmed instruction and without a manual operator directly controlling the machining operation.

6. Manufacturing resource planning (MRP) is defined as a method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning, and has a simulation capability to answer “what-if” questions and is an extension of closed-loop MRP (Material Requirements Planning). This is not exclusively a software function, but the management of people skills, requiring a dedication to database accuracy, and sufficient computer resources. It is a total company management concept for using human and company resources more productively.

**Q11:**

Group technology or GT 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. Group technology is based on a general principle that many problems are similar and by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort. The group of similar parts is known as part family and the group of machineries used to process an individual part family is known as machine cell. It is not necessary for each part of a part family to be processed by every machine of corresponding machine cell. This type of manufacturing in which a part family is produced by a machine cell is known as cellular manufacturing.

**Q16:**

The advantages of CAD systems over manual drafting are the capabilities one often takes for granted from computer systems today; automated generation of bills of materials, auto layout in integrated circuits, interference checking, and many others. Eventually, CAD provided the designer with the ability to perform engineering calculations. During this transition, calculations were still performed either by hand or by those individuals who could run computer programs. CAD was a revolutionary change in the engineering industry, where draftsmen, designers, and engineering roles begin to merge. It did not eliminate departments as much as it merged departments and empowered draftsmen, designers, and engineers. CAD is an example of the pervasive effect computers were beginning to have on the industry.

**Q17:**

The advantages of CAM

Using CAM has a number of benefits when it comes to creating components used in building construction. Compared to manually operated machines, CAM generally offers:

1. Greater speed in producing components.
2. Greater accuracy and consistency, with each component or finished product exactly the same.
3. Greater efficiency as computer controlled machines do not need to take breaks.
4. High sophistication in terms of following complex patterns like tracks on circuit boards.

**Q18:**

The advantages of FMS are:

- Reduced manufacturing cost.
- Lower cost per unit produced.
- Greater labour productivity.
- Greater machine efficiency.
- Improved quality.

Increased system reliability, reduced parts inventories.

Shorter lead times, improved efficiency, Increase production rate.

**Q19:**

The advantages of manufacturing production scheduling include:

Process change-over reduction.

Inventory reduction, levelling.

Reduced scheduling effort.

Increased production efficiency.

Labour load levelling.

Accurate delivery date quotes.

Real time information.

**Q20:**

The advantages of MRP are:

Better control of inventories.

Improved scheduling.

Productive relationships with suppliers.

For design / engineering.

Improved design control.

Better quality and quality control.

For financial and costing:

Reduced working capital for inventory.

Improved cash flow through quicker deliveries.

Accurate inventory records.

**Q21:**

The advantages of CIM are:

1. Reducing inventory and work-in-progress: This can be accomplished through the utilization of an MRP or ERP system. Careful and reliable



material purchasing planning and production planning can to a great extent eliminate high inventory and work-in-progress level, hence reducing capital overstock and even waste through long-term material storage.

2. Improving production efficiency: Through the integration of a production system, planning system, and material supply system, the production processes can be operated in a well-organized way and hence production can be carried out with the shortest possible waiting times and machine utilization greatly increased. Through the integration of CAD, CAPP, and CAM systems, the setup time for NC machines can be reduced significantly. The improvement of production efficiency will bring economic returns from investment in the CIM system.

3. Improving product quality: The integration of the company's business processes, design processes, and production processes will help in improving product quality. TQM can be put into effect in the CIM integrated environment.

4. Reducing cost: This is the direct effect obtained from the above three benefits.

5. Improving product design ability: Through the integration of CAD, CAPP, and CAM systems, by using the current engineering method, the product design ability of the company can be significantly improved. New and improved products can be designed and developed in a shorter time, and the company can win the market competition with these products.

## **Q22:**

Plant layout is the overall arrangement of the production process, store-room, stock-room, tool-room, and material handling equipment, aisles, racks and sub-stores, employee services and all other accessories required for facilitation of the production in the factory. It encompasses production and service facilities and provides for the most effective utilization of the men, materials and machine' constituting the process, it is a master blueprint for coordinating all operations performed inside the factory.

Investment efficiency also requires that manufacturing facilities be able to simultaneously make several products so that smaller volume products can be combined in a single facility and that fluctuations in product mixes and

volumes can be more easily accommodated. In short, manufacturing facilities must be able to exhibit high levels of flexibility and robustness despite significant changes in their operating requirements.

**Q24:**

A good plant layout strives to attain the following objectives:

1. Minimization of material handling.
2. Elimination of bottlenecks through the balancing of plant capacities.
3. High material turnover through a shorter operating cycle.
4. Effective utilization of installed capacity so that the returns on the investments may be maximized.
5. Effective utilization of cubic space in the factory area.
6. Effective utilization of manpower resources through the elimination of idle time.
7. Elimination, improvement or confinement of objectionable operations e.g., operations with bad odour, vibrating operations etc.
8. Elimination of physical efforts required by operative workers.
9. Avoidance of industrial accidents.
10. Better working conditions for the employees like lighting, ventilation, control of noise and vibrations etc.
11. Decency and orderliness inside the plant area.
12. Better customer services through cheaper and better product supplies according to the delivery promises.

**Q25:**

Advantages of plant layout

1. Maintenance and tool replacement costs are reduced.
2. Spoilage and scrap is minimized.
3. Greater saving in the waste of raw material consumption.

- 4.Improved quality of product due to reduction in the number of handling.
- 5.Saving motive power.
- 6.Effective cost control.

### **Q26:**

#### Type of Plant Layout

The popular types of plant layout are:

- 1.Process layout
- 2.Product layout
- 3.Combined layout
- 4.Project layout
- 5.Group layout

#### Process Layout

This type of layout is also called functional layout. All machines performing a similar type of operations are grouped at one location in the process layout e.g., all lathes, milling, machines, cutting machines etc. in the engineering shop are clustered in their like groups. Thus all forging will be done in one area and all the lathes will be placed in another area.

#### Product layout

In this type of layout, the machines are arranged in the sequence as required by the particular product. All machines as required to balance the particular product line are arranged in a sequential line but not necessarily in the straight line. It is also known as “ the product line layout”.The product is dominating over the process, in the sense that the product is given the primary importance and the process machine must remain present at a point where the product needs its services.

#### Combined Layout

Generally pure process or pure product layout is not found in practice. Both process and product layouts are mutually exclusive. Proper compromise reaping the benefits of both the layouts is possible to some extent. So

efforts are made to have the combined layout incorporating the benefits of process and product layout.

### Project Layout

The manufacturing operation require the movements of men, machines and materials. Generally few inputs tend to be static while the others are moving. In the product layout and process layout generally the machines have fixed installations and the operators are static in terms of their specified work stations.

### Group Layout

Here an attempt is made to introduce some of the advantages of a line layout into a situation where pure line layout is not practicable. Here machines are placed in groups. Each machine group makes maximally of parts which require similar treatment. This layout lies between process layout and line layout. It is easier to control than a strictly process layout and has more flexibility into the manufacturing system as regards the batch size variations and the differing operations sequences.

### Q27:

Comparison between Product layout and Process layout.

Product Layout is a type of layout design in which the resources needed to produce the product are arranged in one line, as per the sequence of operations. Process Layout refers to the type of layout design wherein the resources having homogeneous processes or functions are combined together. Product layout are Standardized but Process layout are Customized.

Workflow of product layout are Identical flow and sequence of operations for each unit. While in process layout are variable flow, relying on the nature of the job.

Effect of breakdown in product layout due to the interrelated system, machinery breakdown can seriously affect production, while in process layout Machinery breaks down does not have a significant effect on the final output.

### Q28:

Industrial safety refers to the management of all operations and events within an industry in order to protect its employees and assets by minimizing hazards, risks, accidents, and near misses.

The primary objective of workplace safety programs should be to help prevent workplace injuries, illnesses and fatalities, according to the Office of Disease Prevention and Health Promotion. Employers develop detailed plans that provide guidance in the event of an accident, fire, natural disaster or other emergency.

### **Q29:**

An accident is an unintended, normally unwanted event that was not directly caused by humans. The term accident implies that nobody should be blamed, but the event may have been caused by unrecognized or unaddressed risks

Most researchers who study unintentional injury avoid using the term accident and focus on factors that increase risk of severe injury and that reduce injury incidence and severity. For example, when a tree falls down during a wind storm, its fall may not have been caused by humans, but the tree's type, size, health, location, or improper maintenance may have contributed to the result.

The workplace can be dangerous, even more so in an industrial environment. Numerous factors can cause accidents, ranging from overexertion to mishandling of hazardous materials. There are also a multitude of variables that can contribute to or influence a workplace incident. Following are eight of the most common causes of accidents in the workplace:

#### **Lifting**

Many employees are prone to sprain strain or tear a muscle by virtue of lifting an object that is too heavy for them to lift on their own. Keep in mind that there is no harm in asking for help with objects that are difficult to lift.

#### **Fatigue**

Failing to take a break is another common cause of accidents. In order to recover from grueling manual labor, it is essential that employees take adequate breaks. Not doing so can lead to a slew of physical issues,

including atrophy and general exhaustion. The results of either of these can be far more devastating than taking a 10-minute breather.

### Dehydration

Not staying hydrated can also bring about disastrous consequences. On exceptionally hot summer days, failing to drink adequate amounts of water can cause heat stroke or cardiac conditions. This can be avoided by simply drinking at least eight glasses of water per day. Management should stress the importance of proper hydration and rest, as it maximizes the efforts of personnel.

### Poor Lighting

Inadequate lighting is responsible for a number of accidents each year. This is often overlooked when attempting to prevent accidents in the warehouse or workplace.

### Hazardous Materials

Improper handling of hazardous materials or not wearing personal protective equipment (PPE) is another common cause of accidents in the workplace. By reading material safety data sheets and providing the appropriate protective attire, many workplace incidents can be avoided.

### Acts of Workplace Violence

Sadly, violence among co-workers has become all too common. It is usually brought about by office politics or other sensitive issues. Integrating conflict resolution and peer mediation can help to reduce the risks of such outbursts.

### Trips and Falls

Slick floors and high-traffic corridors can cause a trip or fall. Improper footwear may also contribute to these accidents, which not only can result in injuries but also workman's compensation-related cases.

### Stress

Stress is one of the leading causes of death. It affects the human body in every facet imaginable. Stress can foster negative effects physiologically, emotionally and mentally, as well as debilitate or distract any worker. Therefore, it is essential to encourage a supportive team environment.

**Q30:**

**Methods of Safety adopted in plant are mentioning below**

### **Safety Equipment**

All workers should wear the required safety gear while on the premises. The equipment must also be kept clean and maintained. Wearing loose clothing or jewelry while on the job should be avoided. In addition, people with long hair must keep it tied back when working with moving machinery.

### **Risk Assessment**

To protect yourself and those around you, always be aware of what could go wrong and what you can do to prevent a potentially dangerous situation. Never take unnecessary risks and stay calm if you find yourself in a perilous predicament. Every company should conduct a risk assessment to identify and prevent work hazards. Some organizations choose to have a safety officer with special training to recognize and analyze hazards.

### **Safety Training**

Safety training is essential when working in a plant. Employees must be aware of all safety procedures, especially as they pertain to their specific position. Special training should occur periodically to reduce the risks of accidents.

### **Emergency Evacuation Drills**

Fire and other evacuation drills are an excellent way to help everyone understand the best conduct in case of an emergency. Employees should be familiar with all emergency exits and know where fire extinguishers are kept and how to use them. It's also important to determine which machines must be shut down and which can be left running while evacuating the building.

### **Working with Tools**

All tools should be kept clean and in perfect working condition. Any defects should be immediately reported. Also, no tools should be left in a location not meant for storage.

### **Operating Heavy Machinery**

Machinery should be in full working condition and have all the manufacturer's safety guards installed. Anytime a malfunction or defect is noticed, go straight to the maintenance department and review the instruction manual. Hazardous manual handling continues to be an underrated risk in many industries. If you're not trained properly in the technical aspects of operating certain machinery, don't use it. After your work is done, always remember to shut down the machine.

### **Maintaining Cleanliness**

Keeping your work area clean does wonders when it comes to preventing accidents. A clean and organized area helps to create a better, less stressful work atmosphere. Many factors should be taken into consideration, including proper ventilation and lighting fixtures.

### **Keeping a Clear Head**

Factories can pose a lot of risks, so maintaining a clear head is mandatory. Working under the influence of drugs or alcohol should be forbidden. People who must take certain medications that have side effects should notify their supervisors.

Every company should ensure that its workers are aware of all safety procedures and that the work environment is safe. The rules must apply to everyone, and each breach in following them should be addressed and/or punished. No employee should ever have to worry about working in unsafe conditions, because when it comes to factory work, the consequences can be severe.

### **Q31:**

Material handling is accompanied by numerous risks, especially when done manually. Tasks such as lifting, carrying and pushing can make the workplace unsafe for employees. Material handling injuries can also be quite expensive with medical costs, lost productivity and decreased employee morale. As an organization, you must take preventive measures to minimize injuries and the costs associated with them. Following are six material handling tips that can help.

#### **1. Minimize Ergonomic Risk Factors**

Ergonomic risk factors are those problems that cause unnecessary physical fatigue in employees. These risk factors are commonly found in the manual



material handling environment. Three primary factors include stressful postures while handling materials like bending or twisting, highly repetitive motions such as frequent reaching and lifting, and forceful exertions like carrying or lifting heavy loads. Identify all such ergonomic risk factors and minimize them by putting control measures in place to limit the exposure of employees to all possible risks.

## 2. Personal Protective Equipment

Offering protective equipment to workers will greatly minimize injuries when moving materials manually. Basic protective equipment includes eye protection, helmets, gloves, steel-toed safety boots and metal fiber or plastic metatarsal guards to protect the in-step area from impact or compression.

## 3. Your Equipment

You can minimize manual material handling by upgrading your equipment. Use conveyor belts as well as forklift and conveyor belt scales to move materials rather than carrying them manually. This not only will help to reduce the material handling risks but also increase productivity and profitability.

## 4. Noise and Vibration

Noise and vibration are widespread in many plants, making it imperative to protect your employees' hearing. Vibration causes noise, but it can also lead to work-related musculoskeletal disorders and general employee fatigue. By introducing the right equipment, such as wheel materials, you can greatly decrease noise and vibration. Matching the wheel materials to the floor surface will minimize vibration and noise as well. You can also use shock-dampening casters and softer wheels to reduce noise and g-forces on a wheeled cart.

## 5. Respond to Reports of Employee Fatigue

Physical weariness and fatigue are common occurrences in manual material handling tasks. Regardless of whether you have an excellent ergonomic process that caters to the workers' capabilities, daily manual work can take a toll on your employees' health. Cumulative fatigue eventually will give way to a musculoskeletal disorder. Therefore, you must encourage employees to report any signs of discomfort and fatigue so you can respond quickly and

put control measures in place to prevent fatigue from developing into serious injuries.

## 6. Use the Right Equipment

Manual material handling is risky, time-consuming and laborious. By choosing the right equipment, you can make the process safer, faster and efficient. Conveyor belt systems offer numerous benefits for handling weight loads of various sizes and styles. Material handling equipment is also available in the form of storage equipment (shelves, racks and pallets) and bulk material equipment (trucks, silos, drums and grain elevators). Designate and train the appropriate individuals on the correct procedures and verify that they always follow the rules. Regardless of the size of the equipment and the simplicity of using it, ensure that only authorized and trained individuals operate it.

### Q32:

The Factories Act, 1948, has been promulgated primarily to provide safety measures and to promote the health and welfare of the workers employed in factories. The object thus brings this Act, within the competence of the Central Legislature to enact. State Governments/Union Territory Administrations have been empowered under certain provisions of this Act, to make rules, to give effect to the objects and the scheme of the Act.

### Section 21: Fencing the Machinery

This section states that the factory should fence the following machinery or substantial construction and maintain them in the right position:

- (a) every moving part of a prime-mover and every flywheel, whether the prime-mover or flywheel is in the engine-house or not.
- (b) the headrace and tailrace of every water-wheel and water-turbine.  
any part of a stock bar which projects beyond the headstock of a lathe.
- (d) every part of an electric generator, a motor or rotary converter.  
every part of transmission machinery.
- (f) every dangerous part of any other machinery.

### Section 22: Work on or Near Machinery in Motion

This section states:

- (a) Firstly, whenever machinery is in motion and it becomes necessary to do the inspection, lubrication, repairs, etc., the factory should appoint a specially trained expert man, wearing tight-fitting clothes to do the job.

Moreover, such worker shall not handle a belt at a moving pulley unless:

1. the belt is not more than fifteen centimeters in width
2. the belt, including the joint and the pulley rim, is in good repair
3. there is reasonable clearance between the pulley and any fixed plant or structure
4. the pulley is normally for the purpose of the drive

- (b) Secondly, the factory owners should not allow any woman or young person to clean, lubricate or adjust any part of a prime-mover or of any transmission machinery while prime-mover or transmission machinery is in motion.

#### Section 23: Employment on Dangerous Machines

This section states that the factory owners or managers cannot allow any worker to work any machine without instructing him/her about the dangerous outcomes and the relevant precautions. Moreover, before the appointment, the manager has to see that the worker has relevant skills and knowledge to work on the machinery.

#### Section 24: Devices for Cutting off Power

This section states:

- (a) In every factory, there should be suitable devices for cutting off power in emergencies from running machinery in all the workrooms. In the case of factories which do not belong to this Act have to just do the arrangements in the workroom in which electricity is used to generate power.
- (b) The factory should provide and maintain suitable striking gear or other efficient mechanical appliance to move driving belts.

© Driving belts when not in use shall not be allowed to rest.

#### Section 25: Self-Acting Machinery

This section states that no factory should allow any traversing part of a self-acting machine in any factory to run within a distance of forty-five centimeters from any fixed structure which is not part of the machine.

#### Section 26: Casing of New Machinery

In all machinery driven by power and installed in any factory after the commencement of this Act,-

- (a) every set screw, bolt or key on any revolving shaft, spindle, wheel shall be so sunk, encased or otherwise effectively guarded as to prevent danger;
- (b) all spur, worm and other toothed or friction gearing which does not require frequent adjustment while in motion shall be completely encased, unless it is so situated as to be as safe as it would be if it were completely encased.

#### Section 27: Prohibition of Employment of Women and Children Near Cotton-Openers

This section states that the factory should not employ any woman or child in any part of a factory for pressing cotton in which a cotton-opener is at work.

### **Q34:**

#### 1. Conduct a Hazard Analysis

A Dust Hazard Analysis (DHA) is one requirement of NFPA 652, known as the Standard on the Fundamentals of Combustible Dust. It is a tool meant to help improve industrial plant safety by determining combustible dust hazards, so that facility owners and managers can improve their industrial fire safety.

While it is a standard specified for NFPA 652, a DHA is useful for inspecting the entire facility for hazards. It will help to pinpoint what areas of the facility pose the greatest risks in safety, and help determine how to improve and eliminate those risks which will allow you to make your facility safer and help avoid serious fines and penalties from OSHA.

#### 2. Employees in Fire Safety

Training, in general, is critical for employee safety, and especially to help avoid industrial fires. Industrial fire safety training should include general and job-specific safety. Employees should be educated in:

- Causes of fires and explosions
- How they spread
- Spotting hazards
- Handling and storing flammable materials.
- How to prevent fires

Fire prevention should also cover the proper cleaning techniques to ensure that materials like combustible dust do not linger where they can pose a danger. Fire safety training should also include what to do in case of a fire, from extinguishing to safe evacuation of all personnel.

### 3. Practice Good Housekeeping

The fire safety industry also states that good housekeeping is essential in preventing fires and explosions. OSHA has Good Housekeeping Guidelines that facilities are required to follow by law. These guidelines are for maintaining a clean, safe and sanitary facility. They include:

- Keeping paper and other flammable goods away from electrical and heat sources.
- Keeping flammable products safely contained.
- Reporting problems or issues with equipment as soon as possible.

Since housekeeping guidelines are mandatory, failure to comply can result in serious fines.

### 4. Establish a Fire Prevention Plan and Emergency Procedures

It is critical to have a fire prevention plan and emergency fire procedures in place. An industrial fire safety plan needs to cover everything fire-related, and all employees must be educated in the prevention and emergency plans.

It should include a detailed evacuation plan that explains what employees should do and where they should go in case of an industrial fire. The plan should be accessible to everyone, and it should be practiced so that employees can better understand what they should do in such situations.

It is also vital to keep these plans and procedures up-to-date and always update employees on the procedures.

### 5. Inspect and Maintain Your Equipment and Facility

Poorly maintained equipment is a large factor in industrial fires and explosions. A major part of what the fire safety industry calls for is inspecting and maintaining all equipment within the facility.

Regularly scheduled checks and maintenance need to be done to ensure the equipment works properly and efficiently. Any motors or moving parts should be lubricated to ensure there is no friction that can lead to sparking and fires.

Inspections should be done at least twice a year or more, for frequently used equipment and it should cover all parts of the facility, including sprinklers and fire extinguishers. Any needed repairs should be done immediately.

### **Q35:**

Being a first aider, therefore, carries a range of different and incredibly important responsibilities. If you are a trained first aider and you think someone needs your help, there are numerous responsibilities that you should adhere to.

- Assess the situation quickly and calmly to get an understanding of what happened. This involves determining whether anyone is in danger, the cause of the situation, and how many people are affected.
- Comfort, reassure, stay calm and take charge. You should introduce yourself to the casualty, explain what's happening and why, and explain what you're going to do before you do it.
- Protect yourself and the casualty from any danger. You should always protect yourself first and only move the casualty if leaving them would cause more harm. If you are unable to make an area safe, call 108 for emergency help.
- Prevent infection between you and them. You should wash your hands or use hand sanitiser, wear disposable gloves, and not cough or sneeze over a casualty.
- Assess the casualty. If there are multiple casualties, you must help those with life-threatening injuries or conditions first.
- Give first aid treatment, such as CPR or applying pressure to bleeding wounds. Life-threatening injuries and conditions must be prioritised before giving treatment to less serious cases.

- Arrange for the right kind of help. Call 108 for an ambulance if it's serious, or take/send them to a hospital if it's serious but unlikely to get any worse. For less serious conditions, suggest they see a doctor if they are concerned or if the condition worsens. You should always stay with them until you can leave them in the right care.

### Q36:

#### Classification of Engineering Material

Depending upon the nature of substance materials are classified as:

Metals and alloys

Ferrous metals

Non ferrous metals

Non metals

Ceramics

Polymers

Composites

Semi conductors

Bio materials

Metallic materials are combination of metallic elements.

The most prominent property of metals is electrons are non localized i.e. in atomic arrangement outer valency electrons do not belong to individual atom rather it belong to whole bulk of material. Non localized electron is free to carry charge to conduct electricity. Hence they are good conductors for electrical and thermal charge.

Metals have lustrous appearance. At normal temperature majority of the materials are in solid state, but some metals like mercury lies in liquid state.

Based upon the presence of iron content metals are named as

Ferrous metals

Non ferrous metals

## Ferrous metals

The primary content of ferrous metals is iron and carbon. Ferrous metals are magnetic and are vulnerable to rust when exposed to moisture. Wrought iron won't rust due to purity and stainless steel due to presence of chromium.

Eg : iron, steel, etc.

Due to their magnetic property ferrous metals are used in motor and electrical applications.

## Non Ferrous Metals

Iron is not primary content. Due to the non presence of iron these metals have high resistance to rust and corrosion and they are non magnetic.

Eg: copper, brass, aluminium, tungsten, lead, zinc, gold, etc.

## Alloy

Alloy is a combination of two or more metals. It is named based on metallic bonding character. It is of two types' ferrous metal alloy and non ferrous metal alloy. Cast iron is an alloy made from iron, carbon and silicon. Brass is an alloy of copper and zinc.

## CERAMICS

A particle or fibrous which are used in terms of making ceramic products. Ceramics have regular atomic structure and crystal structure. Ceramics are mainly oxides, nitrides and carbides. They are non conducting materials, due to its insulating property they are used as insulators. They are very hard and brittle in nature.

## POLYMERS

Polymers have chain molecule structure of carbon as back bone atoms. They are mainly made up of tough organic materials. They are low density materials and also flexible. In some cases polymers are not flexible.

Eg : polyester as fibers, phenolics and epoxides as resins.

Elastomers are also polymers but they are considered separately due to their specific design for certain purposes like shock and vibration absorption.



Natural polymers:

Eg : wool, silk, DNA, cellulose, proteins, etc.

Synthetic polymers:

Thermo plastics

Thermosetting plastics

Eg: nylon, polyethylene, polyester, Teflon, epoxy, Bakelite, etc.

## COMPOSITE

Composite material is the composition of two or more constituent materials with different physical and chemical properties to produce a different characteristic Material.

Composite material may be both metals or metal and ceramic or metal and polymer, depending upon the application requirement the combination is made.

Eg : wood, concrete, fiber glass, CFRP (carbon fiber reinforced plastic), GFRP (glass fiber reinforced plastic), etc.

## SEMICONDUCTORS

Semiconductor is an intermediate conducting material. Their conductivity is not high as like metals and low as like insulating ceramic materials. In these materials resistance decreases as their temperature increases. The unique atomic structure allows to control the conductivity. Eg : silicon, germanium, gallium arsenide, selenium, etc.

## BIO MATERIALS:

Bio materials are non-viable materials .Eg : alumina, zirconia, titanium, tantalum, niobium, carbon, etc.

## Q37:

Ferrous metals	Non Ferrous metals
Ferrous indicates the presence of iron in a bivalent state.	Non-ferrous metals do not contain any iron.
As ferrous contains iron, it shows magnetic feature.	Non-ferrous metals don't show any magnetic feature which means it's non-magnetic.

Ferrous metals are less resistant to corrosion.	Non-ferrous metals are more resistant to corrosion.
One special feature of ferrous metals is it possesses high tensile strength and durability.	One special feature of non-ferrous metals is their malleability.
Some ferrous metals are vehicle scrap metal, demolition site scrap metal, metal offcuts from manufacturing industries.	Some non-ferrous metals are- aluminum and aluminum alloys, copper, brass, lead, zinc, stainless steel, electronic cable etc.

### Q38:

The ores are usually rich in iron oxides and vary in color from dark grey, bright yellow, or deep purple to rusty red. The iron is usually found in the form of Magnetite ( $\text{Fe}_3\text{O}_4$ , 72.4% Fe), Hematite ( $\text{Fe}_2\text{O}_3$ , 69.9% Fe), Goethite ( $\text{FeO}(\text{OH})$ , 62.9% Fe), Limonite ( $\text{FeO}(\text{OH}) \cdot n(\text{H}_2\text{O})$ , 55% Fe) or Siderite ( $\text{FeCO}_3$ , 48.2% Fe).

#### Magnetite

Magnetite is a mineral and one of the main iron ores, with the chemical formula  $\text{Fe}_3\text{O}_4$ . It is one of the oxides of iron, and is ferrimagnetic; it is attracted to a magnet and can be magnetized to become a permanent magnet itself. It is the most magnetic of all the naturally occurring minerals on Earth. Naturally magnetized pieces of magnetite, called lodestone, will attract small pieces of iron, which is how ancient peoples first discovered the property of magnetism.

Magnetite is black or brownish-black with a metallic luster, has a Mohs hardness of 5–6 and leaves a black streak. Small grains of magnetite are very common in igneous and metamorphic rocks.

#### Hematite

Hematite also spelled as haematite, is a common iron oxide compound with the formula,  $\text{Fe}_2\text{O}_3$  and is widely found in rocks and soils. Hematite crystals belong to the rhombohedral lattice system which is designated the alpha polymorph of  $\text{Fe}_2\text{O}_3$ . It has the same crystal structure as corundum ( $\text{Al}_2\text{O}_3$ ) and ilmenite ( $\text{FeTiO}_3$ ). With this it forms a complete solid solution at temperatures above  $950^\circ\text{C}$  ( $1,740^\circ\text{F}$ ).

Hematite naturally occurs in black to steel or silver-gray, brown to reddish-brown, or red colors. It is mined as an important ore of iron. It is electrically conductive. Hematite varieties include kidney ore, martite (pseudomorphs after magnetite), iron rose and specularite (specular hematite). While these forms vary, they all have a rust-red streak. Hematite is not only harder than pure iron, but also much more brittle. Maghemite is a polymorph of hematite ( $\gamma\text{-Fe}_2\text{O}_3$ ) with the same chemical formula, but with a spinel structure like magnetite.

### Goethite

Goethite is a mineral of the diaspore group, consisting of iron(III) oxide-hydroxide, specifically the “ $\alpha$ ” polymorph. It is found in soil and other low-temperature environments such as sediment.

Its main modern use is as an iron ore, being referred to as brown iron ore. It does have some use as a clay earth pigment. Iron-rich lateritic soils that have developed over serpentinite rocks in tropical climates are mined for their iron content, as well as other metals. Fine goethite specimens are rare and therefore are valued collectibles. Banded or iridescent varieties are cut and polished into cabochons for jewelry making.

### Limonite

Limonite is an iron ore consisting of a mixture of hydrated iron(III) oxide-hydroxides in varying composition. The generic formula is frequently written as  $\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$ , although this is not entirely accurate as the ratio of oxide to hydroxide can vary quite widely.

One of the first uses was as a pigment. The yellow form produced yellow ochre for which Cyprus was famous, while the darker forms produced more earthy tones. Roasting the limonite changed it partially to hematite, producing red ochres, burnt umbers and siennas. Bog iron ore and limonite mudstones are mined as a source of iron, although commercial mining of them has ceased in the United States.

Iron caps or gossans of siliceous iron oxide typically form as the result of intensive oxidation of sulfide ore deposits. These gossans were used by prospectors as guides to buried ore. In addition the oxidation of those sulfide deposits which contained gold, often resulted in the concentration of gold in the iron oxide and quartz of the gossans.

**Q39:**

Both steel and cast iron are two forms of iron alloys. Cast iron is cheaper than most steels. Also, the melting temperature of cast iron is lower compared to steel, but it has high compressive strength, high hardness, and high wear resistance. Therefore, the key difference between steel and cast iron is that the steel is ductile and malleable whereas the cast iron is hard and has high compressive strength.

As another important difference between steel and cast iron, we can say that carbon in steel is in the form of iron carbide while the carbon in cast iron is in the form of graphite or iron carbide or both. Furthermore, cast iron has excellent fluidity, which steel does not have.

**Q40:**

Cast Iron contains small percentages of silicon, sulphur, manganese and phosphorous. The effect of these impurities on the cast iron are as follows:

**Silicon:** It may be present in cast iron upto 4%. It provides the formation of free graphite which makes the iron soft and easily machinable. It also produces sound castings free from blow-holes, because of its high affinity for oxygen.

**Sulphur:** It makes the cast iron hard and brittle. Since too much sulphur gives unsound casting, therefore, it should be kept well below 0.1% for most foundry purposes.

**Manganese:** It makes the cast iron white and hard. It is often kept below 0.75%. It helps to exert a controlling influence over the harmful effect of sulphur.

**Phosphorus:** It aids fusibility and fluidity in cast iron, but induces brittleness. It is rarely allowed to exceed 1%. Phosphoric irons are useful for casting of intricate design and for many light engineering castings when cheapness is essential.

**Q4:**

Wrought iron is an iron alloy with very low carbon content with respect to cast iron. It is soft, ductile, magnetic, and has high elasticity and tensile strength. It can be heated and reheated and worked into various shapes.

Although wrought iron exhibits properties that are not found in other forms of ferrous metal, it lacks the carbon content necessary for hardening through heat treatment. Wrought iron may be welded in the same manner as mild steel, but the presence of oxides or inclusions will provide defective results. The following sections will discuss wrought iron in more detail.

### Chemical Composition

The chemical composition of wrought iron is outlined in the following table.

Element	Content (%)
Iron, Fe	99-99.8
Carbon, C	0.05-0.25
Phosphorus, P	0.05-0.2
Silicon, Si	0.02-0.2
Sulphur, S	0.02-0.1
Manganese, Mn	0.01-0.1

### Physical Properties

The following table shows the physical properties of wrought iron.

Properties	Metric	Imperial
Density	7.7 g/cm <sup>3</sup>	0.278 lb/in <sup>3</sup>
Melting point	1540°C	2800°F

### Mechanical Properties

The mechanical properties of wrought iron are displayed in the following table.

Properties	Metric	Imperial
Tensile strength	234-372 MPa	34000-54000 psi
Yield strength	159-221 MPa	23000-32000 psi
Modulus of elasticity	193100 MPa	28000 ksi

### Applications

The following are the list of applications of wrought iron:

Decorative items such as railings, outdoor stairs, fences and gates.

Nuts and bolts

Handrails

#### **Q42:**

Carbon steel is a steel with carbon content from about 0.05 up to 2.1 percent by weight. The definition of carbon steel from the American Iron and Steel Institute (AISI) states:

No minimum content is specified or required for chromium, cobalt, molybdenum, nickel, niobium, titanium, tungsten, vanadium, zirconium, or any other element to be added to obtain a desired alloying effect.

The specified minimum for copper does not exceed 0.40 per cent or the maximum content specified for any of the following elements does not exceed the percentages noted: manganese 1.65 per cent; silicon 0.60 per cent; copper 0.60 per cent.

Types of Plain Carbon steel

Low-carbon steel

Low-carbon steel is the most widely used form of carbon steel. These steels usually have a carbon content of less than 0.25 wt.%. They cannot be hardened by heat treatment (to form martensitic) so this is usually achieved by cold work.

Carbon steels are usually relatively soft and have low strength. They do, however, have high ductility, making them excellent for machining, welding and low cost.

High-strength, low-alloy steels (HSLA) are also often classified as low-carbon steels, however, also contain other elements such as copper, nickel, vanadium and molybdenum. Combined, these comprise up to 10 wt.% of the steel content. High-strength, low-alloy steels, as the name suggests, have higher strengths, which is achieved by heat treatment. They also retain ductility, making them easily formable and machinable. HSLA are more resistant to corrosion than plain low-carbon steels.

Applications

Carbon steels are often used in automobile body components, structural shapes (I-beams, channel and angle iron), pipes, construction and bridge components, and food cans.

#### Medium-carbon steel

Medium-carbon steel has a carbon content of 0.25 – 0.60 wt.% and a manganese content of 0.60 – 1.65 wt.%. The mechanical properties of this steel are improved via heat treatment involving austenitising followed by quenching and tempering, giving them a martensitic microstructure.

Heat treatment can only be performed on very thin sections, however, additional alloying elements, such as chromium, molybdenum and nickel, can be added to improve the steels ability to be heat treated and, thus, hardened.

Hardened medium-carbon steels have greater strength than low-carbon steels, however, this comes at the expense of ductility and toughness.

#### Applications

As a result of their high strength, resistance to wear and toughness, medium-carbon steels are often used for railway tracks, train wheels, crankshafts, and gears and machinery parts requiring this combination of properties.

#### High-carbon steel

High-carbon steel has a carbon content of 0.60– 1.25 wt.% and a manganese content of 0.30 – 0.90 wt.%. It has the highest hardness and toughness of the carbon steels and the lowest ductility. High-carbon steels are very wear-resistant as a result of the fact that they are almost always hardened and tempered.

Tool steels and die steels are types of high-carbon steels, which contain additional alloying elements including chromium, vanadium, molybdenum and tungsten. The addition of these elements results in the very hard wear-resistant steel, which is a result of the formation of carbide compounds such as tungsten carbide (WC).

#### Applications

Due to their high wear-resistance and hardness, high-carbon steels are used in cutting tools, springs high strength wire and dies.

### Q43:

Alloy steel is steel that is alloyed with a variety of elements in total amounts between 1.0% and 50% by weight to improve its mechanical properties. Alloy steels are broken down into two groups: low alloy steels and high alloy steels.

Strictly speaking, every steel is an alloy, but not all steels are called “alloy steels”. The simplest steels are iron (Fe) alloyed with carbon (about 0.1% to 1%, depending on type). However, the term “alloy steel” is the standard term referring to steels with other alloying elements added deliberately in addition to the carbon. Common alloyants include manganese (the most common one), nickel, chromium, molybdenum, vanadium, silicon, and boron. Less common alloyants include aluminium, cobalt, copper, cerium, niobium, titanium, tungsten, tin, zinc, lead, and zirconium.

The following is a range of improved properties in alloy steels (as compared to carbon steels): strength, hardness, toughness, wear resistance, corrosion resistance, hardenability, and hot hardness. To achieve some of these improved properties the metal may require heat treating.

Some of these find uses in exotic and highly-demanding applications, such as in the turbine blades of jet engines, and in nuclear reactors. Because of the ferromagnetic properties of iron, some steel alloys find important applications where their responses to magnetism are very important, including in electric motors and in transformers.

By definition, steel is a combination of iron and carbon. Steel is alloyed with various elements to improve physical properties and to produce special properties such as resistance to corrosion or heat. Specific effects of the addition of such elements are outlined below:

#### Carbon

The most important constituent of steel. It raises tensile strength, hardness, and resistance to wear and abrasion. It lowers ductility, toughness and machinability.

#### Chromium (CR)

Increases tensile strength, hardness, hardenability, toughness, resistance to wear and abrasion, resistance to corrosion, and scaling at elevated temperatures.



### Cobalt (CO)

Increases strength and hardness and permits higher quenching temperatures and increases the red hardness of high speed steel. It also intensifies the individual effects of other major elements in more complex steels.

### Columbium (CB)

Used as stabilizing elements in stainless steels. Each has a high affinity for carbon and forms carbides, which are uniformly dispersed throughout the steel. Thus, localized precipitation of carbides at grain boundaries is prevented.

### Copper (CU)

In significant amounts is detrimental to hot-working steels. Copper negatively affects forge welding, but does not seriously affect arc or oxyacetylene welding. Copper can be detrimental to surface quality. Copper is beneficial to atmospheric corrosion resistance when present in amounts exceeding 0.20%. Weathering steels are sold having greater than 0.20% Copper.

### Manganese (MN)

A deoxidizer and degasifier and reacts with sulfur to improve forgeability. It increases tensile strength, hardness, hardenability and resistance to wear. It decreases tendency toward scaling and distortion. It increases the rate of carbon-penetration in carburizing.

### Molybdenum (MO)

Increases strength, hardness, hardenability, and toughness, as well as creep resistance and strength at elevated temperatures. It improves machinability and resistance to corrosion and it intensifies the effects of other alloying elements. In hot-work steels and high speed steels, it increases red-hardness properties.

### Nickel (NI)

Increases strength and hardness without sacrificing ductility and toughness. It also increases resistance to corrosion and scaling at elevated temperatures when introduced in suitable quantities in high-chromium (stainless) steels.

### Phosphorus (P)

Increases strength and hardness and improves machinability. However, it adds marked brittleness or cold-shortness to steel.

### Silicon (SI)

A deoxidizer and degasifier. It increases tensile and yield strength, hardness, forgeability and magnetic permeability.

### Sulfur (S)

Improves machinability in free-cutting steels, but without sufficient manganese it produces brittleness at red heat. It decreases weldability, impact toughness and ductility.

### Tantalum (TA)

Used as stabilizing elements in stainless steels. Each has a high affinity for carbon and forms carbides, which are uniformly dispersed throughout the steel. Thus, localized precipitation of carbides at grain boundaries is prevented.

### Titanium (TI)

Used as stabilizing elements in stainless steels. Each has a high affinity for carbon and forms carbides, which are uniformly dispersed throughout the steel. Thus, localized precipitation of carbides at grain boundaries is prevented.

### Tungsten (W)

Increases strength, wear resistance, hardness and toughness. Tungsten steels have superior hot-working and greater cutting efficiency at elevated temperatures.

### Vanadium (V)

Increases strength, hardness, wear resistance and resistance to shock impact. It retards grain growth, permitting higher quenching temperatures. It also enhances the red-hardness properties of high-speed metal cutting tools.

**Q44:**

**Alloy steel and their classification:** Steel alloys have traditionally been used in applications where strength and stiffness are of much greater importance than weight reduction. Steel alloys can be found anywhere from buildings to bridges to ships to home appliances. The first steel alloys were discovered when iron was refined in such a way as to add carbon into the final product, strengthening it immensely.

#### Low Alloy Steel

Usually iron base alloys, which can be hardened to high strength. A common steel alloy for use in the 180 to 200 ksi (1 ksi = 1000 psi) strength range is AISI 4130. Another type is AISI 4340, with a strength range from 200 ksi to 280 ksi, which is used in the 260 to 280 ksi range. A very high strength alloy in this family is 300M, which can be used up to 290 ksi. It is used for landing gears, and in high strength applications. This family of steels is very corrosion prone, and must be plated in order to avoid corroding in most environments.

Inexpensive steel alloy used in landing gear, especially on general aviation airplanes. Little corrosion resistance.

**Martensitic Stainless Steel** – Steel alloys with 12% to 18% Chromium, with no nickel and are heat treatable by quench and temper. Maximum strength ranges are 140 ksi – 230 ksi for the 410 and 420 series, and 275 ksi – 285 ksi for 440C series. Some typical uses of these alloys are in cutlery and in turbine blades. This is the least corrosion resistant of the stainless steels, and should be considered only for mild environments like household use, aerospace usage away from the ocean, etc.

Precipitation hardened stainless steel used in airframe and marine applications where high strength and corrosion resistance are desirable.

#### **Q45:**

Brass is an alloy of copper and zinc, in proportions which can be varied to achieve varying mechanical, electrical, and chemical properties. It is a substitutional alloy: atoms of the two constituents may replace each other within the same crystal structure.

Brass is similar to bronze, another alloy containing copper that uses tin instead of zinc. Both bronze and brass also may include small proportions of

a range of other elements including arsenic, lead, phosphorus, aluminum, manganese, and silicon.

The composition of brass, generally 66% copper and 34% zinc, makes it a favorable substitute for copper based jewelry, as it exhibits greater resistance to corrosion. Brass is often used in situations in which it is important that sparks not be struck, such as in fittings and tools used near flammable or explosive materials.

### **Properties**

Brass is more malleable than bronze or zinc. The relatively low melting point of brass (900 to 940 °C, 1,650 to 1,720 °F, depending on composition) and its flow characteristics make it a relatively easy material to cast. By varying the proportions of copper and zinc, the properties of the brass can be changed, allowing hard and soft brasses. The density of brass is 8.4 to 8.73 g/cm<sup>3</sup> (0.303 to 0.315 lb/cu in).

Today, almost 90% of all brass alloys are recycled. Because brass is not ferromagnetic, it can be separated from ferrous scrap by passing the scrap near a powerful magnet. Aluminium makes brass stronger and more corrosion-resistant. Aluminium also causes a highly beneficial hard layer of aluminium oxide (Al<sub>2</sub>O<sub>3</sub>) to be formed on the surface that is thin, transparent, and self-healing. Tin has a similar effect and finds its use especially in seawater applications (naval brasses). Combinations of iron, aluminium, silicon, and manganese make brass wear- and tear-resistant. Notably, the addition of as little as 1% iron to a brass alloy will result in an alloy with a noticeable magnetic attraction

### **Applications**

#### **Free Cutting Brass**

Alloy C-360 brass, also called “free cutting brass,” is alloyed with copper, zinc, and lead.

Nuts, Bolts, Threaded Parts, Terminals, Jets, Taps, Injectors, Valve Bodies, Balance Weights, Pipe or Water Fittings.

#### **Gilding Metal (Red Brass)**

Gilding metal is a form of brass that is made up of 95% copper and 5% zinc.

Architectural fascias Grillwork, Jewelry, Ornamental Trim, Badges, Door Handles, Marine Hardware, Primer Caps, Pen, Pencil and Lipstick Tubes.

#### Arsenical Brass

Arsenical brass (C26000, C26130 or 70/30 brass) contains about .03% arsenic to improve corrosion resistance in water.

Heat Exchangers, Drawn and Spun Containers, Radiator Cores, Tubes, and Tanks, Electrical Terminals, Plugs and Lamp Fittings, Locks, Cartridge Casings.

#### High Tensile Brass

High tensile brass is a particularly strong alloy which includes a small percentage of manganese.

Marine Engines, Hydraulic Equipment Fittings, Locomotive Axle Boxes, Pump Casting, Heavy Rolling Mill Housing Nuts, Heavy Load Wheels etc.

#### **Q46:**

Bronze is an alloy consisting primarily of copper, commonly with about 12–12.5% tin and often with the addition of other metals (such as aluminium, manganese, nickel or zinc) and sometimes non-metals or metalloids such as arsenic, phosphorus or silicon. These additions produce a range of alloys that may be harder than copper alone, or have other useful properties, such as strength, ductility, or machinability.

There are many different bronze alloys, but typically modern bronze is 88% copper and 12% tin. Alpha bronze consists of the alpha solid solution of tin in copper. Alpha bronze alloys of 4–5% tin are used to make coins, springs, turbines and blades.

Commercial bronze (90% copper and 10% zinc) and architectural bronze (57% copper, 3% lead, 40% zinc) are more properly regarded as brass alloys because they contain zinc as the main alloying ingredient. They are commonly used in architectural applications.

Silicon bronze has a composition of Si: 2.80–3.80%, Mn: 0.50–1.30%, Fe: 0.80% max., Zn: 1.50% max., Pb: 0.05% max., Cu: balance. Other bronze alloys include aluminium bronze, phosphor bronze, manganese bronze, bell metal, arsenical bronze, speculum metal and cymbal alloys.

#### Properties

Bronzes are typically ductile alloys, considerably less brittle than cast iron. Typically bronze oxidizes only superficially; once a copper oxide (eventually becoming copper carbonate) layer is formed, the underlying metal is protected from further corrosion.

Copper-based alloys have lower melting points than steel or iron and are more readily produced from their constituent metals. They are generally about 10 percent denser than steel, although alloys using aluminium or silicon may be slightly less dense. Bronze is a better conductor of heat and electricity than most steels. The cost of copper-base alloys is generally higher than that of steels but lower than that of nickel-base alloys.

Copper and its alloys have a huge variety of uses that reflect their versatile physical, mechanical, and chemical properties. Some common examples are the high electrical conductivity of pure copper, low-friction properties of bearing bronze (bronze that has a high lead content— 6–8%), resonant qualities of bell bronze (20% tin, 80% copper), and resistance to corrosion by seawater of several bronze alloys.

The melting point of bronze varies depending on the ratio of the alloy components and is about 950 °C (1,742 °F). Bronze is usually nonmagnetic, but certain alloys containing iron or nickel may have magnetic properties.

## Uses

Bronze, or bronze-like alloys and mixtures, were used for coins over a longer period. Bronze was especially suitable for use in boat and ship fittings prior to the wide employment of stainless steel owing to its combination of toughness and resistance to salt water corrosion.

Bronze is still commonly used in ship propellers and submerged bearings.

Bronze parts are tough and typically used for bearings, clips, electrical connectors and springs.

## Q47:

Aluminium alloys (or aluminium alloys; see spelling differences) are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products,

for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

## **Wrought alloys**

The International Alloy Designation System is the most widely accepted naming scheme for wrought alloys. Each alloy is given a four-digit number, where the first digit indicates the major alloying elements, the second if different from 0 indicates a variation of the alloy, and the third and fourth digits identify the specific alloy in the series. For example, in alloy 3105, the number 3 indicates the alloy is in the manganese series, 1 indicates the first modification of alloy 3005, and finally 05 identifies it in the 3000 series.

1000 series are essentially pure aluminium with a minimum 99% aluminium content by weight and can be work hardened.

2000 series are alloyed with copper, can be precipitation hardened to strengths comparable to steel. Formerly referred to as duralumin, they were once the most common aerospace alloys, but were susceptible to stress corrosion cracking and are increasingly replaced by 7000 series in new designs.

3000 series are alloyed with manganese, and can be work hardened.

4000 series are alloyed with silicon. Variations of aluminium-silicon alloys intended for casting (and therefore not included in 4000 series) are also known as silumin.

5000 series are alloyed with magnesium, and offer superb corrosion resistance, making them suitable for marine applications. Also, 5083 alloy has the highest strength of not heat-treated alloys. Most 5000 series alloys include manganese as well.

6000 series are alloyed with magnesium and silicon. They are easy to machine, are weldable, and can be precipitation hardened, but not to the high strengths that 2000 and 7000 can reach. 6061 alloy is one of the most commonly used general-purpose aluminium alloys.

7000 series are alloyed with zinc, and can be precipitation hardened to the highest strengths of any aluminium alloy (ultimate tensile strength up to 700 MPa for the 7068 alloy). Most 7000 series alloys include magnesium and copper as well.

8000 series are alloyed with other elements which are not covered by other series. Aluminium-lithium alloys are an examples

### **Cast alloys**

The Aluminum Association (AA) has adopted a nomenclature similar to that of wrought alloys. British Standard and DIN have different designations. In the AA system, the second two digits reveal the minimum percentage of aluminium, e.g. 150.x correspond to a minimum of 99.50% aluminium. The digit after the decimal point takes a value of 0 or 1, denoting casting and ingot respectively. The main alloying elements in the AA system are as follows:

1xx.x series are minimum 99% aluminium

2xx.x series copper

3xx.x series silicon, with added copper and/or magnesium

4xx.x series silicon

5xx.x series magnesium

6xx.x unused series

7xx.x series zinc

8xx.x series tin

9xx.x other elements.

### **Named alloys**

A380 Offers an excellent combination of casting, mechanical and thermal properties, exhibits excellent fluidity, pressure tightness and resistance to hot cracking. Used in the Aerospace Industry

Alferium an aluminium-iron alloy developed by Schneider, used for aircraft manufacture by Société pour la Construction d'Avions Métallique "Aviméta"



Alclad aluminium sheet formed from high-purity aluminium surface layers bonded to high strength aluminium alloy core material

Birmabright (aluminium, magnesium) a product of The Birmetals Company, basically equivalent to 5251

Duralumin (copper, aluminium)

Hindalium (aluminium, magnesium, manganese, silicon) product of Hindustan Aluminium Corporation Ltd, made in 16ga rolled sheets for cookware

Lockalloy (Lockalloy is an alloy that consists of 62% beryllium and 38% aluminum. It was used as a structural metal in the aerospace industry, developed in the 1960s by the Lockheed Missiles and Space Company.

Pandalloy Pratt&Whitney proprietary alloy, supposedly having high strength and superior high temperature performance.

Magnalium

Magnox (magnesium, aluminium)

Silumin (aluminium, silicon)

Titanal (aluminium, zinc, magnesium, copper, zirconium) a product of Austria Metall AG. Commonly used in high performance sports products, particularly snowboards and skis.

Y alloy, Hiduminium, R.R. alloys: pre-war nickel-aluminium alloys, used in aerospace and engine pistons, for their ability to retain strength at elevated temperature. These are replaced nowadays by higher-performing iron-aluminium alloys like 8009 capable to operate with low creep up to 300C.

#### **Q48:**

Wrought Nickel

Pure nickel UNS N02200 is used in the chemical industry for its corrosion resistance – particularly to alkalis. It is also used for its properties in shielding against electromagnetic interference and in transducers.

Nickel-Iron Alloys

These are used as soft magnetic materials, as glass-to-metal seals and as materials with defined thermal expansion properties.

Invar (UNS K93600), with 36% nickel and the remainder iron, is unique in having an almost zero coefficient of thermal expansion around room temperature. This makes it valuable where high dimensional stability is required, such as in precision measuring instruments and thermostat rods. It is also used at cryogenic temperatures because of its very low thermal expansion rates.

Alloys containing 72-83% nickel have the best soft magnetic properties and are used in transformers, inductors, magnetic amplifiers, magnetic shields and memory storage devices.

#### Nickel-Copper Alloys

These are highly resistant to corrosion by alkaline solutions, non-oxidizing salts and seawater. The best-known is Alloy 400.

#### Nickel-Molybdenum Alloys

These are highly resistant to reducing acids in the absence of oxidizing ions, such as ferric and cupric or dissolved oxygen. The best-known is Alloy B-2.

#### Nickel-Chromium Alloys

These are characterised by their high resistance to corrosion at both normal and high temperatures (resistance to scaling), good high-temperature strength and high electrical resistance. There are three main groups of alloys:

Ni-Cr (and also Ni-Cr-Fe) alloys with high electrical resistance for heating elements, such as 70-30 (UNS N06008) and C-Grade (UNS N06004)

Ni-Cr alloys (with Fe and other alloying elements) with good corrosion resistance. The best-known are Alloy 600 (UNS N06600) and Alloy 601 (UNS N06601).

Ni-Cr alloys with high-temperature strength and creep resistance, mostly age-hardenable, such as Alloy X-750 (UNS N07750)

#### Nickel-Chromium-Iron Alloys

There are basically two groups of alloys:

Ni – Cr – Fe alloys with excellent strength at high temperature and the ability to resist oxidation, carburisation and other types of high-temperature corrosion. The best-known is alloy 800 (UNS No8800) and its variants 800H (UNS No8810) and 800HT (UNS No8811). (Recently, these alloys were classified as stainless steels reflecting their high Fe content)

Ni – Cr – Fe (with Mo and Cu) alloys with excellent corrosion resistance in specific applications. Probably the best-known is alloy 825 (UNS No8825), which offers exceptional resistance to sulphuric acid. Alloy G-3 (UNS No6985) offers exceptional corrosion resistance to commercial phosphoric acids as well as many complex solutions containing highly oxidizing acids.

#### Nickel-Chromium-Molybdenum Alloys

These are highly corrosion-resistant, of which Alloy C-276 (N10276) is the best-known. They offer exceptional resistance to reducing acids such as hydrochloric and sulphuric. There are a number of variants based on this composition, which have modified the Cr and Mo levels and, in some cases, added Cu or W in order to extend the corrosion resistance to conditions that are more oxidising or more reducing. These include Alloy C-22 (No6022), Alloy 59 (No8059), Alloy C-2000 (UNS No6200), and Alloy 686 (No6686).

#### Nickel-Chromium-Cobalt Alloys

The addition of cobalt and molybdenum imparts solid-solution strengthening and high levels of creep-rupture strength to alloy 617 (UNS No6617). The addition of cobalt to HR-160 (N12160) provides outstanding resistance to various forms of high-temperature corrosion attacks, such as sulphidation and chloride attack in both reducing and oxidizing atmospheres.

#### Nickel-Titanium Alloys

55% nickel-titanium alloy (UNS No1555) (also known as Nitinol) has shape-memory properties. When formed at one temperature and then deformed at a lower one, it regains its original form when reheated. The transition temperatures can be adjusted through careful control of the composition. Medical devices and specialised connectors are two of specific the applications. The same alloy can also undergo considerable elastic deformation and still return to its original shape (super-elastic property). This property has been exploited for applications as diverse as spectacle

frames and shock absorbers that provide earthquake resistance in historic stone buildings.

#### **Q49:**

Nuclear fuel is material used in nuclear power stations to produce heat to power turbines. Heat is created when nuclear fuel undergoes nuclear fission.

Most nuclear fuels contain heavy fissile actinide elements that are capable of undergoing and sustaining nuclear fission. The three most relevant fissile isotopes are uranium-233, uranium-235 and plutonium-239. When the unstable nuclei of these atoms are hit by a slow-moving neutron, they split, creating two daughter nuclei and two or three more neutrons. These neutrons then go on to split more nuclei. This creates a self-sustaining chain reaction that is controlled in a nuclear reactor, or uncontrolled in a nuclear weapon.

The processes involved in mining, refining, purifying, using, and disposing of nuclear fuel are collectively known as the nuclear fuel cycle. Not all types of nuclear fuels create power from nuclear fission; plutonium-238 and some other elements are used to produce small amounts of nuclear power by radioactive decay in radioisotope thermoelectric generators and other types of atomic batteries.

#### **Molten salts**

Molten salt fuels have nuclear fuel dissolved directly in the molten salt coolant. Molten salt-fueled reactors, such as the liquid fluoride thorium reactor (LFTR), are different from molten salt-cooled reactors that do not dissolve nuclear fuel in the coolant.

Molten salt fuels were used in the LFTR known as the Molten Salt Reactor Experiment, as well as other liquid core reactor experiments. The liquid fuel for the molten salt reactor was a mixture of lithium, beryllium, thorium and uranium fluorides:  $\text{LiF-BF}_3\text{-ThF}_4\text{-UF}_4$  (72-16-12-0.4 mol%). It had a peak operating temperature of 705 °C in the experiment, but could have operated at much higher temperatures since the boiling point of the molten salt was in excess of 1400 °C.

- The metal used for the tubes depends on the design of the reactor. Stainless steel was used in the past, but most reactors now use a

zirconium alloy which, in addition to being highly corrosion-resistant, has low neutron absorption. The tubes containing the fuel pellets are sealed: these tubes are called fuel rods. The finished fuel rods are grouped into fuel assemblies that are used to build up the core of a power reactor.

- Cladding is the outer layer of the fuel rods, standing between the coolant and the nuclear fuel. It is made of a corrosion-resistant material with low absorption cross section for thermal neutrons, usually Zircaloy or steel in modern constructions, or magnesium with small amount of aluminium and other metals for the now-obsolete Magnox reactors. Cladding prevents radioactive fission fragments from escaping the fuel into the coolant and contaminating it.

Zirconium alloys are solid solutions of zirconium or other metals, a common subgroup having the trade mark Zircaloy. Zirconium has very low absorption cross-section of thermal neutrons, high hardness, ductility and corrosion resistance. One of the main uses of zirconium alloys is in nuclear technology, as cladding of fuel rods in nuclear reactors, especially water reactors. A typical composition of nuclear-grade zirconium alloys is more than 95 weight percent zirconium and less than 2% of tin, niobium, iron, chromium, nickel and other metals, which are added to improve mechanical properties and corrosion resistance. The water cooling of reactor zirconium alloys elevates requirement for their resistance to oxidation-related nodular corrosion. Furthermore, oxidative reaction of zirconium with water releases hydrogen gas, which partly diffuses into the alloy and forms zirconium hydrides. The hydrides are less dense and are weaker mechanically than the alloy; their formation results in blistering and cracking of the cladding – a phenomenon known as hydrogen embrittlement.

#### **Q50:**

Refining consists of purifying an impure metal. It is to be distinguished from other processes such as smelting and calcining in that those two involve a chemical change to the raw material, whereas in refining, the final material is usually identical chemically to the original one, only it is purer.[clarification needed] The processes used are of many types, including pyrometallurgical and hydrometallurgical techniques.

Copper

## Fire refining

The initial product of copper smelting was impure black copper, which was then repeatedly melted to purify it, alternately oxidizing and reducing it. In one of the melting stages, lead was added. Gold and silver preferentially dissolved in this, thus providing a means of recovering these precious metals. To produce purer copper suitable for making copper plates or hollow-ware, further melting processes were undertaken, using charcoal as fuel. The repeated application of such fire-refining processes was capable of producing copper that was 99.25% pure.

## Electrolytic refining

The purest copper is obtained by an electrolytic process, undertaken using a slab of impure copper as the anode and a thin sheet of pure copper as the cathode. The electrolyte is an acidic solution of copper sulphate. By passing electricity through the cell, copper is dissolved from the anode and deposited on the cathode. However impurities either remain in solution or collect as an insoluble sludge. This process only became possible following the invention of the dynamo.

## Iron

### Wrought iron

The product of the blast furnace is pig iron, which contains 4–5% carbon and usually some silicon. To produce a forgeable product a further process was needed, usually described as fining, rather than refining. At the end of the 18<sup>th</sup> century, this began to be replaced by puddling (in a puddling furnace), which was in turn gradually superseded by the production of mild steel by the Bessemer process.

### Refined iron

The term refining is used in a narrower context. Henry Cort's original puddling process only worked where the raw material was white cast iron, rather than the grey pig iron that was the usual raw material for finery forges. To use grey pig iron, a preliminary refining process was necessary to remove silicon. The pig iron was melted in a running out furnace and then run out into a trough. This process oxidised the silicon to form a slag, which floated on the iron and was removed by lowering a dam at the end of the

trough. The product of this process was a white metal, known as finers metal or refined iron.

### Precious metals

Precious metal refining is the separation of precious metals from noble-metalliferous materials. Examples of these materials include used catalysts, electronic assemblies, ores or metal alloys.

### **Q53:**

In metallurgy, a fluxing is a chemical cleaning agent, flowing agent, or purifying agent. Fluxes may have more than one function at a time. They are used in both extractive metallurgy and metal joining.

Some of the earliest known fluxes were sodium carbonate, potash, charcoal, coke, borax, lime, lead sulfide and certain minerals containing phosphorus. Iron ore was also used as a flux in the smelting of copper. These agents served various functions, the simplest being a reducing agent, which prevented oxides from forming on the surface of the molten metal, while others absorbed impurities into the slag, which could be scraped off the molten metal.

Fluxes are also used in foundries for removing impurities from molten nonferrous metals such as aluminium, or for adding desirable trace elements such as titanium.

As cleaning agents, fluxes facilitate soldering, brazing, and welding by removing oxidation from the metals to be joined. In some applications molten flux also serves as a heat-transfer medium, facilitating heating of the joint by the soldering tool or molten solder.

### **Q56:**

Material selection should be based mainly upon the properties of material. The designer must decide the properties required of a material for a part under design and then weight the properties of candidate material. There are literally hundreds of properties that are measured in laboratories for the purpose of comparing materials, but we shall concentrate on the more important ones, e.g., chemical, physical, mechanical, dimensional properties.

#### 1.Chemical Properties:

Chemical properties are material characteristics that relate to the structure of a material and its formation from the elements.

The important chemical properties are:

- i. Composition,
- ii. Structure,
- iii. Corrosion Resistance.

### Composition

Composition of material can be determined by analytical chemistry. In metals, composition usually means percentage of the various elements that make up the metal. In material selection, composition is a fundamental consideration. The designer should always have at least some idea of what a material is made of.

### Structure

Studies of the structure of the materials are one of the most useful tools of the metallurgist. Structure of a material generally refers to its micro-structure, i.e. the components seen when the metal is examined under a microscope. Microstructure is invaluable to the materials engineer in solving problems and in understanding material responses to treatments.

Microstructure studies are also an important tool in analyzing as to why a part failed in service.

### Corrosion

Corrosion is a gradual, chemical or electrochemical attack on a metal by its surroundings so that the metal is converted into an oxide, salt or some other compound. It may be brought about by almost unlimited number of factors of corrosive media such as air, industrial atmosphere soils, acids, bases and salt solutions. It may also occur at elevated temperature in media which are inert when near or below room temperature.

## 2. Physical Properties:

Material used in industry possess some definite physical characteristics which render them suitable for particular use and their choice for a particular use is governed mostly by these properties. Physical properties are characteristics of materials that are determined by nature.

### Density



Density is a measure of the mass per unit volume and can be interpreted in various ways as:

- a. Crystallographic density—the ideal density that would be calculated from continuous defect-free crystal lattice of the material,
- b. Theoretical density same as crystallographic density but taking into account solid solutions and multiple phases.
- c. Bulk density—the measured density of a material which includes all lattice defects, phases and fabrication porosity.

Specific Heat:

Specific heat is the quantity of heat in calories required to raise the temperature of 1 gm of a material by one degree centigrade. Different substances possess different specific heats. Water has the highest specific heat.

Specific Gravity:

Specific gravity is the relative mass of a certain volume of a material compared to mass of the same volume of water. Consequently, it is the ratio of densities of the material to that of water.

Porosity:

Porosity is the ratio of volume occupied by pores to the volume of a material. Low porosity of a material makes it light in mass. More porous material is better insulating materials i.e. thermal conductivity of a material can be decreased by increasing its porosity.

Refractoriness:

Refractoriness is the property due to which a material is able to withstand high temperature without fusing e.g. silica, alumina and fireclay.

Thermal Conductivity:

Thermal conductivity is the ability of a material to conduct heat from the hot end to the cold end-silver is the best conductor of heat. A material that conducts heat very badly is called heat insulator. The insulating materials are frequently employed to prevent the loss of heat.

Electrical Conductivity:

Electrical conductivity is the ability of a material to conduct electricity. A material which allows electric current to pass through it with minimum loss is called a good conductor of electricity. Silver is the best electrical conductor and copper is the next one. Material which offers great resistance to the flow of electric current is called electrical insulator or dielectric.

#### Magnetic Property:

Materials which are attracted by a magnet are magnetic in nature, e.g. Fe, Ni, Co, Cr, Mn, Gd. Materials which are repelled feebly by a magnet are called diamagnetic e.g. Cu, Zn, Pb, Sb, Bi etc.

#### Colour:

Colour results from the absorption of a relatively narrow wavelength of radiation within the visible region of the em spectrum (0.4 to 0.7 mm). For this type of absorption, transition of electrons must occur. The melting point, boiling point and linear coefficient of expansion are some of other physical properties.

#### Dimensional Properties:

Dimensional properties form an important selection factor. The available size, shape and tolerances materials are important in selecting a material. Other dimensional properties include surface roughness, waviness and micro topography. The microscopic characteristics of a surface are called micro topography and it includes various surface characteristics such as surface layout, roughness height, roughness width, waviness height, waviness width etc. Total surface profile, which is the net of the surface roughness and waviness, is usually measured using a profilometer a device that electronically measures surface texture with a stylus. The profilometers yield contour maps, single-line surface profiles and roughness data.

**Mechanical Properties:** Mechanical properties are the characteristics of a material that are displayed when a force is applied to the material. They usually relate to the elastic and plastic behaviour of the material. Important mechanical properties are hardness, modulus of an elasticity, yield strength, tensile strength, percent elongation, reduction in area, impact, fatigue and creep strengths and wear resistance.

Mechanical properties are of foremost importance in selecting materials for structural machine components. There are many tests to measure mechanical properties such as hardness test, tensile test, bend test, impact test, fatigue test and creep test.