Syllabus:
General consideration in design:
Based on Functional requirement, Effect on environment Life, Reliability, Safety Principles of Standardization, Assembly, Feasibility, Maintenance-Cost, Quantity, Legal issues and Patents, Aesthetic and Ergonomic factors, Choice of Materials, Feasibility of Manufacturing Processes

Machine design :

Definition - The subject Machine Design is the creation of new and better machines and improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation.

Classifications of Machine Design:

The machine design may be classified as follows :

1. Adaptive design: In most cases, the designer's work is concerned with adaptation of existing designs. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training. The designer only makes minor alternation or modification in the existing designs of the product.

2. Development design: This type of design needs considerable scientific training and design ability in order to modify the existing designs into a new idea by adopting a new material or different method of manufacture. In this case, though the designer starts from the existing design, but the final product may differ quite markedly from the original product.

3. New design:. This type of design needs lot of research, technical ability and creative thinking. Only those designers who have personal qualities of a sufficiently high order can take up the work of a new design.

General Considerations in Machine Design-

Following are the general considerations in designing a machine component:

1. Type of load and stresses caused by the load: The load, on a machine component, may act in several ways due to which the internal stresses are set up.

2. Motion of the parts or kinematics of the machine: The successful operation of any ma chine depends largely upon the simplest arrangement of the parts which will give the motion required. The motion of the parts may be :

a) Rectilinear motion which includes unidirectional and reciprocating motions.
b) Curvilinear motion which includes rotary, oscillatory and simple harmonic.
c) Constant velocity.
d) Constant or variable acceleration.

3. Selection of materials: It is essential that a designer should have a thorough knowledge of the properties of the materials and their behaviour under working conditions. Some of the important characteristics of materials are : strength, durability, flexibility, weight, resistance to heat and corrosion, ability to cast, welded or hardened, machinability, electrical conductivity, etc.

4. Form and size of the parts: The form and size are based on judgement. The smallest practicable cross-section may be used, but it may be checked that the stresses induced in the designed cross-section are reasonably safe. In order to design any machine part for form and size, it is necessary to know the forces which the part must sustain. It is also important to anticipate any suddenly applied or impact load which may cause failure.

5. Frictional resistance and lubrication: There is always a loss of power due to frictional resistance and it should be noted that the friction of starting is higher than that of running friction. It is, therefore, essential that a careful attention must be given to the matter of lubrication of all surfaces which move in contact with others, whether in rotating, sliding, or rolling bearings.

6. Convenient and economical features: In designing, the operating features of the machine should be carefully studied. The starting, controlling and stopping levers should be located on the basis of convenient handling. The adjustment for wear must be provided employing the various take up devices and arranging them so that the alignment of parts is preserved. If parts are to be changed for different products or replaced on account of wear or breakage, easy access should be provided and the necessity of removing other parts to accomplish this should be avoided if possible. The economical operation of a machine which is to be used for production, or for the processing of material should be studied, in order to learn whether it has the maximum capacity consistent with the production of good work.

7. Use of standard parts: The use of standard parts is closely related to cost, because the cost of standard or stock parts is only a fraction of the cost of similar parts made to order. The standard or stock parts should be used whenever possible ; parts for which patterns are already in existence such as gears, pulleys and bearings and parts which may be selected from regular shop stock such as screws, nuts and pins. Bolts and studs should be as few as possible to avoid the delay caused by changing drills, reamers and taps and also to decrease the number of wrenches required. Design considerations play important role in the successful production of machines.

8. Safety of operation: Some machines are dangerous to operate, especially those which are speeded up to insure production at a maximum rate. Therefore, any moving part of a machine which is within the zone of a worker is considered an accident hazard and may be the cause of an injury. It is, therefore, necessary that a designer should always provide safety devices for the safety of the operator. The safety appliances should in no way interfere with operation of the machine.

9. Workshop facilities. A design engineer should be familiar with the limitations of his employer's workshop, in order to avoid the necessity of having work done in some other workshop. It is sometimes necessary to plan and supervise the workshop operations and to draft methods for casting, handling and machining special parts.

10. Number of machines to be manufactured. The number of articles or machines to be manufactured affects the design in a number of ways. The engineering and shop costs which are called fixed charges or overhead expenses are distributed over the number of articles to be manufactured. If only a few articles are to be made, extra expenses are not justified unless the machine is large or of some special design. An order calling for small number of the product will not permit any undue expense in the workshop processes, so that the designer should restrict his specification to standard parts as much as possible.

11. Cost of construction. The cost of construction of an article is the most important consideration involved in design. In some cases, it is quite possible that the high cost of an article may immediately bar it from further considerations. If an article has been invented and tests of handmade samples have shown that it has commercial value, it is then possible to justify the expenditure of a considerable sum of money in the design and development of automatic machines to produce the article, especially if it can be sold in large numbers. The aim of design engineer under all conditions, should be to reduce the manufacturing cost to the minimum.

12. Assembling. Every machine or structure must be assembled as a unit before it can function. Large units must often be assembled in the shop, tested and then taken to be transported to their place of service. The final location of any machine is important and the design engineer must anticipate the exact location and the local facilities for erection.

Essential requirement of a good product design Based on:

a. Functional requirement : The product must be designed in such a way that it optimally performs the main task or function for which it is purchased by a buyer. In other words, the product must satisfy the needs and wants of the consumer.

b. Effect on environment: Eco-design minimizes a product's negative impact by factoring environmental concerns into its specifications, such as the preservation of precious or non-renewable resources, the prevention of pollution and the absence of danger for animal and plant species.

c. Life, Reliability, Safety:

Durability refers to the life of a product. A durable product performs flawlessly for a longer period. It is a sign of a good-quality product. Consumers want their products to have a longer life. The product must be designed in such a way that it can be easily repaired whenever necessary during a malfunction. The product repairs must be done quickly that too at a low repair cost.

Reliability means dependability on a product. Consumers prefer to purchase and use often those products which perform their main function or task optimally for a longer period without any annoying malfunctions, breakdowns or failures.

The designer must ensure that the products they design are safe to use. Quality products will have certificates such as BSI, ISO, and other standards. Designers must create their products according to the regulations of these organizations. Gaining these certificates validates the product's quality and tempts the general public to buy and use these products

d. Principles of Standardization: The design of the product must be very simple. The simpler a design, the easier, it is to produce and use (handle). Simple products are also economical and reliable. The product must have the least number of operations without affecting its functionality.

e. Assembly Feasibility: Design for assembly is an Analysis of products that results in simplified product designs that are easier and less costly to assemble, particularly by attempting to reduce the number of parts. It is primarily a cost-saving tool that is concerned with reducing the product assembly cost by minimizing the part count, the number of assembly operations needed to produce the part and by making these assembly operations as easy and fail- proof as possible.

f. Maintenance-Cost-Quantity: Most of the designers concentrate more on functions and aesthetics, and forget about maintenance. Proper maintenance can prolong the longevity of the product. Using durable materials for easy maintenance adds to the overall cost of the product. But this cost can be justified. Designers are trained to design a cost-efficient and higher quality product that will attract more consumers. While designing a complementary product, the designer must consider the primary product's price and make their plans accordingly.

g. Legal issues and Patents: Legal issues to consider during product development are Licensing: Licensing your product basically gives someone else the right to produce and sell your product for a given period of time. Product Liability: some products may be recalled due to defects. There are manufacturing defects, which you aren't in control of, and design defects, which you most definitely are to be guaranteed for replacement or warranted or money back policy or free services.

Patents: Patents are the best way to ensure that your invention is legally protected, should someone try to copy your idea or challenge your ownership

h. Aesthetic and Ergonomic factors: Aesthetics must be kept in mind while designing a product. It refers to, how the product looks, feels, sounds, tastes or smells. That is, the product must look, feel, sound, taste or smell very good. It must be attractive, compact and convenient to use. Its packaging must also be made graphically appealing and colorful. If this aspect is not considered, product will fail in the market. Aesthetics is the final and most crucial factor that needs to be considered in product design. Customers have their own aesthetics, and they purchase products guided by this sense. Even when the product quality is less than other products of the same cost, consumers will recommend buying a product because of its aesthetics.

Ergonomics is defined as "The applied science of equipment design, as for the workplace, intended to maximize productivity by reducing operator fatigue and discomfort". Ergonomic design customizes a product to meet specific user needs, we can surmise that ergonomic design is the process of developing a product/service that is easy to use and provides a favorable, enjoyable experience for the end user. It involves creating and designing a product in its most effective and useful form.

i. Choice of Materials: Before manufacturing a product, the designer must decide the material to be used. The designer must ensure that their choices are compatible with each other. Since the materials used in their products also define its quality and guarantee, the designer must have perfect knowledge about the product's materials.

j. Feasibility of Manufacturing Processes: The product must be designed in such a way that it can be produced in large quantities with ease at a minimum production cost. The production department must be able to produce the product easily, quickly, in ample quantities and at a low production cost. The production process must not be very complex, and it must not require costly machines to produce the product.

General Procedure in Machine Design

General Procedure in Machine Design In designing a machine component, there is no rigid rule. The problem may be attempted in several ways. However, the general procedure to solve a design problem is as follows:

1. Recognition of need: First of all, make a complete statement of the problem, indicating the need, aim or purpose for which the machine is to be designed.

2. Synthesis (Mechanisms): Select the possible mechanism or group of mechanisms which will give the desired motion.

3. Analysis of forces: Find the forces acting on each member of the machine and the energy transmitted by each member.

4. Material selection: Select the material best suited for each member of the machine. 5. Design of elements (Size and Stresses). Find the size of each member of the machine by considering the force acting on the member and the permissible stresses for the material used. It should be kept in mind that each member should not deflect or deform than the permissible limit.

6. Modification: Modify the size of the member to agree with the past experience and judgment to facilitate manufacture. The modification may also be necessary by consideration of manufacturing

7. Detailed drawing: Draw the detailed drawing of each component and the assembly of the machine with complete specification for the manufacturing processes suggested.

8. Production: The component, as per the drawing, is manufactured in the workshop.

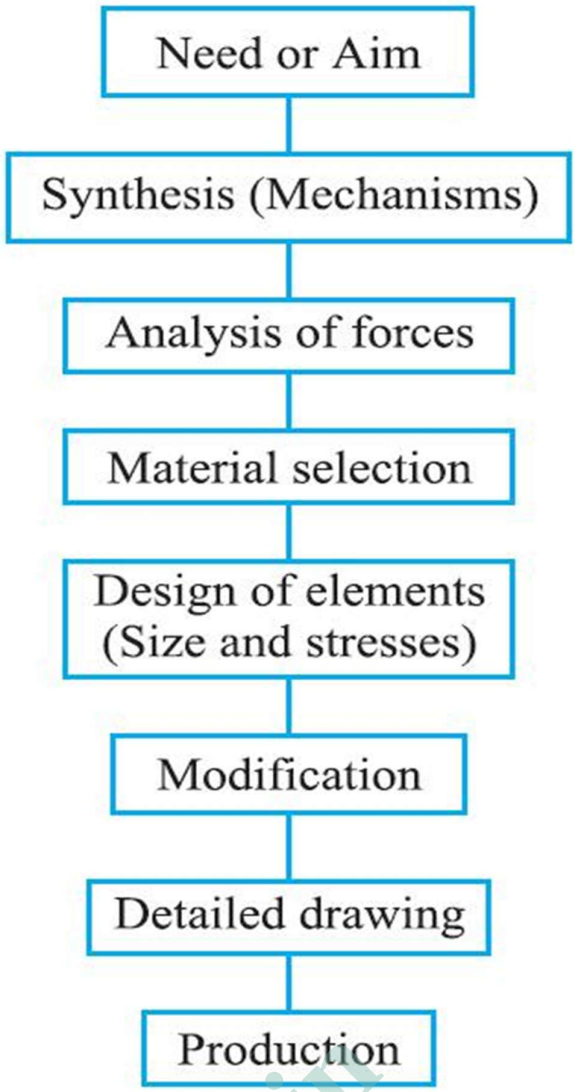

Fig. General procedure in Machine Design