

Joint Beginning and Intermediate Engineering Graphics
8th Week Meeting Lecture Notes
Instructor: Edward N. Locke
Topic: Theory of Design

1st Subject: Product Design

A. Principles of product design: before designing and preparing production drawings for apart, the designer or drafter should consider what manufacturing processes are to be used, and these processes will determine the description of the detailed features of the part, the selection of dimensions, and the machining or processing accuracy. Things should be designed in a way that they can be realistically manufactured with processes that are as simple as possible, and provide for maximum strength of the material, in a cost-effective way.

B. Use of fillets (inside rounded corners) and rounds (outside rounded corners): They are used to provide for maximum strength and pleasing appearance in the finished casting. Because crystals of cooling metal tend to arrange themselves perpendicular to the outside surface, a much stronger casting will result if the corners of a casting are rounded, and the larger the radius, the heavier load a part can safely carry. Fillets and rounds should be shown on the drawings. Preformed leather with a range of radii are used to apply fillets to patterns, fastened with glue and firmly pressed in place with a spherical tool (a stick with spheres at both ends). Wax stripes are applied to the pattern for form a fillet, using a heated spherical tool. Rounds are applied to the pattern by rounding off the corners of the pattern through sanding, planning or turning. Fillets and rounds can be formed on the lathe as well.

C. Product design step-by-step: Product design includes **two components:**

- **Empirical design or conceptual design** using knowledge, experience and reference resources such as handbooks.
- **Scientific design** using principles of mechanics, electronics, mathematics, chemistry, physics and other scientific knowledge acquired through education and experience, in the new or revised design of tools, equipments, structures or systems.
Product design and manufacturing in modern corporations usually involve cooperation among mechanical, electronic engineers, product designers, and marketing specialists and other people, and is a team effort.

The correct sequence of stages of the design process is:

Stage 1 Investigation of Market: investigation of the existing products in various types of markets, and recognition of any need for new or improved products, leading towards research and development or R&D efforts for a solution to satisfy this need. All sources of ideas, including engineers, drafters, drafting teachers, salesman, retail and wholesale business manager and owners are consulted on price range, sales potential, consumer reaction to existing products, complaint against shortcomings, ideas about possible improvement, etc. A **problem report and solution proposal** with a few paragraphs or pages can be submitted to the management. If approved, the designer will further define the problem in details by determining guidelines for time, cost, and function in terms of design objectives, estimated cost limit, unit price, clientele,

or marketing potential of the new or revised products, the deadlines for the prototypes to be ready for testing, for the production drawings to be ready for presentation, for the actual production to start, and for the product to be available to consumers. When all of these are explored in a revised report, the designer will proceed to Stage 2 with the blessing from the management.

Stage 2 Concept Ideation: usually developed at first with freehand **sketches** of views and pictorials, which are then revised and digitized in CAD programs, and dated and archived for record-keeping, possible patent proof and reference purposes. At this initial stage, things can happen in the garage or basement of one or several individual designers or inventors, in a “wild”, unrestricted or “brainstorming” manner to come up with all possible solutions that are creative and unique. All sources of reference materials such as patents, articles and reports from trade and technical magazines, existing designs are broadly explored to generate the largest collection of ideas possible for reference and refinement. Concepts are communicated verbally with speech and writing, symbolically with equation and formulas, and graphically with sketches, drawings and renderings etc.). But ideas generated so far will not be evaluated at this stage.

Stage 3 Compromise Solutions: at this stage, things happen in a collective team environment and in a well-organized, tightly-disciplined, orderly and strictly official manner. All ideas are evaluated carefully for the selection of the best ones that integrate the best strength and function of the parts/components and the lowest possible production cost, which are then simplified and combined into a few promising compromise solutions; then, the best initial design concept is generated and shared between members of the design and marketing team, revised and finalized by taking into consideration all technical and financial requirements and limitations, in terms of the use of power in the product, either manual or electric motor, the type of motion needed, either rotary or linear or a combination of both, all of these are graphically expressed with preliminary **schematic drawings** which show various parts/components of the product in skeleton form (circles, squares, etc.). A full-scale or to-scale **design layout** is then made to visualize the actual sizes and proportions of the product and to show how the parts/components fit together and are assembled. All related factors such as stress, speed, load and others need to be carefully evaluated. The designers must pay special attention to clearance of moving parts, ease of assembly, convenience and safety for the user (“ergonomics”), and serviceability. Industry standards and the company’s standards should be strictly followed by constantly consulting related manuals and handbooks. As much as possible, standard parts or stock items should be used. The designers should also try to modify shapes and change materials if need, so as to come up with the ideal design solution that will perform the required function at the lowest possible cost.

Stage 4 Models or Prototypes-making: full-scale or to-scale visual models are made to study, analyze and refine a design. Full-size working models called prototypes can be made to final specifications except possibly for materials, tested and modified if needed. The results of such modifications are recorded in the revision of sketches and working drawings.

Stage 5 Production or Working Drawings Presentation: the approved production design layouts are submitted to the engineering department for the production drawings; a final set of production or working drawings for the parts/components (also known as **detail drawings**) with detailed dimensions and notes in title or record strips or in the parts list is made, checked and approved by staff (drafters, detailers, checkers, etc.) and leaders (chief engineer, etc.) of the design team. Unaltered standard parts do NOT need detail drawings but are shown on the **assembly drawing** and listed with specifications in the **parts list**; an assembly drawing is

usually generated by combining the drawings of various parts, and is intended to show the relationship between the parts, NOT the shape of the individual parts; on assembly drawings, hidden lines are avoided and sections are used; dimensions are NOT given, but parts are identified by circled numbers with leaders and arrowheads; the part list should include the number and description of the part, the quantity needed and material used. Part list can be substituted by direct notation next to the end of the leader. Finally, a **patent drawing** can be made and filed with the US Patent Office to protect the manufacturer. Patent drawings may use pictorials to explain the invention, and should follow the rules of the Patent Office. Contact The Superintendent of Documents, US Government Printing Office, Washington DC 20402 for a Guide for Patent Draftsmen.

For assembling or erecting machines and equipment, an **installation assembly drawing** (also called **outline assembly drawing**) showing the outline of the parts is needed. If changes were made in the details of the parts, a **check assembly drawing** is often needed to make sure that the parts will fit together properly.

Any of the above-mentioned stage can be repeated if no satisfactory result is achieved.

2nd Subject: Use of Working Drawings

The drawings must offer a comprehensive description of the shape, size, material, heat treatment, dimensional accuracy, and finish, and if necessary, the manufacturing or machining processes required to produce the product, without further information than that furnished on the drawings.

Study Questions:

- What are the two major components of design? What are the major differences between them?
- What types of people are involved in the product design process in modern corporations? In the final analysis, who are the ultimate bosses of this process?
- What is involved in the stage of market investigation? Who are contacted? What is submitted for approval?
- What is involved in the stage of concept ideation? Who are involved? What is the manner used to generate as many ideas as possible? What types of written materials are consulted? How are concepts or ideas presented? Are concepts and ideas thoroughly evaluated at this stage? Please explain why.

- What is involved in the stage of compromise solution? Who are involved? What is the manner used to generate as many ideas as possible? What factors are taken into consideration before the design is finalized? How are concepts or ideas presented? Are concept and ideas thoroughly evaluated at this stage? Please explain why.
- What is involved in the stage of model or prototype making? Who are involved? What is the difference between a visual model and a working prototype? What should be done in this stage?
- What is involved in the stage of production or working drawing presentation? Who are involved? How to avoid costly mistakes in mass production? What types of documents are needed, and what are the major conventions for each type of documentation?
- What is the function of standard parts? And for what reasons are they used?
- What should be included on the working drawings?
- What are the major principles of product design?
- What can fillets and rounds do in the design of parts and components?