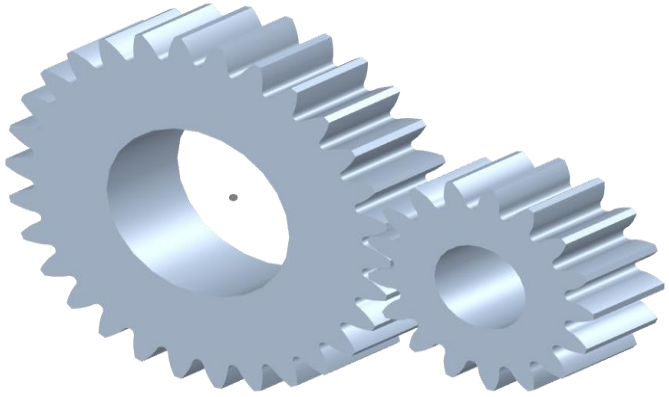
Machining

Level-IV

Based on October 2023, Curriculum Version II



Module Title: Developing and Manufacture Precision Model

Module Code: IND MAC4 M03 1023

Nominal Duration: 60 Hours

Prepared by: Ministry of Labor and Skill

October2023

Addis Ababa, Ethiopia

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

ASME	American Society of Mechanical Engineers
CAD	Computer-aided design
DOE	Design of experiments
GD&T	Geometric Dimensioning and Tolerance
IEEE	Institute of Electrical and Electronics Engineers
IMAS.	International Mine Action Standards
MS	Manufacturing sequence
MS	Manufacturing sequence
OSHA	Occupational Safety and Health Administration
PCE	Price Cost Estimate
PFI	Pipe Fabrication Institute
SPC	Statistical process controls
UXO	Unexploded ordnance

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Introduction to Module

In machining field, Developing and Manufacture Precision Model is especially important for the overall quality of products. It helps to determine job requirements, manufacturing process, how to select materials and working instructions, producing parts and assemble components, Comply with Quality assurance

This module is designed to meet the industry requirement under the Machining occupational standard, particularly for the unit of competency: Developing and Manufacture Precision Model.

This module covers the units:

- Introduction of Precision Model
- Layout model
- Manufacture model
- Quality Assurance

Learning Objective of the Module

- Determine work requirements
- Layout model
- Manufacture model
- Assure Quality

Module Instruction

For effectively use this module trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one:- Introduction of Precision Model

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Precision model manufacturing
- Design requirements
- Drawing Instructions and specifications
- Materials Selection
- Time schedule

This unit will also assist you to attain the learning outcomes stated in the cover page.
Specifically, upon completion of this learning guide, you will be able to:

- Identify requirements.
- Interpret and understand drawings, instructions and specifications
- Select appropriate materials.
- Prepare time schedule of specific work to be performed
- Study functional and formal relationships
- Determine detail specifications

- **Introduction to Precision model manufacturing**

Precision manufacturing is what happens when a design is developed that requires highly accurate components and is made into a workable part. There are many industries that have very precise tolerance that has to be exact. When it comes to parts for the aerospace industry, for example, this precision can save lives.

Precision Engineering is a discipline encompassing the design, development, and measurement of and for high-accuracy components. By extension, the field also includes the design of systems in

which high dimensional accuracy is a central concern, as well as the design of machine tools and measuring machines to accomplish the necessary manufacture and measurement.

1.1. Design requirements

A design process, in general, involves not only the construction of a description of an arte fact, but also the determination of (additional orsubstitute) requirements of the arte fact, and the strategic co-ordination of these activities. In order to thoroughly analyses a design process, or to develop a support system for a design process, a model is indispensable. To develop a model for a specific design process, one of two strategies can be chosen: generate a design process model from scratch, orapply/modify an existing design process model. The second is often only more efficient if a generic model exists with structures that are applicable to the specific design process.

Researchers provided a very broad definition of design as "devising courses of action aimed at changing current situations into preferred ones". Countless competing definitions exist. Common too many definitions is the focus on a specific process, with the goal of creating plans or models for the creation of new artifact/work of art, which have to fit potentially conflicting sets of constraints, requirements, and preferences. To elaborate on these three core characteristics:

- **Design is a process and has structure** — there is a set of core activities designers engage in, regardless of the domain of design.
- **Design is not manufacturing** — for physical artifacts, the final realization is done by someone else. The end product of design is often a specification that will be interpreted and implemented by someone else.
- **Design has a client and users** — it is accountable to external judgment.

Design is thus distinguishable as a unique discipline from art (creation which is accountable to the vision of the artist); engineering ("the application of scientific and mathematical principles to practical ends"; and science (the development of generalizable knowledge through observation, experimentation and hypothesis testing).

Designers adopt solution-focused strategies by generating possible solutions first, then checking to what extent the generated ideas are adequate for the problem. Cross, reporting on a study of designers summarizes: “Instead of generating abstract relationships and attributes, then deriving the appropriate object to be considered, the designers always generated a design element and then determined its qualities.” Creation comes before analysis, and only through the creation of prototypes and other representations is it possible to test to what extent a design idea fulfills the design goals.

Finally, designers tend think with, and communicate through artifacts and models rather than written language – sketches, diagrams, models and prototypes are used both to work through problems as well as to anchor communication with design team members and other stakeholders. More care and planning were needed before manufacturing commenced to ensure that the manufactured product was in fact functional and desirable to consumers.

A manufacturer business model is a system that describes how a manufacturing organization will create, deliver, and capture value in economic, social, and cultural domains.

It is a way for manufacturers to generate revenue and ensure business survival. Manufacturing is the process of creating goods either by hand or by machine, which are then sold for profit as part of a larger business model. Manufacturing models can also be computer-based simulations that help maintain or improve efficiency at the lowest possible cost.

Researchers classified ways in which prototypes can be valuable to designers. Prototypes in their view include “any representation of a design idea, regardless of medium.” Their model defines three types of questions a prototype can address: the role of a product in the larger use context; its look and feel; and its technical implementation. These questions are set up as end points in a triangular, bar centric coordinate design space into which prototypes are plotted (Figure 1).

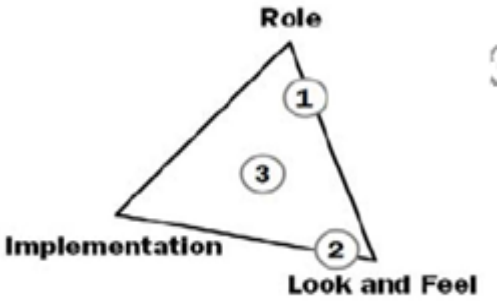


Fig.1.1.1Model distinguishes Role, Implementation, and Look and Feel functions of Model.

Role refers to questions about the function that an artifact serves in a user's life—the way in which it is useful to them. Look and feel is concerned with questions about the concrete/existing sensory experience of using an artifact—what the user looks at, feels and hears while using it. Implementation refers to algorithms and engineering techniques used to realize functionality of a product — "the 'nuts and bolts' of how it actually works." For reasons of economy, any given prototype will only address some of these aspects, or prioritize some over others.

Any new idea or design has to be tested and verified at its initial stages from the point of view of an end-user before taking shape into a finished product and being launched to the market.

A sample is a complete working model of an innovation, which is built in such a way that it can be tested on various points like design, features, cost effectiveness, usability, user friendliness etc. To produce your idea or innovation as an end product, model is a critical step and an eminent part of the system design process. Developing a model in general minimizes the overall project risk and cost. Modeling an idea rules out the chances of getting deficiency and errors in the final design of the product

Model of an innovation is the first original working form of the idea which clears a path for its future stages/ versions. In order to develop a model, a proper documentation of the process, ideas and the flow has to be done initially. The innovation or idea can be a product or a service. The fundamental design and documentation of these ideas demands thorough understanding and knowledge of the functionality and target group of the product. The

requirements from the end-user point of view are collected with respect to the innovation. The objective of the application or the product, input required, its processing and possible outputs are listed to develop a working model

There are different types of models depending upon the type of product and its functionality. Low fidelity/reliability prototypes give a static, non-computerized working model, whereas high fidelity prototypes give a dynamic, computerized working model. Exploratory models are developed to examine the large and complex systems. Experimental and operational models work to validate product specifications and iterations for finalizing the product. The models with little details are the Horizontal Models and that with full details are Vertical models. Similarly Global prototypes provide working models of the entire system and Local models are focused on the single usability or functionality of the product. A model is developed to show proof of innovation to senior management and investors.

1.2. Drawing Instructions and specifications

Drawing instructions and specifications are essential in various fields, including engineering, architecture, manufacturing, and design. They provide detailed information about how to create a drawing or design and ensure that the final product meets the desired specifications. Here are some key components and considerations when creating drawing instructions and specifications:

Requirements and Specifications

Requirements are general ways that the designer/engineer will meet the needs of the users. Specifications are more specific and often measurable needs for the product design; they serve as guidelines for designing and manufacturing the product. Spell out in precise, measurable detail what the product should do and what is required in order to achieve this. You should plan for your model; you will have lots of sketches of your ideas before developing the prototype and may develop a few models. You should have come up with your design requirements. You are going to use those to develop design specifications.

To develop models using drawing techniques such as 3D printing or additive manufacturing, drawing drawing instructions and specifications typically involves the following steps

- **Model Design**: Begin by creating a detailed 3D model of the desired object using computer-aided design (CAD) software. The model should include all the necessary geometric features, dimensions, and design elements.

- **Software Preparation:** Import the 3D model into the software specific to the growing technique being used. This software will generate the instructions for the growing process. Different growing techniques may require different software packages
- **Slice the Model**: In the software, slice the 3D model into thin cross-sectional layers. This step converts the 3D model into a series of 2D layers that will be sequentially printed or grown.

- **Drawing Parameters**: Specify the drawing parameters for the process, such as layer thickness, printing speed, temperature, material type, and any other relevant settings These parameters may vary depending on the growing technique and the specific equipment being used

- **Material Selection**: Select the appropriate material for the growing process based on factors such as mechanical properties, compatibility with the growing technique, and desired final characteristics of the model
- **Quality Control:** Define any quality control measures or inspections that need to be performed during or after the growing process. This can include dimensional checks, surface finish evaluations, or other specific criteria to ensure the model meets the desired specifications
- **Documentation**: Document the growing instructions, including the specific settings, parameters, and any additional notes or considerations. This documentation is important for repeatability, troubleshooting, and future reference.

It's important to note that the exact steps and requirements may vary depending on the specific drawing technique and equipment being used. It's recommended to refer to the user manuals, guidelines, and best practices provided by the equipment manufacturer or seek guidance from experts familiar with the specific drawing technique.

1.3. Materials Selection

All manufactured products, constructed structures, and infrastructure, everything from toys, domestic utensils, and furniture, to agricultural, commercial, and industrial machines, to roads, bridges, and dams, is made of material. Therefore, at some point in the process of engineering design, decisions have to be made as to which materials and what processes will be used in order to realize the product. The importance of materials to mankind is perhaps best underscored by the fact that epochal eras in civilization have been identified by the materials that were then in prevalent use

Model Materials

Building a model/prototype can be fun and challenging. Here are a few tips to keep in mind:

1. Make it large enough. Remember that others will want to see the detail, and you will want to make sure all the parts work.
2. Pay attention to detail. Be sure that you show all the parts and components.
3. Make it strong. Use durable materials.
4. Make it "green." Use recyclable materials when possible.
5. Make it realistic. The model should be as close to the real product as possible.

Answer the following question to plan your models:

1. What materials are you considering using for your prototype?
2. Now, in your design notebook, draw a sketch of your prototype and label the materials.

Materials to demonstrate what may be used in prototypes: wood, foam, flexi-glass, fiberglass, metal, canvas fabric, cotton balls, tubing, sandpaper, sponges, steel wool pads, string or twine, glue, masking tape, and duct tape.

Decision making – the choice of appropriate courses of action from among the available alternatives – is implicit in all engineering design activities. Simply stated, the major objective of engineering design is to realize products that will be satisfactory. To meet this objective requires the manufacture of products with the required geometrical form and precision, from selected materials that will be optimum for the product's service environment.

It therefore follows that among the major decisions to be made during the design process will be decisions that fall into the following three basic categories:

- Decisions that are concerned with the geometry of components and mechanisms. These are often more creative than selective.
- Decisions that are concerned with the materials of construction. These are largely selective.
- Decisions that are concerned with production processes. These too are largely selective.

The above three categories of design decisions are not entirely independent of each other. Consider the following examples:

- The components of a table to be made of wood would be machined (cut) and then appropriately joined to make the complete table. On the other hand, the components of a table to be made of some plastic material would be molded and then probably interaction between design decisions that are concerned with materials and those that are concerned with manufacturing processes.
- It is not generally feasible, though it might be possible, to produce a component of intricate shape, such as an engine block, entirely by machining. Usually, the block is cast and then finished by machining. This example illustrates the interaction between the design decisions that are concerned with geometry and those that are concerned with manufacturing processes.
- The interaction between design decisions concerned with geometry and those concerned with materials is more obvious than it might appear to be at first. For example, liquid and gaseous materials do not possess definite shapes of their own and cannot, therefore, be used to make components with definite shapes. For another example, rubber should be a suitable material for the manufacture of springs, from the point of view of its elasticity. Yet rubber cannot be formed into coil springs due to its lack of plasticity and its very low stiffness. These examples illustrate the interaction between the design decisions that are concerned with materials and those that are concerned with geometry.

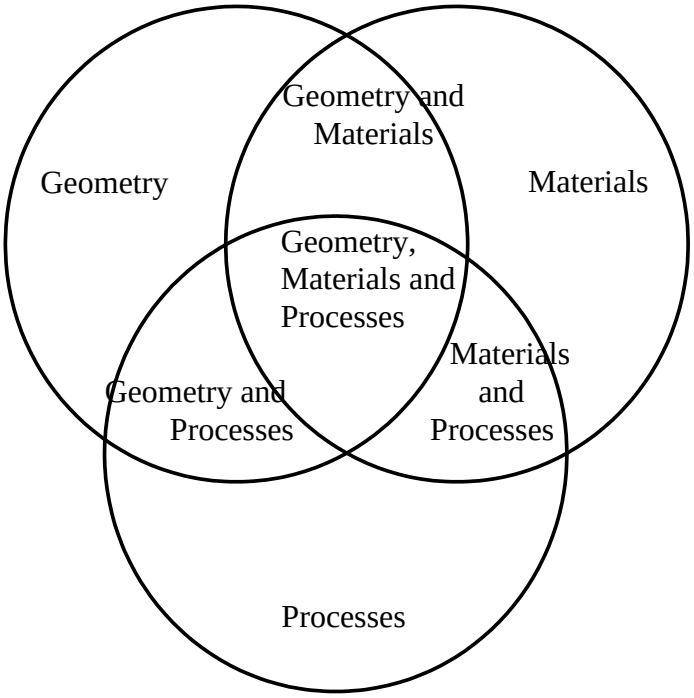


Fig.1.3.1 – The Interactions of Geometric, Material, and Processing Decision

Figure 13.1 above illustrates the interactions of design decisions concerned with materials, geometry and manufacturing.

- **Materials Selection and Product Performance**

To realize products that will adequately perform their designated functions, design and manufacturing engineers need to establish clear objectives that are to be achieved. In general, the goal should be to realize products that have the desired technical and operational characteristics, and will satisfy the needs of society most efficaciously and economically.

1.4. Time schedule

Developing a model or prototype can vary significantly depending on the complexity of the project, available resources, and team expertise. However, in general time schedule that can be adapted to different development scenarios. Here's a typical outline for the model/prototype development process:

Project Initiation (1-2 weeks): During this phase, the project goals, requirements, and constraints are defined. This includes gathering user requirements, clarifying objectives, and setting project milestones.

Design and Planning (2-3 weeks): In this phase, the high-level design of the model or prototype is created. This involves defining the architecture, algorithms, and data requirements. Additionally, the project plan, including resource allocation, timelines, and potential risks, is finalized.

Data Collection and Preparation (2-4 weeks): Depending on the availability and quality of data, this phase involves collecting, cleaning, and preprocessing the data needed to train and evaluate the model. This may require data gathering, labeling, and transformation tasks.

Model Development (4-8 weeks): Here, the actual development of the model or prototype takes place. Depending on the complexity, this phase may include implementing and fine-tuning machine learning algorithms, designing and training neural networks, or developing rule-based systems.

Testing and Evaluation (2-4 weeks): The model or prototype is rigorously tested and evaluated against predefined metrics and criteria. This phase includes validating the model's performance, identifying and resolving issues, and iterating on the design if necessary.

Documentation and Reporting (1-2 weeks): The project documentation, including technical specifications, user guides, and any relevant reports, is prepared. This ensures that the project outcomes are well-documented and can be easily understood by stakeholders.

Deployment and Feedback (ongoing): Once the model or prototype is deemed satisfactory, it can be deployed to the intended environment. Continuous monitoring, user feedback, and potential updates are essential to ensure the model's effectiveness and address any emerging issues.

It's important to note that these timeframes are approximate and can vary significantly depending on the specific project requirements, team size, and other factors. It's recommended to conduct a detailed project scoping and estimation exercise to generate a more accurate time schedule for your specific development project.

Modeling Plans

In this activity, you will start to plan your model. Like anything, the more planning you do in advance, the better your chances of achieving what you want. It's best to put answers to the questions below in your design.

1. What do you want or need a model of? (List at least three possibilities.)
2. For each model possibility, consider the following questions and answer them in your design:
   a. Is this a system or a component of your design project?
   b. What will this model help you understand about your idea?
   c. Will it be a small or full-scale version?
   d. What will you need to build it?
   e. What materials on hand will work for your model?
   f. What is not on hand for building your model?
3. As you plan, you may select and manipulate different materials. Be sure about the materials that you study: their flexibility, strength, and suitability as a modeling material.

Tip: When planning your model, it is better to plan to build a bigger model so that the details can be seen, tested, and understood.

Self-check .1.

Part I:-

Directions: Answer all the questions listed below & circle the answer on the later

1. Drawing instructions and specifications are essential in various fields, including

   A. engineering, B. architecture, C. Manufacturing and design D.all

2. ---------- is begin by creating a detailed 3D model of the desired object using computer-aided design (CAD) software

   A. Slice the Model B. Model Design

   C. Software Preparation D. Drawing Parameters

3. --------measures or inspections that need to be performed during or after the growing process..

   A. Documentation: C. Material Selection

   B. Quality Control D. Documentation:

4. Developing a model or prototype can vary significantly depending on

   A. the complexity of the project C. available resources

   B. Team expertise D. all

5. ---------- is the process, such as layer thickness, printing speed, temperature, material type, and any other relevant settings

   A. Material Selection C. Drawing Parameters

   B. Documentation D. Model Design

PART **II:-**

Directions true or false

1. In order to thoroughly analyses a design process, or to develop a support system for a design process, a model is indispensable
2. The end product of design is often a specification that will be interpreted and implemented by someone else.
3. Any new idea or design has to be tested and verified at its initial stages from the point of view of an end-user before taking shape into a finished product and being launched to the market.
4. When planning your model, it is better to plan to build a bigger model so that the details can be seen, tested, and understood
5. The interaction between design decisions concerned with geometry and those concerned with materials is more obvious than it might appear to be at first
6. Requirements are general ways that the designer/engineer will meet the needs of the users

Unit two: - Layout model

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Model design
- Cost estimation
- Engineering Standards
- Properties of Datum boards, jigs and fixtures

This unit will also assist you to attain the learning outcomes stated in the cover page.
Specifically, upon completion of this learning guide, you will be able to:

4.1. Conceptualize and plan finished model design

4.2. Accomplish estimated cost calculation for models

4.3. Calculate contractions allowances, clearances, tapers etc.

4.4. Design and manufacture datum boards, jigs and fixtures

2.1. Model design

Layout design is the process of arranging visual and textual elements on-screen or on-paper in order to grab a reader's attention and communicate information in a visually appealing way. Layout design can be used for various purposes, such as creating websites, posters, flyers, magazines, books, presentations, info graphics and more. Layout design involves using one or more grids to organize the elements and create a balanced and harmonious composition. Grids are the backbone of layout design, as they help maintain consistency, alignment and hierarchy among the elements. There are different types of grids that can be used for layout design, such as column grids, modular grids, hierarchical grids and asymmetrical grids. Each type of grid has its own advantages and disadvantages depending on the content and the purpose of the design. Layout

design also requires an understanding of the principles of design, such as contrast, repetition, alignment, proximity, balance, scale, color and typography. These principles help create visual interest, harmony and clarity in the layout. Layout design is both an art and a science, as it requires creativity and logic to achieve effective communication

Begin to make your idea tangible-going from what's in your mind to things in your hand. Build initial models. This could be a model of the overall design, a model of a single working component, or a test of materials for a single part. Later, you will build working prototypes to test form and function of your designs.

Key Concepts

Both models and prototypes are constructions that determine if a design or components of a design will work in both form (how does it look and feel) and function (does it work?).

Both models and prototypes are used to:

- Test and trial a concept.
- Test and trial the way something looks or feels to the user.
- Try out dimensions and fit between components.
- Test a mechanism or subsystem of a design.

Model: Models can be visual representations of a total design that is nonfunctional. Or, they represent some aspect (form or function) of a specific component. The steps of the design process rarely happen one after another but often are repeated or revisited in many cycles (or iterations) of change that lead to improvements. For example, drawing your idea may have caused you to revise your requirements in some way. In fact, with each step in the process that makes your idea more real (moving from "think" to "thing"), revisions can get more comprehensive as you see new ways of looking at your idea— you might even throw out a solution and go back to an earlier idea.

It's time to make project ideas tangible-to go from what's in your mind to things in your hands. You are now at the stage of building models-a way to test, revises, and improves your design. Models allow you to see your idea as a "trial run." You might build a model to test dimensions and fit between components. Or you might build a model to test a mechanism or some system in your project.

- Model is small but exact copy of something. Eventually you will build a prototype- a model that works. Models tend to be smaller in scope than prototypes; they are not as concerned with representing a final product in functionality, size, materials, and scope.
- Prototype is working model of a machine or other object used to test it before producing the final version.

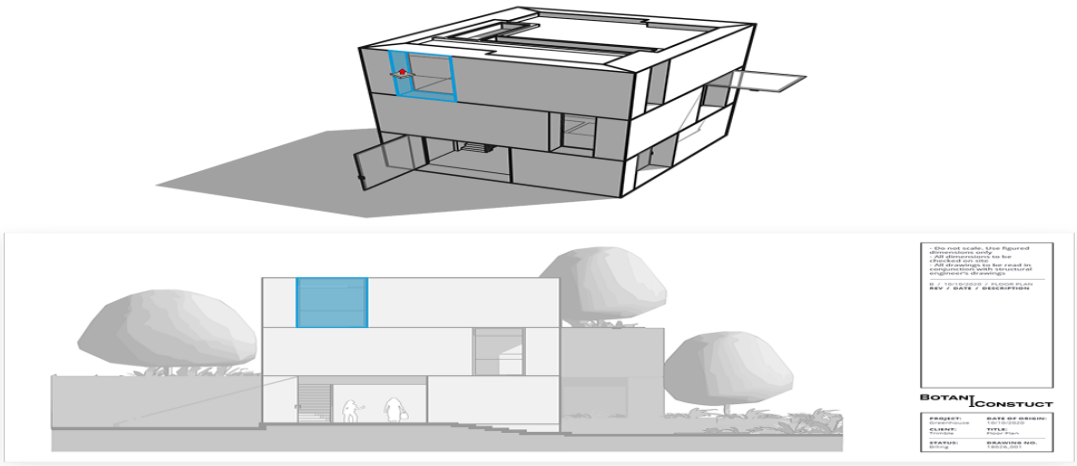


Fig 2.1.1Associative dimensions

Need to make a change to your model? Lay Out instantly updates dimensions, labels, and model geometry when you make the change in Sketch Up Easy.

2.2. Cost estimation

A **cost estimate** is the approximation of the cost of a program, project, or operation. The cost estimate is the product of the cost estimating process. The cost estimate has a single total value and may have identifiable component values.

A problem with a cost overrun can be avoided with a credible, reliable, and accurate cost estimate.

A cost estimator is the professional who prepares cost estimates.

There are different types of cost estimators, whose title may be preceded by a modifier, such as building estimator, or electrical estimator, or chief estimator.

Other professionals such as quantity surveyors and cost engineers may also prepare cost estimates or contribute to cost estimates.

Manufacturing cost is the sum of costs of all resources consumed in the process of making a product. The manufacturing cost is classified into three categories: direct materials cost, direct labor cost and manufacturing overhead. It is a factor in total delivery cost

Direct materials costs are the raw materials that become a part of the finished product. Manufacturing adds value to raw materials by applying a chain of operations to maintain a deliverable product. There are many operations that can be applied to raw materials such as welding, cutting and painting. It is important to differentiate between direct materials and indirect materials.

The direct labour cost is the cost of workers who can be easily identified with the unit of production. Types of labour who are considered to be part of the direct labour cost are the assembly workers on an assembly line.

Manufacturing overhead is any manufacturing cost that is neither direct materials cost nor direct labour cost. Manufacturing overhead includes all charges that provide support to manufacturing.

Manufacturing overhead includes

- **Indirect labour cost**: The indirect labour cost is the cost associated with workers, such as supervisors and material handling team, who are not directly involved in the production.
- **Indirect materials cost**: Indirect materials cost is the cost associated with consumables, such as lubricants, Grease (lubricant)|grease and water, that are not used as raw materials.
- **Other indirect manufacturing cost**: includes machine depreciation, land rent, property insurance, electricity, freight and transportation, or any expenses that keep the factory operating**.**

When you have your inspired idea for a new product, you're thinking about all the problems it will solve and the features in design magazines it's going to get. What probably doesn't cross your mind is how much getting to that point is going to cost.

Whether you're an old hand at bringing products to market or this is your first time looking into the process, knowing how deep your pockets are going to need to be is vital. If you don't get your cost estimations right, there are going to be some serious effects.

A big chunk of your investment into your product will come at the designing and prototyping stage. This is where a lot of money will get spent on prototype design services while no cash is rolling in, and knowing the price of things ahead of time isn't always easy. That's why doing a Price Cost Estimate (PCE) is important

Once you've got through the design stage, you will have begun racking up a fair amount of costs. If your early price cost estimates were done with some detail, you shouldn't be surprised at your investment up to this point.

Along with a pile of invoices and expenses, you will also have a Bill of Materials. This is a list, likely a spread sheet; of everything you are going to need to produce a single unit of your product. Done properly, this document will have started out with some general ideas and morphed into a list of every single piece needed.

To get a cost estimate for your prototype, you can start by adding together the price of one of everything on this list. Add to that the cost of your prototype design engineering services and you've got a reasonable idea of how much you need to spend on your prototype. Just remember, everything you've spent up to this point also goes into the final costs.

Challenges of Cost Estimation

According to a study out of Aberdeen University, the three biggest challenges when managing costs on a project that is producing a product are:

1. **A lack of overall perspective,** meaning that the big picture is looked at early on so that costs just roll in without having an understanding of where they belong in the process. This is why you need to be assessing your costs at every stage, plugging in your new data into your current estimates, and moving from qualitative to quantitative estimation as you know more details
2. **Taking too long to understand costs** means that decisions can get held up. For example, if your designer needs to know whether to use aluminum or magnesium alloy to finalize the 3D model but you have to do a load of calculations in a spreadsheet, things can get held up. Planning ahead and understanding your cost variable early on will make things quicker

3. **Raw material cost fluctuations** aren't really something you can have much of an effect on for some products. However, you can think smart when you're conceptualizing and designing and choose materials that have less volatile market prices

Knowing these challenges before getting started in estimating costs of design and prototyping will help you choose the right methods of calculation for you.

The costs of getting your idea through the design and prototype stages and heading towards production cover three main areas:

- The materials that will be used
- The costs of hiring the people to design and engineer your product
- Fixed costs for running the business

It's not always easy to get an accurate estimate of these costs, and that's why there are plenty of people who make a lucrative career out of being a cost estimator. The complexity of the item you want to produce will decide whether you need to bring in a professional 3D modeling design freelancer or whether to do it yourself.

In the end, the things that will influence the costs of your design and prototype are:

- The complexity of what you want to make
- What you will make it out of
- Who you will use to move you through the process
- The level of custom and standard parts used
- How innovative your product is

2.3. Engineering Standards

The main technical standards shall be determined after economic comparisons which figure out the project role in railway network, transport demand, engineering specification to meet the demand of travel time target.

Engineering standards are documents that establish uniform engineering or technical criteria, methods, processes and practices. They are usually developed by professional organizations or committees that have expertise in the relevant field. Engineering standards can serve various

purposes, such as ensuring the quality, safety, reliability, compatibility, interoperability, efficiency, or performance of products, services, systems, or processes. Engineering standards can also facilitate innovation, communication, collaboration, and trade among engineers and other stakeholders.

Some examples of engineering standards are:

IEEE Standards: These are standards developed by the Institute of Electrical and Electronics Engineers (IEEE), a leading professional association for the advancement of technology. IEEE standards cover a broad range of topics, such as electrical engineering, computer engineering, communications, robotics, artificial intelligence, biomedical engineering, and more.

ASME Codes and Standards: These are standards developed by the American Society of Mechanical Engineers (ASME), a professional organization that promotes the art, science, and practice of mechanical engineering. ASME codes and standards cover various aspects of mechanical engineering, such as pressure technology, power plants, elevators, construction equipment, piping, nuclear components, and more.

PFI Standards: These are standards developed by the Pipe Fabrication Institute (PFI), a trade association that represents the interests of the pipe fabrication industry. PFI standards provide guidance for the design, fabrication, installation, and inspection of piping systems and components.

2.1.1. Allowances,

Pattern Making Allowances

- Patterns are not made to the correct sizes of the castings. This extra size given on the pattern is called pattern allowance.
- Pattern allowances are given for the purpose of compensating the metal shrinkage, to provide extra metal for machining, to avoid metal distortion, for easy withdrawal of pattern from mould and for rapping.
- If allowances are not given on the pattern, the castings will become smaller (i.e) undersize.

The various types of pattern allowances are:

1. Shrinkage allowance
2. Machining or finish allowance
3. Draft allowance
4. Distortion allowance

(1) *Shrinkage allowance:* - When any metal cools, it naturally shrinks in size. Hence, if the actual object itself is used for the pattern, the resulting casting would be slightly smaller than desired. To compensate for this possibility, a shrink rule is used in laying out of measurements for the pattern. A shrink rule for cast iron is 10 mm per meter (the average shrinkage for cast iron) longer than the standard rule. When metal patterns are to be cast from the original patterns, double shrinkage must be allowed.

In other words shrinkage allowance is:

a. When molten metal is poured into the mould it will solidify and cool.
b. During cooling, the metal will shrink and reduce in size.
c. To compensate this, the pattern is made larger than the required casting.
d. This extra size given on the pattern for metal shrinkage is called shrinkage allowance.

If shrinkage allowance is not given, the casting will become smaller. Cast iron

Cast iron	10 mm per meter
Steel	15 mm per meter
Brass	14 mm per meter
Aluminum	18 mm per meter
Aluminum Alloys	13.3 to 17.0 mm per meter
Bronze	10.4 to 20.8 mm per meter
Magnesium	14.0 mm per meter

Manganese steel	26.5 mm per meter

Fig2.3.1. Shrinkage allowance for various metals

(2) Draft allowance: - When a pattern is drawn out from a mould, the tendency to tear away the edges of the mould in contact with the pattern is greatly decreased if the surfaces of the pattern are given a slight taper in a direction parallel to which it is being withdrawn. This tapering of the sides of the pattern, known as draft, is done to provide a slight clearance for the pattern as it is lifted up. The amount of draft on exterior surfaces is about 1 to 2 mm per meter. On interior holes, which are fairly small, the draft should be around 3 mm per meter. In other words draft allowance is

- When a pattern is removed from the mould, the edges of the mould may be damaged.
- This can be avoided by giving a taper on the vertical surfaces of the pattern.
- This slight taper given on the vertical sides of the pattern is called draft allowance.
- The draft usually given is 3 mm per meter..

(3) Machining or Finish allowance: - When a draftsman draws up the details of a part to be made each surface to be machined is indicated by a finish mark. The mark indicates that additional metal must be provided at this point so that there will be some metal to machine. The amount that is to be added depends upon the size, shape of casting, but in general, the allowance for small castings and average sized castings is 3 mm. In other words machining or finish allowance is:

- All the castings are to be machined to finish the rough surfaces and to remove excess metal.
- For this purpose the pattern is made larger than the required casting.
- This extra size added to the pattern for machining purpose is called machining or finish allowance.
- In general, a machining allowance of 3 mm is given for ferrous metals.

- For non-ferrous metals like brass and aluminum a machining allowance of 1.5 mm is given.

Machining Allowances

- Cast iron 3 mm (medium) 10 mm (large).
- Steel 4.5 mm (medium) 12 mm (large)
- Brass, Bronze , Aluminum 1.5 to

(4) ***Distortion Allowance:*** **-** This allowance applies only to those castings of irregular shapes, which are distorted in the process of cooling as a result of metal shrinkage

Such an allowance depends on the judgment and experience of the pattern maker, who understands the shrinkage characteristics of the metal. In other words distortion allowance is:

- Some castings, because of their shape and size may warp or distort during cooling.
- This is due to uneven metal thickness.
- To avoid this, the shape of the pattern is slightly bent in the opposite direction.
- For example, a casting of U shape may distort and the legs become divergent, instead of being parallel.
- To avoid this, the legs are slightly bent convergent. So after cooling, the legs will become parallel and correct.

2.3.2. Clearances,

Clearance is the gap or space between two mating parts, such as a shaft and a hole. Tolerance and clearance affect the quality, performance, and reliability of the product, as well as the ease and cost of assembly.

The term “mechanical clearance” is here defined as the application of machines as the primary clearance method to remove and/or destroy mines and unexploded ordnance (UXO) from a given area to the quality of clearance laid down for clearance by the International Mine Action Standards (IMAS).

Usually, clearance is measured in **L/h or mL/min**. The quantity reflects the rate of drug elimination divided by plasma concentration. Excretion, on the other hand, is a measurement of the amount of a substance removed from the body per unit time

2.3.3. Tapers

Taper is a word used to refer to a geometrical shape that describes geometry with a gradual reduction in cross-sectional area. Machining tools commonly have a tapered end designed to aid the changing of tools.

All propellers in stock at Tech Pro Max have the standard taper 1:10. This means that the difference between the largest and the smallest diameter of the tapered hole represents 10% of the length of the propeller's boss (D-d=0.1 x L).

1. Tapers - charts and how to measure

You can measure the taper bore of a propeller with digital vernier calipers.

Measure the small end to the taper inside diameter of propeller - nut end I.D. (inside diameter) Measure the large end to the taper inside diameter of propeller - front end I.D. (inside diameter) Measure the overall length of the boss (hub) of propeller Measure the keyway width.

Check how the old prop fits the taper shaft and the amount of draw - i.e. the overhang distance at the nut end so the prop tightens on the taper properly.

Propeller tapers are often not to any standard which makes this game a challenge. There are 4 common tapers used - 1 in 10 , 1 in 12 , 1 in 16 and 1 in 20 and then there are odd back yard ones.

Also check and confirm PROPELLER ROTATION - L/H or R/H - A Right hand propeller rotates clockwise when viewed from astern facing forward. A Left hand propeller rotates counter clockwise when viewed astern facing forward. On a twin screw vessel the left hand prop is normally fitted to the port side.

2.4. Properties of Datum boards, jigs and fixtures

2.4.1. Datum boards

Datum: It is a theoretically exact geometric reference (such as axes, planes, straight lines, etc.) to which the tolerance features are related.

Datums are theoretically exact points, axes, lines, and planes or a combination thereof that is derived from datum features. A datum feature is the tangible surface or feature of size (comprised of multiple surfaces or revolved surfaces) that is indicated by the datum feature symbol.

Datum feature

A datum feature is a feature of a part, such as an edge, surface, or a hole, which forms the basis for a datum or is used to establish its location

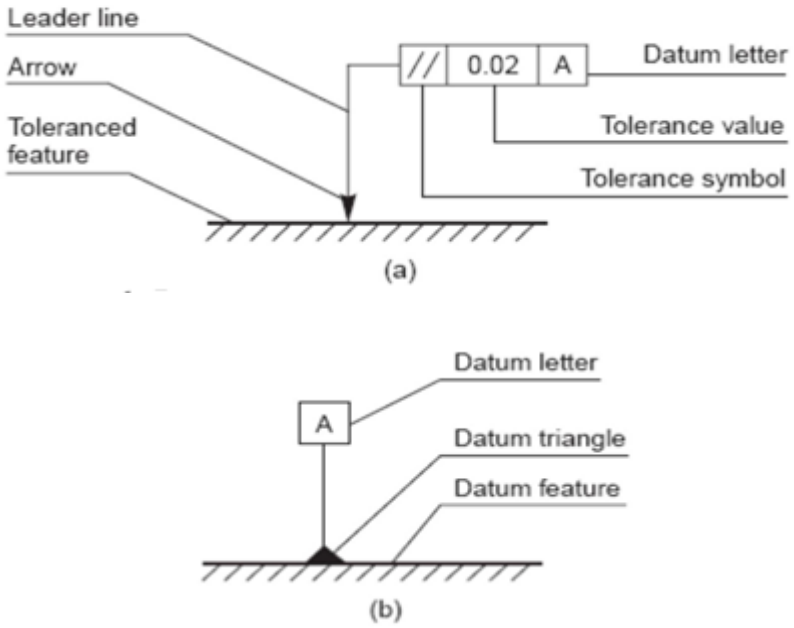


Fig2.4.1. Datum Features

Datum triangle: The datum is indicated by a leader line, terminating in a filled or an open triangle (Figure 2.4.1 b).

Datum Letter: To identify a datum for reference purposes, a capital letter is enclosed in a frame, connected to the datum triangle (Figure 2.4.1)

The datum feature is the feature to which tolerance of orientation, position and run-out are related. Further, the form of a datum feature should be sufficiently accurate for its purpose and it may therefore be necessary in some cases to specify tolerances of form from the datum features

Surface Finish Specification

Considering the trace of a supposedly flat surface, the 'flat' surface is far from a perfect straight line. Things related to the machine tool, such as vibrations and slide-way inaccuracies cause the long wavelength deviations where the undulations are of the order of millimeters. These deviations are the *surface finish*. They are of the order of tens of microns and they are the machining marks. They are caused by a combination of the tool shape and the feed across the work piece. In many instances the surface finish and texture can have a significant influence on functional performance.

Surface Roughness

The geometrical characteristics of a surface include,

1. Macro-deviations,
2. Surface waviness, and
3. Micro-irregularities.

The surface roughness is evaluated by the height, *Rt* and mean roughness index *Ra* of the micro-irregularities. Following are the definitions of the terms indicated in Figure Fig 2.4.2.

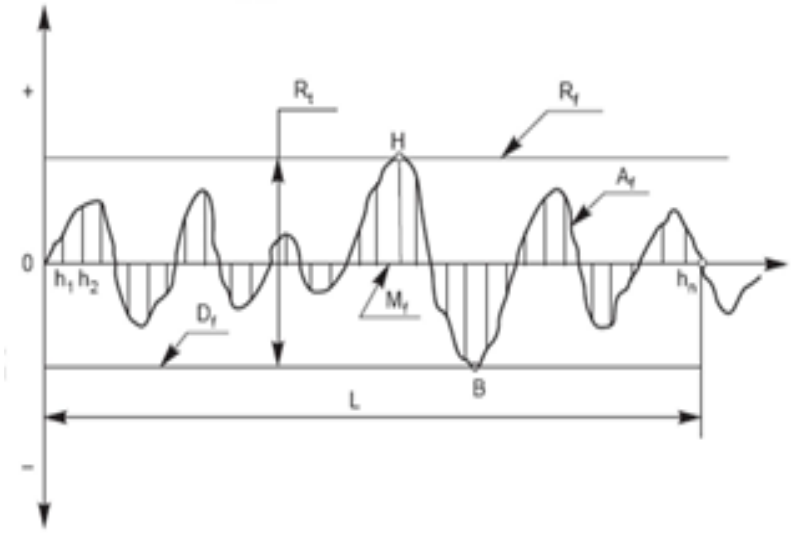


Fig2.4.2. Definitions of the terms

Actual Profile, AF

It is the profile of the actual surface obtained by finishing operation

Reference Profile, Rf

It is the profile to which the irregularities of the surface are referred to. It passes through the highest point of the actual profile.

Datum Profile, Df

Mean Profile, Mf

It is that profile, within the sampling length chosen (*L*), such that the sum of the material filled areas enclosed above it by the actual profile is equal to the sum of the material- void areas enclosed below it by the profile.

Peak to Valley Height, Rt

It is the distance from the datum profile to the reference profile.

Mean Roughness Index, Ra

It is the arithmetic mean of the absolute values of the heights *hi* between the actual and mean profiles.

Surface Roughness Number

The surface roughness number represents the average departure of the surface from perfection over a prescribed sampling length, usually selected as 0.8 mm and is expressed in microns. The measurements are usually made along a line, running at right angle to the general direction of tool marks on the surface. Surface roughness values are usually expressed as the *Ra* value in microns.

Indication of Surface Roughness

The value or values, defining the principal criterion of roughness, are added to the symbol as shown in Figure

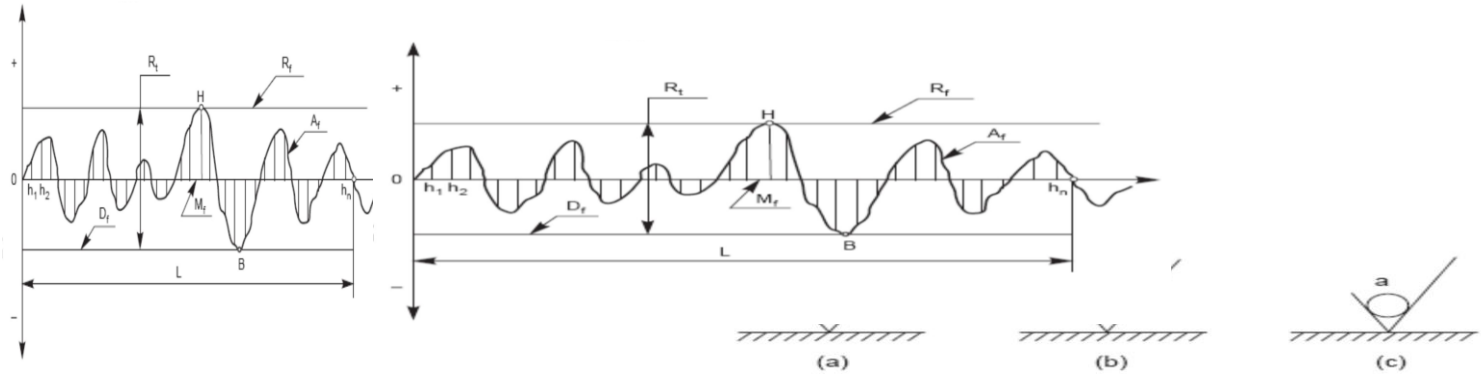


Figure2.4.3. Symbol for surface roughness

A surface texture specified

- as in Figure 2.4.3. *a*, may be obtained by any production method
- as in Figure 2.4.3. *b*, must be obtained by removal of material by machining.
- as in Figure 2.4.3. *c*, must be obtained without removal of material.

When only one value is specified to indicate surface roughness, it represents the maximum permissible value. If it is necessary to impose maximum and minimum limits of surface roughness, both the values should be shown.

The principal criterion of surface roughness, R*a* may be indicated by the corresponding roughness grade number, as shown in Table 2.4.1.

Table 2.4.1 Equivalent surface roughness symbols

Roughness values R_a *µm*	*Roughness grade number*	*Roughness grade symbol*
50	N12	
25	N11	
12.5	N10	
6.3	N9	
3.2	N8	
1.6	N7	
0.8	N6	
0.4	N5	
0.2	N4	
0.1	N3	
0.05	N2	
0.025	N1	

Surface finish reference

Common surface finishes for shafts are:

- ≤ 50 mm. diameter = 32 Ra finish maximum
- 50 mm. diameter = 65 Ra finish maximum for straight shafts
- 50 Ra finish maximum for tapered shafts

Machined surface finishes for shafts and housings

The inner and outer ring seats should be smooth and within specified tolerances for size, roundness and taper. Ground finish is usually suggested for shafts whenever possible.

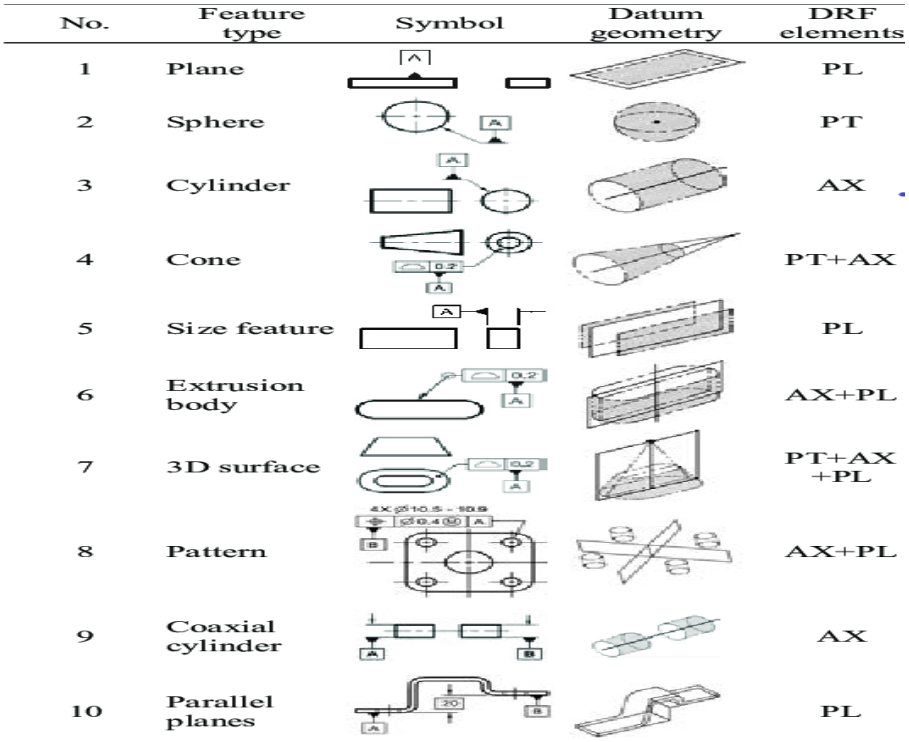
The suggested finish for ground and turned surfaces is:

- Inner ring seats – Ground: 1.6 Ra micrometers (65 micro inches) maximum
- Inner ring seats – Turned: 3.2 Ra micrometers (125 micro inches) maximum
- Outer ring seats – Turned: 3.2 Ra micrometers (125 micro inches) maximum

Bearing seat finishes rougher than these limits reduce the contact area between the bearing and the seat. This can create a more loose fit, especially if the ring is pressed on and off several times.

A datum feature can be a plane, line, or point—these are selectively used depending on the tolerance and feature you need to specify.

- Datum Plane.
- Datum Line.
- Point.



No.	Feature type	Symbol	Datum geometry	DRF elements
1	Plane			PL
2	Sphere			PT
3	Cylinder			AX
4	Cone			PT+AX
5	Size feature			PL
6	Extrusion body			AX+PL
7	3D surface			PT+AX +PL
8	Pattern			AX+PL
9	Coaxial cylinder			AX
10	Parallel planes			PL

Fig2.4.2.Major Types of Datum Features

Datums are indicated using the following symbols (datum symbols). Datum symbols use either a white or black triangle. The letters indicating the datums are always oriented to the direction the reader looks at the drawing. The position of the datum symbol on the drawing is also relevant to the target area.

2.4.2. Jigs and fixtures

Jigs and fixtures are special purpose tools which are used to facilitate production (machining, assembling and inspection operations) when work pieces are to be produced on a mass scale The mass production of work pieces is based on the concept of interchangeability according to which every part will be produced within an established tolerance. Jigs and fixtures provide a means of manufacturing interchangeable parts since they establish a relation, with predetermined tolerances, between the work and the cutting

tool. They eliminate the necessity of a special set up for each individual part. Once a jig or fixture is properly set up, any number of duplicate parts may be readily produced without additional set up.

jigs are work holding device that holds, supports and locates the work piece and guides the cutting tool for a specific operation but. fixtures are also work holding device that holds, supports and locates the work piece for specific operation , does not guide the cutting tool.

Hence jigs and fixtures are used:

1. To reduce the cost of production, as their use eliminates the laying out of work and setting up of tools.
2. To increase the production.
3. To assure high accuracy of the parts.
4. To provide for interchangeability.
5. To enable heavy and complex-shaped parts to be machined by being held rigidly to a machine
6. Reduced quality control expenses.
7. Increased versatility of machine tool.
8. Less skilled labor.
9. Saving labor.
10. Their use partially automates the machine tool.
11. Their use improves the safety at work, thereby lowering the rate of accidents.

A jig may be defined as a device which holds and positions the work, locates or guides the cutting tool relative to the work piece and usually is not fixed to the machine table. It is usually lighter in construction.

A fixture is a work holding device which only holds and positions the work, but does not in itself guide locate or position the cutting tool. The setting of the tool is done by machine adjustment and a setting block or by using slip gauges. A fixture is bolted or clamped to the machine table. It is usually heavy in construction.

Jigs are used on drilling, reaming, tapping and counter boring operations, while fixtures are used in connection with turning, milling, grinding, shaping, planning and boring operations. To fulfill their basic functions, both jigs and fixtures should possess the following components or elements:

1. A sufficiently rigid body (plate, box or frame structure) into which the work pieces are loaded.
2. Locating elements.

3. Clamping elements.
4. Tool guiding elements (for jigs) or tool setting elements (for fixtures).
5. Elements for positioning or fastening the jig or fixture on the machine on which it is used.

Locating pins are stops or pins which are inserted in the body of jig or fixture, against which the work piece is pushed to establish the desired relationship between the work piece and the jig or fixture. To assure interchangeability, the locating elements are made from hardened steel. The purpose of clamping elements is to exert a force to press a work piece against the locating elements and hold it there in opposition to the action of the cutting forces. In the case of a jig, a hardened bushing is fastened on one or more sides of the jig, to guide the tool to its proper location in the work. However, in the case of a fixture, a target or set block is used to set the location of the tool with respect to the work piece within the fixture.

Most jigs use standard parts such as drill bushings, screws, jig bodies and many other parts. Fixtures are made from grey cast iron or steel by welding or bolting. Fixtures are usually massive bodies because they have to withstand large dynamic forces. Because the fixtures are in between the machine and the work piece, their rigidity and the rigidity of their fastening to the machine table are most important. Jigs are positioned or supported on the machine table with the help of feet which slide or rest on the machine table. If the drill size is quite large, either stops are provided or the jig is clamped to the machine table to withstand the high drilling torque.

The jigs and fixtures are the economical ways to produce a component in mass. So jigs and fixtures are used and serve as one of the most important facility of mass production system. The following are the purpose and advantages of jigs and fixtures:

1) It reduces or sometimes eliminates the efforts of marking, measuring and setting of work piece on a machine and maintains the accuracy of performance.
2) The work piece and tool are relatively located at their exact positions before the operation automatically within negligible time. So it reduces product cycle time.
3) Variability of dimension in mass production is very low so manufacturing processes supported by use of jigs and fixtures maintain a consistent quality.
4) Due to low variability in dimension assembly operation becomes easy, low rejection due to les defective production is observed.

5) It reduces the production cycle time so increases production capacity.
6) Simultaneously working by more than one tool on the same work piece is possible.
7) The operating conditions like speed, feed rate and depth of cut can be set to higher values due to rigidity of clamping of work piece by jigs and fixtures.

Operators working become comfortable as his efforts in setting the work piece can be eliminated.

Semi-skilled operators can be assigned the work so it saves the cost of manpower also.

There is no need to examine the quality of produce provided that quality of employed jigs and fixtures is ensured.

Designing of jigs and fixtures depends upon so many factors. These factors are analyzed to get design inputs for jigs and fixtures. The list of such factors is:

a. Study of work piece and finished component size and geometry.
b. Required level of the accuracy in the work and quality to be produced.

Jigs along with fixtures are specifically designated machine parts, which can be manufactured by any of the following methods:

a. Machining,
b. Forging, and
c. Casting.

Self-Check 2.

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Both models and prototypes are used to:
   A. Test and trial a concept.
   B. Test and trial the way something looks or feels to the user.
   C. Try out dimensions and fit between components.
   D. Test a mechanism or subsystem of a design.
   E. All
2. ----------is small but exact copy of something
   A. Design B. Model C, project D. prototype
3. ----------is working model of a machine or other object used to test it before producing the final version.
   A. Model B, project C. Prototype D. Design
4. ----------is the cost of workers who can be easily identified with the unit of production.
   A. Direct labour cost C. Direct
   B. Manufacturing cost D. all
5. Manufacturing overhead cost includes
   A. Indirect labour cost
   B. Indirect materials cost
   C. Other indirect manufacturing
   D. All

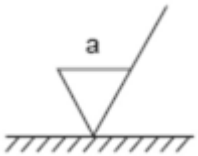
Part **II:-**

Directions true or false

1. Layout design is the process of arranging visual and textual elements on-screen or on-paper
2. Manufacturing cost is the sum of costs of all resources consumed in the process of making a product.
3. Indirect materials cost the cost associated with workers, such as supervisors and material handling team, who are not directly involved in the production.
4. Indirect materials cost is the cost associated with consumables, such as lubricants, Grease (lubricant)|grease and water, that are not used as raw materials.
5. This extra size given on the pattern for metal shrinkage is called shrinkage allowance.

Part III

Direction:- Matching

A	B
1. Shrinkage allowance Cast iron	A. 
2. Shrinkage allowance Aluminum	B. 18 mm per meter
3. Datum letter	C. 
4. Datum feature	D. 10 mm per meter
5. Surface roughness Must be obtained by removal of material by machining	E. 

Unit three: - Manufacture model

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

4.5. Sequence of manufacturing model

4.6. machines and machining processes Select ion

4.7. Hand- and hand-held power tools Selection

4.8. Measurement & calculations

4.9. Components assembling

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

4.10. Determine sequence of manufacture, including build-up on datum board, establishing datum's mark out of model and areas

4.11. Select appropriate machines and machining processes

4.12. Select and use a range of hand- and hand-held power tools

4.13. Undertake appropriate measurement/calculations

4.14. Assemble all components

3.1. Sequence of manufacturing model

The manufacturing sequence influence, to a large extent, component properties like fatigue life, shape accuracy and manufacturability. By simulating the manufacturing sequence, using numerical or empirical models, and extracting important accumulated data, like residual stress, hardness and shape, the possibilities of early analysis of a design concept and the associated manufacturing sequence will increase. An established methodology has the potential of reducing physical testing and the time and costs of product design and process planning.

The development of the manufacturing industry relies on research into manufacturing processes and materials and the development of new products. Global competition forces manufacturing companies to continuously optimize process sequence performance and efficiency in order to assure product quality and competitiveness. Manufacturing sequence (MS) optimization refers to at least two manufacturing processes in consideration of one or more target criteria. The objective of process chain design is a target-oriented

arrangement of adequate processes depending on certain component characteristics as defined by the design specifications, to enable highly efficient manufacturing. The purpose of modeling and simulation of manufacturing sequences is to improve efficiency in product design and process planning. This will lead to the economic manufacturing of high-quality products with the greatest possible productivity.

- **Manufacture model**

Making Models

A model is worth a thousand words. If your idea is an idea for a product for which you already have a rough concept of shape, a three dimensional model or even just a reasonable mock-up that looks like your design will, but is not necessarily to scale, will also help if your design is not easy to visually describe in a sentence or two. If 3 or more out of 10 people don't understand the design when described in words, a model is almost an essential.

Manufacture

Once the design and planning for manufacture have been completed, the manufacturing can begin. If the planning has been well done, there should not be too many problems. During manufacture the following are the most common factors that can affect quality:

(a) **Set-up**. Some processes, such as punching, cutting, printing and labeling, are so consistent that, if the initial set-up is correct, the whole lot will conform to the specifications. However, the initial set-up has to be checked by carrying out first-piece inspection;

(b) **Machines and tools**. From time to time changes can occur in machine or tool settings, which can then lead to defects. Processes of this type include machining, resistance welding and filling. Here it is necessary to carry out periodic checks by patrol inspection;

(c) **Operator.** There are some processes where the result depends on the skill and attention of the operator, such as welding, hand soldering and painting processes. For such processes it is necessary at the manufacture planning stage for the operator's working methods to be decided upon;

(d) **Materials and components.** It is important to ensure the quality of raw materials and components by undertaking regular checks on the suppliers' processes and also where necessary by carrying out incoming inspection.

Datum: It is a theoretically exact geometric reference (such as axes, planes, straight lines, etc.) to which the tolerance features are related.

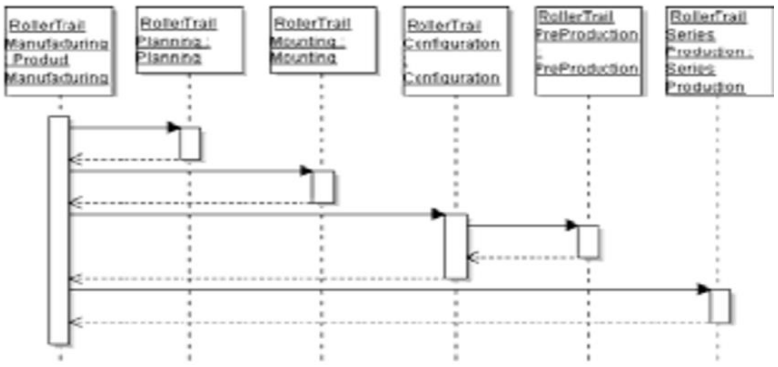


Fig3.1.1. Sequence diagram of manufacturing process

Manufacturing a precision model typically involves several sequential steps to ensure accuracy and quality. Here is a general sequence of the manufacturing process for a precision model:

1. **Design:** The first step is to create a detailed design of the precision model using computer-aided design (CAD) software. The design will specify the dimensions, features, and tolerances of the model.
2. **Material Selection**: Select the appropriate material for the precision model based on its intended use and desired properties. Common materials used for precision models include metals (such as aluminum or steel) or engineering plastics (such as nylon or ABS).
3. **Prototyping**: Before proceeding with full-scale production, it is often beneficial to create a prototype of the precision model. Prototyping allows for testing and validation of the design and can help identify any necessary design modifications or improvements.
4. **Tooling**: Once the design is finalized, specialized tools and fixtures are created to aid in the manufacturing process. These tools may include molds, dies, jigs, or other custom equipment needed for specific manufacturing steps.
5. **Machining**: Precision models often require machining processes such as milling, turning, drilling, or grinding. Computer Numerical Control (CNC) machines are commonly used for precise and accurate machining operations.
6. **Finishing**: After machining, the precision model may undergo various finishing operations. This can include surface treatments such as polishing, deburring, sandblasting, or coating to enhance the appearance or functionality of the model.

7. **Assembly:** If the precision model consists of multiple components, the assembly process is performed. This involves joining the different parts together using techniques like welding, adhesive bonding, or fasteners.
8. **Inspection and Quality Control**: Throughout the manufacturing process, inspections and quality control checks are conducted to ensure that the precision model meets the required specifications. This can involve dimensional measurements, visual inspections, or non-destructive testing methods.
9. **Testing and Validation**: Once the precision model is manufactured, it may undergo functional testing or performance validation to ensure that it meets the intended requirements. This can include tests for strength, durability, accuracy, or any other relevant performance criteria.
10. **Packaging and Shipping**: Once the precision model has passed all inspections and tests, it is packaged appropriately to protect it during transportation. The model is then shipped to its intended destination.

It's important to note that the specific sequence and steps may vary depending on the complexity of the precision model, the manufacturing techniques used, and the industry requirements.

3.2. Machines and machining processes

The selection of machine-tools is largely a matter of judgment, based on the consideration of many variable factors. No fixed rules can be laid down, but the uses to which the machines are put are divided roughly into three classes which govern to a large extent the types of machine that should be purchased, whether they should be machines of a wide range of usefulness, standardized machines equipped with special tooling or special-purpose machines of special design capable of very large and continuous production. To determine into which of these classes the requirement for new machines falls, an analysis should be made of the following factors: (*a*) quantity of production required and its duration, (*b*) method of machining and tolerances and finish required, (*c*) possibility of a change in design of the product, (*d*) cost of production, (*e*) when delivery of machine is required, and (*f*) money available for the purchase

When the type of equipment needed has been decided, an inquiry to elicit offers of machine-tools and quotations of prices may be broadcast through trade journals or addressed to a selected list of machine-tool builders. The former method is not recommended as it usually

brings representatives of firms that build other types of equipment as well as the particular type desired. Information given in the inquiry should be as complete as possible and in the case of a special machine should be accompanied by a rough sketch and a statement of the method of handling the work into and out of the machine, surfaces to be machined, work that has been performed in previous operations, hardness of the material and data on feeds and speeds, and, if possible, a sample of the work to be performed. The builder should be given as much latitude as possible in making his recommendations, because the buyer is dependent largely upon the manufacturer for information regarding new methods and processes that have been developed among machine-tool users.

3.3. Hand- and hand-held power tools Selection

Power tools are classified as either stationary or portable, where portable means hand-held. Portable power tools have obvious advantages in mobility. Stationary power tools, however, often have advantages in speed and precision.

Hand and Portable Power Tool Safety Program prescribes the duty to maintain tools and equipment; use hand and portable power tools in a safe manner; and to minimize injury and/or accidents associated with their use. This program is developed in accordance with the following Occupational Safety and Health Administration (OSHA) regulations

All hand and portable power tools must be maintained in a useable condition. The following applies to all hand and portable power tool maintenance and use to minimize hazards associated with their use.

- Maintain all tools in useable condition through following manufacturer recommendations for service. Store tools in the appropriate manner to minimize exposure to excessive temperature, humidity and corrosive materials and report defects or deficiencies associated with tools to departmental supervisors upon discovery.
- Use the appropriate tool for the job. Hand and portable power tools are designed and manufactured for specific uses. Supervisors shall ensure the proper tools are available to complete a job. If a task is required to be completed by an employee where an appropriate tool is not present, the supervisor shall ensure the job is not completed until the appropriate tool is available.
- Prior to use, tools and equipment should be inspected by the user to ensure they are in proper working order with no defects or deficiencies, which may result in unsafe use or injury to the user.

- Damaged tools and equipment must be removed from service and tagged to ensure unauthorized use does not take place.
- Operate tools and portable power equipment according to the manufacturer's specifications. Failure to do so may result in injury to the user.
- Proper personal protective equipment (PPE) must be provided and work areas must bead equate lighted for the work to be performed.
- Departments must maintain the following records as part of the hand and portable power tool safety program:
    - Employee training records
    - Specialized Standard Operating Procedures (SOPs)
    - Manufacturer specifications/manuals
    - Maintenance/service records

USE OF HAND TOOLS

Hand tools are non-powered, which includes axes, wrenches, screw drivers, hammers, etc. The greatest hazards posed by hand tools results from misuse and improper maintenance.

Employee instruction/training programs shall provide detailed training in the proper use of hand tools for the specific area of operations in which they will be working in. Attention will be given to tool selection, tool use, and proper personal protective equipment that are required to be used when operating the specific tool as outlined in the following sections:

3.4. Measurement & calculations

Precision model/prototype development often requires accurate measurements and calculations to ensure the design meets the required specifications. Here are some important considerations for measurement and calculations in precision model/prototype development:

1. Units of Measurement: Ensure that all measurements and calculations are performed using consistent units. This could be metric units (e.g., millimeters, micrometers) or imperial units (e.g., inches). Consistency is crucial to avoid errors and misinterpretations.

2. Tolerances: Determine the acceptable tolerances for each measurement. Tolerances define the allowable deviation from the desired measurement value. They are essential for ensuring the precision and accuracy of the prototype. Consider factors such as manufacturing capabilities, material properties, and functional requirements when establishing tolerances.

3. Measurement Tools: Select appropriate measurement tools based on the required accuracy and precision. Common measurement tools include calipers, micrometers, height gauges,

coordinate measuring machines (CMMs), and optical measurement systems. Ensure that the measurement tools are properly calibrated and maintained.

4. Geometric Dimensioning and Tolerance (GD&T): GD&T is a system for defining and communicating tolerances for geometric features on a part. It provides a standardized language for specifying dimensions and tolerances, ensuring clear communication between design engineers, manufacturers, and quality control personnel.

5. Statistical Analysis: Employ statistical analysis techniques to assess and control the variation in measurements. Statistical methods such as process capability analysis, statistical process controls (SPC), and design of experiments (DOE) can help identify sources of variation and optimize the prototype development process.

6. Material Properties: Consider the properties of the materials used in the prototype when performing calculations. Material properties such as density, modulus of elasticity, thermal expansion coefficient, and coefficient of friction can affect the overall performance and dimensional stability of the prototype.

7. Simulation and Finite Element Analysis (FEA): Utilize simulation software and FEA to predict and analyze the behavior of the prototype under different conditions. These tools can help optimize the design, identify potential weaknesses, and reduce the need for physical iterations.

8. Environmental Factors: Take into account environmental factors such as temperature, humidity, and vibration that may affect the measurements and the performance of the prototype. Consider compensating for these factors or conducting measurements under controlled conditions.

9. Documentation: Maintain detailed documentation of all measurements, calculations, and design iterations. This documentation is crucial for traceability, quality control, and future reference.

Remember that precision model/prototype development is an iterative process, and measurements and calculations play a critical role in ensuring the accuracy and functionality of the final product.

3.5. Components assembling

The assembling of components is a crucial step in the manufacturing process. There are a range of options available and selecting the one that works best for the product is of crucial importance.

The choice of assembly method is determined by factors such as design requirements, cost, and the materials to be used.

The purpose of assembling a component is to bring together various parts or elements to create a functional whole. In the context of manufacturing or engineering, components are often assembled as part of the process of creating a larger product or system.

Assembling components can involve a variety of techniques, such as fastening, bonding, or welding, depending on the specific requirements of the product or system. Components may be assembled manually or with the use of automated equipment.

The purpose of assembling components is to create a functional product or system that meets the desired specifications and performs its intended function. Assembling components can also be a way to improve the efficiency and effectiveness of a product or system by bringing together the right combination of parts and elements.

In conclusion, the purpose of assembling a component is to bring together various parts or elements to create a functional whole, typically as part of the process of creating a larger product or system. Assembling components can involve a variety of techniques and is done to create a functional product or system that meets specific specifications and performs its intended function.

Self-Check 3.

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The manufacturing sequence influence, to a large extent, component properties like A. fatigue life, B. shape C. accuracy and manufacturability D. all
2. ---------- is a theoretically exact geometric reference (such as axes, planes, straight lines, etc.) to which the tolerance features are related
   A. Datum B. photo C. sketch D. set up
3. During manufacture the following are the most common factors that can affect quality
   A. Set-up. C. Operator.
   B. Machines and tools. D. all
4. **Finishing operation** can include surface treatments such as
   A. Polishing, C. Sandblasting, or coating
   B. Deburring D. all
5. Once the precision model is manufactured, testing and validation include tests except
   A. strength, C. accuracy
   B. durability, D. Defect
6. of the following one is not metric units
   A. millimeters C. Inches
   B. micrometers D. meters

Part **II:-**

Directions true or false

1. The purpose of modeling and simulation of manufacturing sequences is to improve efficiency in product design and process planning.
2. If the planning has been well done, there should be too many problems
3. Before proceeding with full-scale production, it is often beneficial to create a prototype of the precision model.
4. Precision model/prototype development does not requires accurate measurements and calculations to ensure the design meets the required specifications
5. Tolerances is the allowable deviation from the desired measurement value

Unit four: - Quality Assurance

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Model functionality testing procedures
- Record and report deviations or modifications
- Model documentation

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Test **f**unctionality of model
- Record and report
- Compile model documentation

4.1. Model functionality testing procedures

Quality assurance vs. quality control:

Quality assurance is a subset of quality management. QA involves a set of activities and procedures occurring during product development that helps ensure a high-quality release. QA includes team members from across the software development organization discussing, planning and executing tests to validate product quality.

QA establishes policies and procedures that affect the entire organization. Additionally, QA requires adherence to standards defined by the business as well as any applicable technical standards, such as ISO 25010, or industry standards, such as HIPAA for healthcare organizations. The organization must establish QA policies to ensure every product release meets these standards

Ultimately, effective QA relies on many moving parts, and it requires diligence and adaptation to meet customer expectations for any product at any given time. What worked yesterday might not work today — that's why QA must evolve along with product offerings.

Quality control is a subset of QA. In QC, teams ensure that the developed product meets the organization's quality standards. Defects in a software product, such as UI glitches, design imperfections, accessibility issues or security gaps, can cause irreparable damage to a brand's reputation.

Through a systematic QC process, the organization can correct products to ensure that they meet business requirements and customer expectations.

Digital QC involves a number of tasks, including:

- identifying product errors or blemishes;
- testing against quality requirements set forth during planning;
- ensuring conformance with regulations or industry standards;
- creating and maintaining test reports;
- documenting bugs that either must be fixed before product release or can wait until the next iteration;
- determining areas where quality or the user experience could be improved

When designing a product, delivering something that offers a viable solution to the audience is the final step of a long and iterative process. As you try to do this while creating something that can establish itself in the target market as well, failure at any stage is just a part of this long and complicated process. **This is where prototype/model/ testing come in!**

Before a product goes out for public access, the developers need to ensure that it is fully operational, offers promised functionality, and solves real-world problems. Testing prototypes is an ongoing process where the developers seek continuous validation from real-world users through feedback and surveys.

That's the reason why developers hold prototype testing in high regard. It is the single most effective way of knowing how a product will perform in the market before it performs.

By now, you have a basic idea of how important prototype testing and evaluation are and why developers consider it one of the key elements of the development phase. You may still be wondering what prototype testing is, so let's take a closer look.

Prototypes are the **first draft** in the product development phase before we reach the final product. When these prototypes are circulated to real-world users to find flaws and areas of improvement, it is known as prototype testing.

You can deploy a prototype in the field for people to use your product before finally launching it to ensure that you offer the best quality. A process known as **crowd-testing** is one of the most effective ways of analyzing the quality, features, and other crucial components.

Prototype testing is not just about gathering feedback and insights from the users and giving that information to the developers. There are a lot of benefits that prototype testing and evaluation offer; let's have a look at 4 top ones:

Reduces Overall Time and Cost

Increases User Involvement

Gathers Accurate Requirements

Helps Resolve Conflict

Testing a prototype is a complex and sequential process. But before we get into the steps, there are a few basic rules that every prototype tester should glance through:

- The type of prototype you have (sketch, physical prototype, paper interface, digital prototype) will define how your users interact with it.
- Your testing goals are extremely important, and they can help you develop testing scenarios, questionnaires, and the overall prototype testing method.
- Setting time constraints will also help you decide the best prototype testing method for you.

Here are the steps that need to be followed with precision to ensure that you're testing yields the most effective results:

- Collect and Analyze User Information
- Build The Prototype
- Decide What You Want to Test
- Create a Preliminary Design
- Prepare Your Test Scenarios and Questions
- Initiate User Evaluation
- Correction of quality deficiencies

In spite of all the efforts made, the required quality will sometimes not be attained and one may be faced with a pile of scrap and rework. This means that something has gone wrong during the quality planning and maybe also during the manufacturing process. The reason for the trouble must be located and permanently corrected so that it cannot happen again. The following are obvious possibilities:

- The shop-floor operators had no clear idea what standard of quality was required;
- The method was such that it was very difficult to get the job right, but very easy to get it wrong;
- The machine and equipment were incapable of achieving the tolerances required;
- The incoming materials and components were unsatisfactory;

- The operators were untrained and not up to the job;
- Shop-floor quality control was either not properly planned or not properly executed, or both.
- It is helpful to keep good records of your model-building efforts. Good records allow you to adjust your design based on what you learn from each model you build. For each model record your plans, purpose, tests and results, and next steps using the questions below. Use proper records for your design according to the following concept:

Plans

What do you want to build? Is this a system or component of the product? Is this a full-scale model?

Purpose

What will this model help you understand about your design?

Tests and Results

What did your model show you about your design? What features did you test? Does it meet requirements? Did it function as intended? Did the form suit you? Are the materials suitable? What modifications do you need to make? What new ideas do you have for your design?

4.2. Record and report deviations or modifications

If you want to change something — in other words, modify it — you need to make a modification. Lots of things require modification, because they get older or just because they can be improved. A car needs modification — in the form of snow tires — to be ready for the winter.

A *modification* is a change or alteration, usually to make something work better. Computer programs need modification all the time, because of new products or viruses. When you think of the word *modification*, think "change."

A deviation procedure enables a company to document and control non-conformances under their quality management system.

4.3. Model documentation

Model compilation is an activity performed after writing the statements in a model and before training starts. It checks for format errors, and defines the loss function, the optimizer or

learning rate, and the metrics. A compiled model is needed for training but not necessary for predicting.

What is a compilation? The compilation is a process of converting the source code into object code. It is done with the help of the compiler. The compiler checks the source code for the syntactical or structural errors, and if the source code is error-free, then it generates the object code.

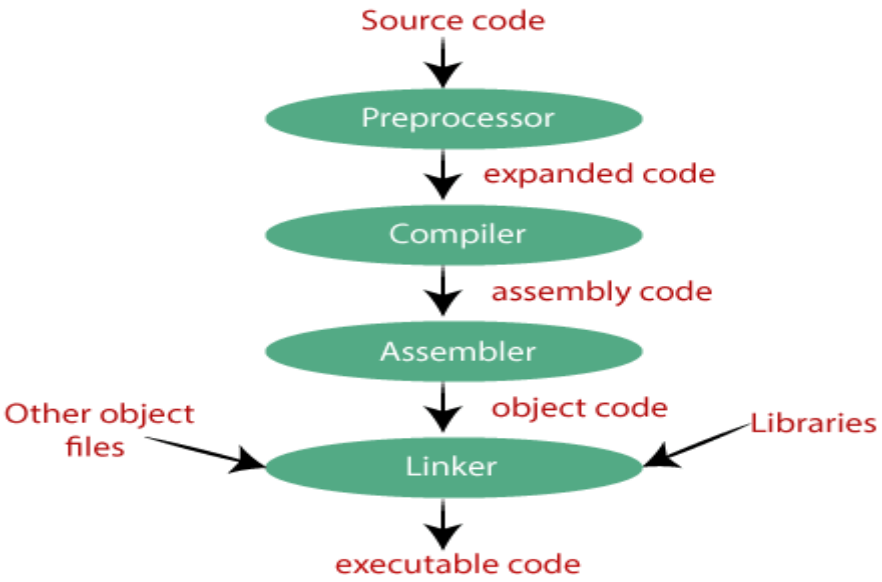


Fig 4.3.1.compilation process

Model compilation is an activity performed after writing the statements in a model and before training starts. It checks for format errors, and defines the loss function, the optimizer or learning rate, and the metrics. A compiled model is needed for training but not necessary for predicting.

Self-Check 4.

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Before a product goes out for public access, the developers need to ensure that
   A. it is fully operational C. Solves real-world problems
   B. Offers promised functionality D. all
2. ----------are the first draft in the product development phase before we reach the final product
   A. Idea C. Hand tools
   B. Prototypes/models D. Finished products
3. There lot of benefits that prototype testing and evaluation offer includes; except

A. Reduces Overall Time and Cost

B. Increases User Involvement

C. Gathers Accurate Requirements

D. Decrease User Involvement

4. Quality assurance primarily focuses on the processes and procedures that improve quality, including
   A. training C. monitoring and audits
   B. documentation D. all

5. QC involves a number of tasks, including:
   A. identifying product errors C. creating and maintaining test report
   B. testing against quality requirements D. all of the above

Part **II:-**

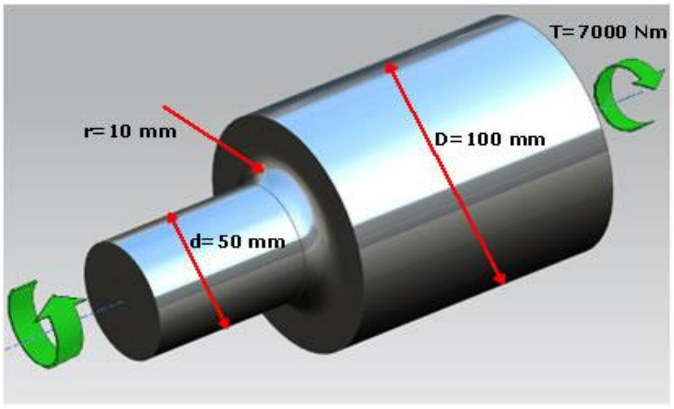
Directions true or false

1. A deviation procedure enables a company to document and control non-conformances under their quality management system.
2. When designing a product, delivering something that offers a viable solution to the audience is the final step of a long and iterative process
3. A *modification* is a change or alteration, usually to make something work better
4. Model compilation is an activity performed after writing the statements in a model and before training starts.
5. Quality control focuses on the product to find defects that remain after development
6. QC professionals find these issues in a variety of ways, including software testing and beta or canary testing

Operation Sheet: -4.

Instruction:-According to the design produce the given project

Operation Title: - Preparation of step shaft



Purpose: - Exercising precision model development

Conditions or situations for the operations: -

- ✓ Safe working area
- ✓ Properly operated tools and equipment's & machines
- ✓ Effectively use of precise model development procedures
- ✓ Good understanding of programming

Procedures:-

- ✓ Design:
- ✓ Select material
- ✓ Prototyping:
- ✓ Tooling
- ✓ Machining:/turning, Facing, chamfering, tapering…/
- ✓ Finishing:

Precautions: - Safe working habits, free from accidents

Equipment Tools and Materials: -

- ✓ Computer/pc for designing with/ soft wares/ solid work, Catia, AutoCAD
- ✓ Measuring instruments /vernier caliper, micrometer
- ✓ Designee,

Quality Criteria: - Accurate, Precise & Exact to the given dimension

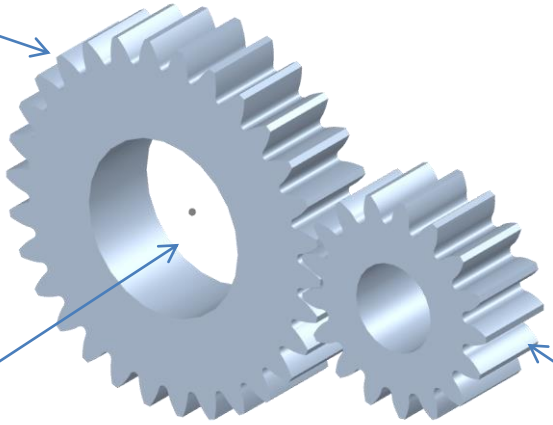
Lap Test 4.

Directions: Gear cutting and assembling

Date: _____Time started: _____ Time finished: _____

Instructions: Given necessary measuring instruments, tools, and materials you are required to perform the following tasks within --- hour

Largest Ø 75mm



Internal hole Ø 25mm

the smaller Ø 55mm

Task 1 **Design the above Two gears**

Task 2 Select material to perform gear cutting

Task 3.Cut the larger gear

Task 4.Cut the small gear

Task 5 Assemble the two gears

When taking a measurement, the largest Ø75mm, the smaller Ø55 mm, internal holes Ø 25mm

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