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Selection of Materials for Bevel Gears

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ABSTRACT

Computer technology has impacted every aspect of our daily lives, from how we buy train tickets to how we get medical advice from afar.. Nowadays, computer-aided design analysis is a standard part of almost every development effort. When it comes to designing, the term "design" has traditionally been used to refer to a specific product, such as mechanical design or electrical design. This kind of product design relies heavily on the use of predetermined approaches to achieve specified results.

The scope of this project comprises the design and modelling of bevel gears, the selection of gear materials, the consideration of safety factors in design, and the analysis of bevel gears. There are two types of gears: those with teeth and those without. The power transfer efficiency of gears may reach as high as 98 percent. For the most part, gears are pricier than chains or belts. In bevel gears, the axes of the two shafts cross, and the tooth bearing sides of the gears themselves are conical in form. When used on shafts that are not 90 degrees apart, bevel gears are most often installed that way, although they may be made to function in different ways. Bevel gears have a cone-shaped pitch surface. Bevel gearing occurs when two bevel gears mesh together. If you're using bevel gearing, you can figure out the pinion and gear pitch cone angles from the intersecting shafts' angles of rotation. In addition to locomotives, maritime applications, autos, printing presses, cooling towers, power plants, steel plants, railway track inspection equipment, etc., the bevel gear may be used in a wide range of other applications.

1. Introduction

It is a kind of conical gear that has conical tooth-bearing faces on both sides of the axis. Bevel gears When used on shafts that are not 90 degrees apart, bevel gears are most often installed that way, although they may be made to function in different ways. Bevel gears have a cone-shaped pitch surface.

Pitch surface and pitch angle are critical gearing concepts. It's possible to approximate the pitch surface of a gear by averaging the peak and valley heights and widths of its individual teeth. A cylinder is the form of the pitch surface of an ordinary gear. When speaking about a gear's pitch, it's defined as the angle between the gear's pitch surface and the gear axis.

Most bevel gears are cone-shaped because their pitch angle is less than 90 degrees. It is referred to as an external bevel gear because the teeth point outward rather than within.

In external bevel gears, pitch surfaces that are coaxial with the gear shafts are located at the apexes of the two surfaces.

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More than any other replacement component, using a genuine bevel gear is critical to the axle's durability. Internal bevel gears are bevel gears with teeth that point inward and have a pitch angle larger than ninety degrees.

Pitch angles of precisely 90 degrees provide bevel gears with teeth that point outward parallel to their centre of rotation. The crown gear is a name given to this particular kind of bevel gear.

Equal-toothed bevel gears with right-angle axes make up a mitre gear.

Crown gear teeth that are straight and oblique make up Skew bevel gears, which are the only kind of bevel gear.

Types

Bevel gears are classified in different types according to geometry:

Straight bevel gears have conical pitch surface and teeth are straight and tapering towards apex.

Spiral bevel gears have curved teeth at an angle allowing tooth contact to be gradual and smooth.

Zerol bevel gears are very similar to a bevel gear, but the teeth are curved: the ends of each tooth are coplanar with the axis, but the middle of each tooth is swept circumferentially around the gear. Zerol bevel gears can be thought of as spiral bevel gears, which also have curved teeth, but with a spiral angle of zero, so the ends of the teeth align with the axis.

Hypoid bevel gears are similar to spiral bevel, but the pitch surfaces are hyperbolic and not conical. The pinion can be offset above or below the gear center, thus allowing larger pinion diameter, longer life, and smoother mesh. If the beveled surface is made parallel with the axis of rotation, this configuration resembles a worm drive. Hypoid gears were widely used in automobile rear axles.

Mitre gears

Mitre gears are a special case of bevel gears that have equal numbers of teeth. The shafts are positioned at right angles from each other, and the gears have matching pitch surfaces and angles, with a conically-shaped pitch surface.

Mitre gears are useful for transmitting rotational motion at a 90-degree angle with a 1:1 ratio.

Geometry of a bevel gear

The cylindrical gear tooth profile corresponds to an involute (i.e. a triangle wave projected on the circumference of a circle), whereas the bevel gear tooth profile is an octoid (i.e. a triangle wave projected on the normal path of a circle of a sphere). All traditional bevel gear generators (such as Gleason, Klingelnberg, Heidenreich&Harbeck, WMWModul) manufacture bevel gears with an octoidal tooth profile. IMPORTANT: For 5-axis milled bevel gear sets it is important to choose the same calculation / layout like the conventional manufacturing method. Simplified calculated bevel gears on the basis of an equivalent cylindrical gear in normal section with an involute tooth form show a deviant tooth form with reduced tooth strength by 10-28% without offset and 45% with offset Furthermore, those "involute bevel gear sets" cause more noise.

Teeth

There are two issues regarding tooth shape. One is the cross-sectional profile of the individual tooth. The other is the line or curve on which the tooth is set on the face of the gear: in other words the line or curve along which the cross-sectional profile is projected to form the actual three-dimensional shape of the tooth. The primary effect of both the cross-sectional profile and the tooth line or curve is on the smoothness of operation of the gears. Some result in a smoother gear action than others.

Tooth line

The teeth on bevel gears can be straight, spiral or "zerol".

Straight tooth lines

In straight bevel gears the teeth are straight and parallel to the generators of the cone. This is the simplest form of bevel gear. It resembles a spur gear, only conical rather than cylindrical. The gears in the floodgate picture are straight bevel gears. In straight bevel gear sets, when each tooth engages it impacts the corresponding tooth and simply curving the gear teeth can solve the problem.

Spiral tooth lines

Spiral bevel gears have their teeth formed along spiral lines. They are somewhat analogous to cylindrical type helical gears in that the teeth are angled; however, with spiral gears the teeth are also curved.

The advantage of the spiral tooth over the straight tooth is that they engage more gradually. The contact between the teeth starts at one end of the gear and then spreads across the whole tooth. This results in a less abrupt transfer of force when a new pair of teeth come into play. With straight bevel gears, the abrupt tooth engagement causes noise, especially at high speeds, and impact stress on the teeth which makes them unable to take heavy loads at high speeds without breaking. For these reasons straight bevel gears are generally limited to use at linear speeds less than 1000 feet/min; or, for small gears, under 1000 r.p.m

Zerol tooth lines

Zerol bevel gears are an intermediate type between straight and spiral bevel gears. Their teeth are curved, but not angled. Zerol bevel gears are designed with the intent of duplicating the characteristics of a straight bevel gear but they are produced using a spiral bevel cutting process.

Manufacturing bevel gears

Materials used in gear manufacturing process

The various materials used for gears include a wide variety of cast irons, nonferrous material and non – metallic materials. The selection of the gear material depends upon:

Type of work

- Peripheral speed
- Degree of accuracy required
- Method of manufacture
- Required dimensions and weight of the drive
- Allowable stress
- Shock resistance
- Some materials chosen include:

Cast iron, which is popular due to its good wearing properties, excellent machinability and ease of producing complicated shapes by the casting method. It is suitable where large gears of complicated shapes are needed.

Steel, which is sufficiently strong & highly resistant to wear by abrasion.

Cast steel, which is used where stress on the gear is high and it is difficult to fabricate the gears.

Plain carbon steels, which find application for industrial gears where high toughness combined with high strength.

Alloy steels, which are used where high tooth strength and low tooth wear are required.

Aluminum, which is used where low inertia of rotating mass is desired.

Gears made of non–metallic materials give noiseless operation at high peripheral speeds.

Bevel gearing

Two bevel gears in mesh is known as bevel gearing. In bevel gearing, the pitch cone angles of the pinion and gear are to be determined from the shaft angle, i.e., the angle between the intersecting shafts. Figure shows views of a bevel gearing.

Applications

The bevel gear has many diverse applications such as locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.

For examples, see the following articles on:

Bevel gears are used in differential drives, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile.

Bevel gears are used as the main mechanism for a hand drill. As the handle of the drill is turned in a vertical direction, the bevel gears change the rotation of the chuck to a horizontal rotation. The bevel gears in a hand drill have the added advantage of increasing the speed of rotation of the chuck and this makes it possible to drill a range of materials. The gears in a bevel gear planer permit minor adjustment during assembly and allow for some displacement due to deflection under operating loads without concentrating the load on the end of the tooth.

Spiral bevel gears are important components on rotorcraft drive systems. These components are required to operate at high speeds, high loads, and for a large number of load cycles. In this application, spiral bevel gears are used to redirect the shaft from the horizontal gas turbine engine to the vertical rotor. Bevel gears are also used as speed reducers

Advantages

This gear makes it possible to change the operating angle.

Differing of the number of teeth (effectively diameter) on each wheel allows mechanical advantage to be changed. By increasing or decreasing the ratio of teeth between the drive and driven wheels one may change the ratio of rotations between the two, meaning that the rotational drive and torque of the second wheel can be changed in relation to the first, with speed increasing and torque decreasing, or speed decreasing and torque increasing.

Disadvantages

One wheel of such gear is designed to work with its complementary wheel and no other.

Must be precisely mounted.

The shafts' bearings must be capable of supporting significant forces.

GEAR DESIGNCONSIDERATIONS

Bevel and hypoid gears are suitable for transmitting power between shafts at practically any angle and speed. The load, speed, and special operating conditions must be defined as the first step in designing a gear set for a specific application. A basic load and a suitable factor encompassing protection from intermittent overloads, desired life, and safety are determined from

[1.] The power rating of the prime mover, its overload potential, and the uniformity of its output torque

[2.] The normal output loading, peak loads and their duration, and the possibility of stalling or severe loading at infrequent intervals

[3.] Inertia loads arising from acceleration or deceleration

The speed or speeds at which a gear set will operate must be known to determine inertia loads, velocity factor, type of gear required, accuracy requirements, design of mountings, and the type of lubrication. Special operating conditions include

[1.] Noise-level limitations

[2.] High ambient temperature

[3.] Presence of corrosive elements

[4.] Abnormal dust or abrasive atmosphere

[5.] Extreme, repetitive shock loading or reversing

[6]. Operating under variable alignment

[7.] Gearing exposed to weather

[8.] Other conditions that may affect the operation of the set

SELECTION OF TYPE OF GEAR

Straight-bevel gears are recommended for peripheral speeds up to 1000 feet per minute (ft/min) where maximum smoothness and quietness are not of prime importance. However, ground straight bevels have been successfully used at speeds up to 15 000 ft/min. Plain bearings may be used for radial and axial loads and usually result in a more compact and less expensive design. Since straight-bevel gears are the simplest to calculate, set up, and develop, they are ideal for small lots. Spiral-bevel gears are recommended where peripheral speeds are in excess of 1000 ft/min or 1000 revolutions per minute (r/min). Motion is transmitted more smoothly and quietly than with straight-bevel gears. So spiral-bevel gears are preferred also for some lower-speed applications. Spiral bevels have greater load sharing, resulting from more than one tooth being in contact. Zerol bevel gears have little axial thrust as compared to spiral-bevel gears and can be used in place of straight-bevel gears. The same qualities as defined under straight bevels apply to Zerol bevels. Because Zerol bevel gears are manufactured on the same equipment as spiral-bevel gears, Zerol bevel gears are preferred by some,They are more easily ground because of the availability of bevel grinding equipment. Hypoid gears are recommended where peripheral speeds are in excess of 1000 ft/min and the ultimate in smoothness and quietness is required. They are somewhat stronger than spiral bevels. Hypoids have lengthwise sliding action, which enhances the lapping operation but makes them slightly less efficient than spiral-bevel gears.

CALCULATIONS OF A CROWN GEAR AND PINION

The main objective of the project is to verify the best material for the gears in at higher speeds through analyzing stress generation, displacement and also considered weight reduction focus on the mechanical design and contact analysis on assembly of gears in gear box when it transmit more power at different speeds at 2400 rpm, 5000 rpm and 6400 rpm. Analysis is also conducted by varying the natural frequencies. Differential gear is designed in Solidwork.

ASSUMPTIONS:

• Gear profile: -20 degree full depth involute profile (standard)

•pressure angle (α):-20 degree • bevel gear arrangement = 90 degree

• Pitch cone Angle (φ) = 45

• Back cone Angle (β) = 45

• Module (M) = 10

• Number of teeth on gear = Zg =50

•Number of teeth on pinion = Zp = 8 Velocity Ratio (V.R) V.R=TG/TP= DG/DP=NP/NG V.R=TG/TP=50/8=6.25 V.R=NP/NG 6.25=2400/NG NG=384rpm

Minimum no. of teeth on pinion (Zp) For satisfactory operation of bevel gears the number of teeth in the pinion must not be less than hence the assumed value of the pinion is in safe condition Pitch circle diameter (D) Pitch circle diameter for the gear (Dg) = M*Zg Pitch circle diameter for the pinion (Dp) = M*Zp

Pitch angle (θ) Since the shafts are at the right angles, the pitch angle were given as: For the pinion = θp1=tan-1(1/v.r) Pitch angle of gear θp2=90°-9=81 formative number of teeth (Te) for the pinion Zep= Zpsecθp1=8sec9 =8 for the gear = Zeg=Zgsecθp2=50sec81 =319.622 1.Pitch Cone Distance (AO): AO=((d1/2)2 +(d2/2)2) 1/2 AO=250mm 2.Face width (b) b=AO/3 or } which is lesser b=10

CALCULATION OF GEAR AND PINION

1.Pitch circle diameter (D) Diameter of sungear =Dg=150mm

Diameter of pinion =Dp=70mm

2.Number of tooth on gear Number of teeth on gear = Zg =18 Number of teeth on pinion = Zp = 15 D=Dg+Dp=220 T= Zg+ Zp = 33

3.Module = M=D/T=220/33=6.66=7(according to stds)

4.Velocity Ratio V.R = Zg/Zp = DG/DP=NP/NG V.R = Dg/Dp =150/70=2.142 V.R=NP/NG 2.142=2400/NG NG=1120.448rpm

5.Pitch angle Since the shafts are at right angles therefore pitch angle for the pinion = θp1=tan-1(1/v.r) =tan-1(1/2.142)=25.025 Pitch angle of gear θp2=90°-25.025=64.974

6.Formative Number Of Teeeth For the pinion = Zep = Zp secθp1=15sec25.025 =16.554 For the gear = Zeg = Zg secθp2= 8sec64.974 =42.55

7.Pitch Cone Distance (AO): AO=((D1/2)2 +(D2/2)2) 1/2 AO = 82.7mm

8.Face Width (b): 82.7/3 = 27.5 mm

LITERATURE REVIEW

KarlisPaulins et al (2014) created winding incline gear with improved plan of rigging spaces with enhanced tooth closes. It is conceivable to advance rectangular-produced, winding incline pinion/gear sets with steady tooth stature and a typical pitch cone peak. The work effectively accomplished the recalculation of the apparatus spaces, with no adjustments in the flank geometry or tooth-cutting procedure. At the point when the mating pinion is planned without a corresponding front cone, it is silly to structure the rigging with a reciprocal back cone. Progressively reasonable geometry for current machining and checking of spaces, because of the consideration of chamfer type surfaces in the essential structure.

Jihui Liang, 2lili Xin (2013) clarified the dynamic recreation of winding incline gears. Mechanical properties of winding slant apparatus have noteworthy effect in general mechanical structure and assume a significant job in the framework improvement, quality check, flaw conclusion and shortcoming forecast. The rigging tooth cross section and dynamic burden is a significant issue in the apparatus research field. The exact demonstrating of winding angle rigging depends on SOLIDWORKS programming and virtual model of apparatus fitting parameterization is acknowledged through ADAMS.

Xiang Tieming et al (2015) did the free modular examination for winding apparatus wheel dependent on Lanczos strategy. So as to get the winding slope apparatus wheel normal frequencies and mode shapes in the unconstrained state with the end goal of dynamic attributes study. So as to check the adequacy of the limited component examination results, the test modular test dependent on the motivation power hammer percussion transient single-point excitation and multi-point reaction investigation strategy has been finished. The greatest distinction estimation of regular recurrence between exploratory modular test outcome and limited component modular examination results is 29.86 Hz, the most extreme mistake rate is 0.41%, which affirmed the consequence of limited component technique is powerful and solid.

Ratnadeepsinh M. Jadeja, Dipeshkumar M. Chauhan, Jignesh D. Lakhani have done on bending stress analysis of bevel gears which shows that Gears are an integral and necessary component in our day to day lives. They are present in the satellites we communicate with, automobiles and bicycles we travel with. Gears have been around for hundreds of years and their shapes, sizes, and uses are limitless. For the vast majority of our history gears have been understood only functionally. That is to say, the way they transmit power and the size they need to be to transmit that power have been well known for many years. It was not until recently that humans began to use mathematics and engineering to more accurately and safely design these gears. Bevel gears are widely used because of their suitability towards transferring power between nonparallel shafts at almost any angle or speed. The American Gear Manufacturing Association (AGMA) has developed standards for the design, analysis, and manufacture of bevel gears. The bending stress equation for bevel gear teeth is obtained from the Lewis bending stress equation for a beam and bending stress value derive for the spiral bevel gear, straight teeth bevel gear and zerol bevel gear.

Abhijeet .V. Patil , V. R. Gambhir, P. J. Patil have done on Analysis of bending strength of bevel gear by FEM which shows that In bevel gear will have a tangential load, radial load and axial load due to the speed and torque .This will be atransient phenomenon and will need careful stress analysis for determining life of the gear. In gear design, the Mechanism will be more Challenging as it should transmit high torque. All gears are not to be used for such high torque applications due to their low capacity and strength. Bevel gears are used in differential drives, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile, hand drill, to redirect the shaft from the horizontal gas turbine engine to the vertical rotor. In this paper a comparison between Lewis equation and Ansys workbench is done

SOLIDWORKS

solid Works is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs on Microsoft Windows. SolidWorks is published by Dassault Systems. According to the publisher, over two million engineers and designers at more than 165,000 companies were using SolidWorks as of 2013. Also according to the company, fiscal year 2011–12 revenue for SolidWorks totaled $483 million

History

SolidWorks Corporation was founded in December 1993 by Massachusetts Institute of Technology graduate Jon Hirschtick. Hirschtick used $1 million he had made while a member of the MIT Blackjack Team to set up the company. Initially based in Waltham, Massachusetts, United States, Hirschtick recruited a team of engineers with the goal of building 3D CAD software that was easy-to-use, affordable, and available on the Windows desktop. Operating later from Concord, Massachusetts, SolidWorks released its first product SolidWorks 95, in November 1995. In 1997 Dassault, best known for its SOLIDWORKS CAD software, acquired SolidWorks for $310 million in stock. Jon Hirschtick stayed on board for the next 14 years in various roles. Under his leadership, SolidWorks grew to a $100 million revenue company.

SolidWorks currently markets several versions of the SolidWorks CAD software in addition to eDrawings, a collaboration tool, and DraftSight, a 2D CAD product.SolidWorks was headed by John McEleney from 2001 to July 2007 and Jeff Ray from 2007 to January 2011. The current CEO is Gian Paolo Bassi from Jan 2015. GianPaolo Bassi replaces Bertrand Sicot, who is promoted Vice President Sales of Dassault Systèmes' Value Solutions sales channel.DS Solidworks Corp. has sold over 3.5 million licenses of SolidWorks worldwide. This includes a large proportion of educational licenses. The Sheffield Telegraph comments that Solidworks is the world's most popular CAD software.

Its user base ranges from individuals to large corporations, and covers a very wide cross-section of manufacturing market segments. Commercial sales are made through an indirect channel, which includes dealers and partners throughout the world. In the United States, the first reseller of SolidWorks, in 1995, was Computer Aided Technology, Inc, headquartered in Chicago. Directly competitive products to SolidWorks include PTC Solidworks Elements/Pro, Solid Edge, and Autodesk Inventor. SolidWorks also partners with third party developers to add functionality in niche market applications like finite element analysis, circuit layout, tolerance checking, etc. SolidWorks has also licensed its 3D modeling capabilities to other CAD software vendors, notably ANVIL

SolidWorks is a solid modeler, and utilizes a parametric feature-based approach which was initially developed by PTC (Solidworks/Pro-Engineer) to create models and assemblies. The software is written on Parasolid-kernel.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allows them to capture design intent.

Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. SolidWorks allows the user to specify that the hole is a feature on the top surface, and will then honor their design intent no matter what height they later assign to the can.

Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such as fillets, chamfers, shells, applying draft to the faces of a part, etc.

Building a model in SolidWorks usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of SolidWorks means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside of the sketch.

In an assembly, the analog to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. SolidWorks also includes additional advanced mating features such as gear and cam follower mates, which allow modeled gear assemblies to accurately reproduce the rotational movement of an actual gear train.

Finally, drawings can be created either from parts or assemblies. Views are automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards
(ANSI, ISO, DIN, GOST, JIS, BSI and SAC).

File format

SolidWorks files (previous to version 2015) use the Microsoft Structured Storage file format. This means that there are various files embedded within each

SLDDRW (drawing files), SLDPRT (part files), SLDASM (assembly files) file, including preview bitmaps and metadata sub-files. Various third-party tools (see COM Structured Storage) can be used to extract these sub-files, although the subfiles in many cases use proprietary binary file formats.

Capabilities and Benefits:

Complete 3D modeling capabilities enable you to exceed quality arid time to arid time to market goals.

Maximum production efficiency through automated generation of associative C tooling design, assembly instructions, and machine code.

Ability to simulate and analysis virtual prototype to improve production performance and optimized product design.

Ability to share digital product data seamlessly among all appropriate team members

Compatibility with myriad CAD tools-including associative data exchange and industry standard data formats.

Features of SOLIDWORKS

SOLIDWORKS is a one-stop for any manufacturing industry. It offers effective feature, incorporated for a wide variety of purpose. Some of the important features are as follows:

- Simple and powerful tool
- Parametric design
- Feature-based approach
- Parent child relationship
- Associative and model centric

2.4.1. Simple and Powerful Tool

SOLIDWORKS tools are used friendly. Although the execution of any operation using the tool can create a highly complex model

2.4.2. Parametric Design

SOLIDWORKS designs are parametric. The term “parametric” means that the design operations that are captured can be stored as they take place. They can be used effectively in the future for modifying and editing the design. These types of modeling help in faster and easier modifications of design

2.4.3. Feature-Based Approach

Features are the basic building blocks required to create an object. SOLIDWORKS wildfire models are based on the series of feature. Each feature builds upon the previous feature, to create the model (only one single feature can be modified at a time). Each feature may appear simple, individually, but collectively forms a complex part and assemblies.

The idea behind feature based modeling is that the designer construct on object, composed of individual feature that describe the manner in which the geometry supports the object, if its dimensions change. The first feature is called the base feature.

2.4.4. Parent Child Relationship

The parent child relationship is a powerful way to capture your design intent in a model. This relationship naturally occurs among features, during the modeling process. When you create a new feature, the existing feature that are referenced, become parent to the feature.

2.4.5. Associative and Model Centric

SOLIDWORKS drawings are model centric. This means that SOLIDWORKS models that are represented in assembly or drawings are associative. If changes are made in one module, these will automatically get updated in the referenced module.

2.5. SOLIDWORKS Basic Design Modes

When a design from conception to completion in SOLIDWORKS, the design information goes through three basic design steps.

Creating the component parts of the design

Joining the parts in an assembly that records the relative position of the parts.

Creating mechanical drawing based on the information in the parts and the assembly.

2.6 Assembly in SOLIDWORKS:

Bottom-Up Design (Modeling):

The components (parts) are created first and then added to the assembly file. This technique is particularly useful when parts already exist from previous designs and are being re-used.

Top-Down Design (Modeling):

The assembly file is created first and then the components are created in the assembly file. The parts are build relative to other components. Useful in new designs

In practice, the combination of Top-Down and Bottom-Up approaches is used. As you often use existing parts and create new parts in order to meet your design needs.

Degrees of Freedom:

An object in space has six degrees of freedom.

Translation – movement along X, Y, and Z axis (three degrees of freedom)

Rotation – rotate about X, Y, and Z axis (three degrees of freedom)

Assembly Constraints:

In order to completely define the position of one part relative to another, we must constrain all of the degrees of freedom COINCIDENT, OFFSET

OFFSET

Two surfaces are made parallel with a specified offset distance.

COINCIDENT

Two selected surfaces become co-planar and face in the same direction. Can also be applied to revolved surfaces. This constrains 3 degrees of freedom (two rotations and one translation). When Align is used on revolved surfaces, they become coaxial (axes through the centers align).

SOLIDWORKS Modules:-

Sketcher (2D)

Part (3D)

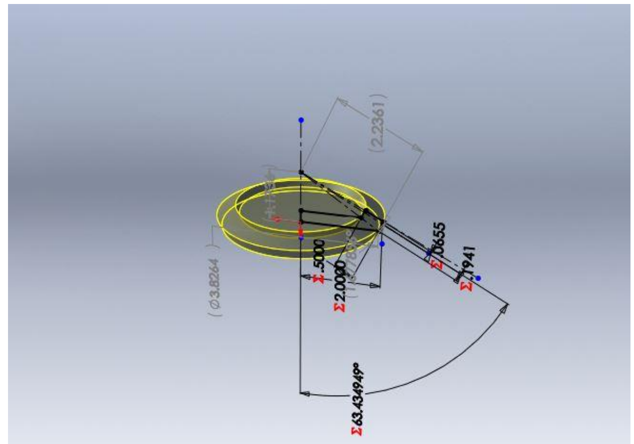
Assembly

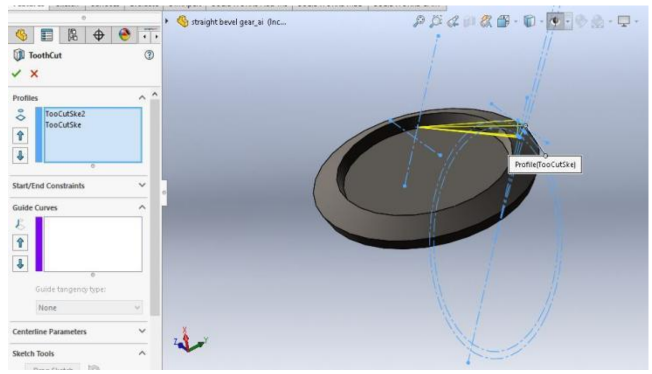
Drawing and Drafting

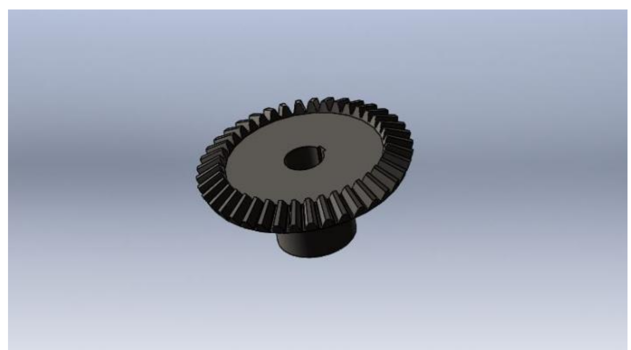
Sheet Metal

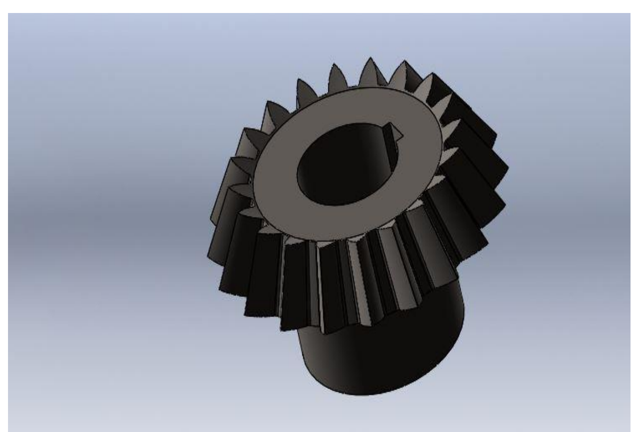
Surface modeling

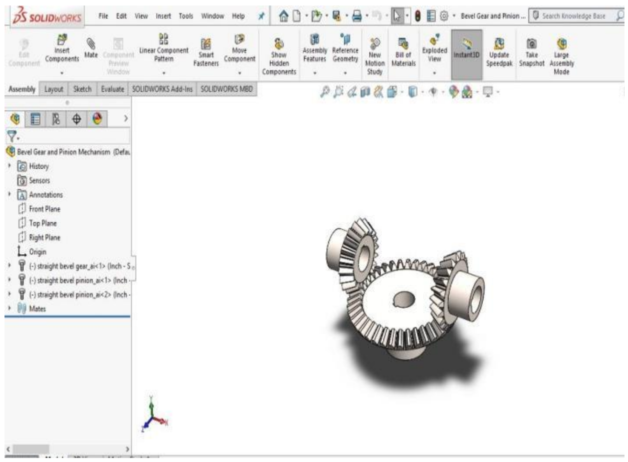
Designing process











Material selection

A material's property is an intensive, often quantitative, property of some material. Quantitative properties may be used as a metric by which the benefits of one material versus another can be assessed, thereby aiding in materials selection.

A property may be a constant or may be a function of one or more independent variables, such as temperature. Materials properties often vary to some degree according to the direction in the material in which they are measured, a condition referred to as anisotropy. Materials properties that relate to different physical phenomena often behave linearly (or approximately so) in a given operating range. Modelling them as linear can significantly simplify the differential constitutive equations that the property describes.

Some materials properties are used in relevant equations to predict the attributes of a system a priori. For example, if a material of a known specific heat gains or loses a known amount of heat, the temperature change of that material can be determined. Materials properties are most reliably measured by standardized test methods. Many such test methods have been documented by their respective user communities and published through ASTM International.

Mechanical properties:

Young’s modulus

Young's modulus, also known as the tensile modulus or elastic modulus, is a mechanical property of linear elastic solid materials. It measures the force (per unit area) that is needed to stretch (or compress) a material sample.

Young's modulus is named after the 19th-century British scientist Thomas Young. However, the concept was developed in 1727 by Leonhard Euler, and the first experiments that used the concept of Young's modulus in its current form were performed by the Italian scientist Giordano Riccati in 1782, pre-dating Young's work by 25 years. The term modulus is the diminutive of the Latin term modus which means measure.

A solid body deforms when a load is applied to it. If the material is elastic, the body returns to its original shape after the load is removed. The material is linear if the ratio of load to deformation remains constant during the loading process. Not many materials are linear and elastic beyond a small amount of deformation. A constant Young's modulus applies only to linear elastic materials. A rigid material has an infinite Young's modulus because an infinite force is needed to deform such a material. A material whose Young's modulus is very high can be approximated as rigid.

A stiff material needs more force to deform compared to a soft material. Therefore, the Young's modulus is a measure of the stiffness of a solid material. Do not confuse:

stiffness and strength: the strength of material is the amount of force it can withstand and still recover its original shape;

material stiffness and geometric stiffness: the geometric stiffness depends on shape, e.g. the stiffness of an I beam is much higher than that of a spring made of the same steel thus having the same rigidity;

stiffness and hardness: the hardness of a material defines the relative resistance that its surface imposes against the penetration of a harder body;

Stiffness and toughness: toughness is the amount of energy that a material can absorb before fracturing.

Young's modulus is the ratio of stress (which has units of pressure) to strain (which is dimensionless), and so Young's modulus has units of pressure. Its SI unit is therefore the Pascal (Pa or N/m^2 or $m^{-1}\cdot kg\cdot s^{-2}$). The practical units used are mega Pascal’s (MPa or N/mm^2) or (GPa or kN/mm^2). In United States customary units, it is expressed as pounds (force) per square inch (psi). The abbreviation ksi refers to "kpsi", or thousands of pounds per square inch.

The Young's modulus enables the calculation of the change in the dimension of a bar made of an isotropic elastic material under tensile or compressive loads. For instance, it predicts how much a material sample extends under tension or shortens under compression. The Young's modulus directly applies to cases uniaxial stress, that is tensile or compressive stress in one direction and no stress in the other directions. Young's modulus is also used in order to predict the deflection that will occur in a statically determinatebeam when a load is applied at a point in between the beam's supports. Other elastic calculations usually require the use of one additional elastic property, such as the shear modulus, bulk modulus or Poisson's ratio. Any two of these parameters are sufficient to fully describe elasticity in an isotropic material.

Young's modulus, E, can be calculated by dividing the tensile stress by the extensional strain in the elastic (initial, linear) portion of the stress–strain curve:

$$E \equiv \frac{\text{tensile stress}}{\text{extensional strain}} = \frac{\sigma}{\varepsilon} = \frac{F/A_0}{\Delta L/L_0} = \frac{FL_0}{A_0 \Delta L}$$

where

E is the Young's modulus (modulus of elasticity)

F is the force exerted on an object under tension;

A_0 is the original cross-sectional area through which the force is applied;

ΔL is the amount by which the length of the object changes;

L_0 is the original length of the object.

Poison's ratio:

Poisson's ratio, named after Siméon Poisson, is the negative ratio of transverse to axial strain. When a material is compressed in one direction, it usually tends to expand in the other two directions perpendicular to the direction of compression. This phenomenon is called the Poisson effect. Poisson's ratio ν (nu) is a measure of this effect. The Poisson ratio is the fraction (or percent) of expansion divided by the fraction (or percent) of compression, for small values of these changes.

Conversely, if the material is stretched rather than compressed, it usually tends to contract in the directions transverse to the direction of stretching. This is a common observation when a rubber band is stretched, when it becomes noticeably thinner. Again, the Poisson ratio will be the ratio of relative contraction to relative expansion, and will have the same value as above. In certain rare cases, a material will actually shrink in the transverse direction when compressed (or expand when stretched) which will yield a negative value of the Poisson ratio.

The Poisson's ratio of a stable, isotropic, linear elastic material cannot be less than −1.0 nor greater than 0.5 due to the requirement that Young's modulus, the shear modulus and bulk modulus have positive values. Most materials have Poisson's ratio values ranging between 0.0 and 0.5. A perfectly incompressible material deformed elastically at small strains would have a Poisson's ratio of exactly 0.5. Most steels and rigid polymers when used within their design limits (before yield) exhibit values of about 0.3, increasing to 0.5 for post-yield deformation (Seismic Performance of Steel-Encased Concrete Piles by RJT Park) (which occurs largely at constant volume.) Rubber has a Poisson ratio of nearly 0.5. Cork's Poisson ratio is close to 0: showing very little lateral expansion when compressed. Some materials, mostly polymer foams, have a negative Poisson's ratio; if these auxetic materials are stretched in one direction, they become thicker in perpendicular direction. Some anisotropic materials have one or more Poisson ratios above 0.5 in some directions.

Assuming that the material is stretched or compressed along the axial direction (the x axis in the below diagram):

$$\nu = -\frac{d\varepsilon_{\mathrm{trans}}}{d\varepsilon_{\mathrm{axial}}} = -\frac{d\varepsilon_{\mathrm{y}}}{d\varepsilon_{\mathrm{x}}} = -\frac{d\varepsilon_{\mathrm{z}}}{d\varepsilon_{\mathrm{x}}}$$

where

ν is the resulting Poisson's ratio,

$\varepsilon_{\mathrm{trans}}$ is transverse strain (negative for axial tension (stretching), positive for axial compression)

$\varepsilon_{\mathrm{axial}}$ is axial strain (positive for axial tension, negative for axial compression).

Yield strength:

A yield strength or yield point of a material is defined in engineering and materials science as the stress at which a material begins to deform plastically. Prior to the yield point the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed, some fraction of the deformation will be permanent and non-reversible. In the three-dimensional space of the principal stresses (

$\sigma_1, \sigma_2, \sigma_3$), an infinite number of yield points form together a yield surface.

Knowledge of the yield point is vital when designing a component since it generally represents an upper limit to the load that can be applied. It is also important for the control of many materials production techniques such as forging, rolling, or pressing. In structural engineering, this is a soft failure mode which does not normally cause catastrophic failure or ultimate failure unless it accelerates buckling.

It is often difficult to precisely define yielding due to the wide variety of stress–strain curves exhibited by real materials. In addition, there are several possible ways to define yielding:

True elastic limit

The lowest stress at which dislocations move. This definition is rarely used, since dislocations move at very low stresses, and detecting such movement is very difficult.

Proportionality limit

Up to this amount of stress, stress is proportional to strain (Hooke's law), so the stress-strain graph is a straight line, and the gradient will be equal to the elastic modulus of the material.

Elastic limit (yield strength)

Beyond the elastic limit, permanent deformation will occur. The elastic limit is therefore the lowest stress at which permanent deformation can be measured. This requires a manual load-unload procedure, and the accuracy is critically dependent on the equipment used and operator skill. For elastomers, such as rubber, the elastic limit is much larger than the proportionality limit. Also, precise strain measurements have shown that plastic strain begins at low stresses.

Yield point

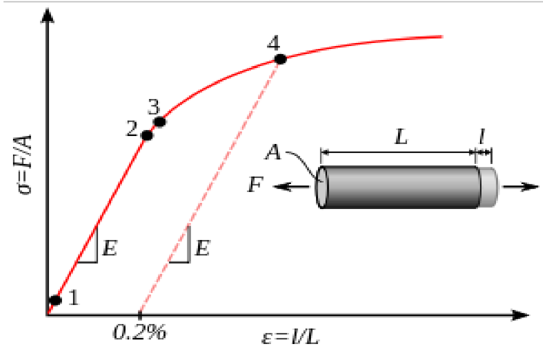
The point in the stress-strain curve at which the curve levels off and plastic deformation begins to occur.

Offset yield point (proof stress)

When a yield point is not easily defined based on the shape of the stress-strain curve an offset yield point is arbitrarily defined. The value for this is commonly set at 0.1 or 0.2% plastic strain.[The offset value is given as a subscript, e.g., $R_{p0.2}$=310 MPa. High strength steel and aluminum alloys do not exhibit a yield point, so this offset yield point is used on these materials

Upper and lower yield points

Some metals, such as mild steel, reach an upper yield point before dropping rapidly to a lower yield point. The material response is linear up until the upper yield point, but the lower yield point is used in structural engineering as a conservative value. If a metal is only stressed to the upper yield point, and beyond, Lüders bands can develop



Stress–strain curve showing typical yield behavior for nonferrous alloys. (Stress (σ) shown as a function of strain (ϵ).)

1: True elastic limit
2: Proportionality limit
3: Elastic limit
4: Offset yield strength

Cast iron

Mechanical Properties

The tensile strengths are dictated by the class of the material. Grey irons are brittle, and have little plastic deformation and thus the yield strength and tensile strengths are almost identical. Further to this, grey irons exhibit little if any strain under tensile loadings and do not follow Hooke’s law very well. This is because microslip is experienced due to the presence of the graphite in the structure.

As these materials do not obey Hooke’s law, the stress-strain curve is not linear, making it difficult to calculate the modulus of elasticity.

The small amount of elastic and plastic deformation these materials exhibit is indicative of low ductility. This in turn leads to low toughness.

Compressive strengths of grey irons are their strong points. It is not uncommon for the compressive strength to be up to five times the tensile strength, while the shear strength may only be 1 to 1.5 times the tensile strength.

Grey irons are also generally quite hard and increase in hardness with increasing class (i.e. from 20 to 60).

Fatigue properties are similar to carbon steels and are typically about 40% of the tensile strengths.

Wear Resistance

Wear resistance is another key design property of gery irons. While they are comparable to medium carbon steels in terms of abrasion, fretting and some forms of corrosive wear, the graphite helps resist metal to metal wear. This is indeed the case when the mating material is a hardened steel, where the graphite provides lubrication and a low wear interface. Consequently, they resist seizing in applications such as screw thread and the like.

Physical Properties

The graphite present in the grey irons is influences damping capacity. This is the ability to suppress elastic deformations or vibrations. In this case, the graphite is thought to absorb vibrations.

Dimensional stability is also somewhat unstable due to the presence of the graphite. Mechanisms responsible for this include pearlite transforming into ferrite resulting in growth, internal oxidation of graphite also resulting in growth. Maintaining operating temperatures below approximately 400°C minimise these effects

Thermal Properties

As their structures are similar to those of plain carbon steels, properties such as thermal conductivity and thermal expansion are very similar.

Electrical Properties

The presence of graphite influences electrical properties of grey irons, and all grey irons will have higher electrical resistivity's compared to steels. Grey irons with coarse graphite's in their structures have higher resistivity's compared to those with finer graphite's

Steel

Steel is an alloy of iron and carbon and other elements. Because of its high tensile strength and low cost, it is a major component used in buildings, infrastructure, tools, ships, automobiles, machines, appliances, and weapons.

Iron is the base metal of steel. Iron is able to take on two crystalline forms (allotropic forms), body centered cubic (BCC) and face centered cubic (FCC), depending on its temperature. In the body-centred cubic arrangement, there is an iron atom in the centre of each cube, and in the face-centred cubic, there is one at the center of each of the six faces of the cube. It is the interaction of the allotropesof iron with the alloying elements, primarily carbon, that gives steel and cast iron their range of unique properties.

In pure iron, the crystal structure has relatively little resistance to the iron atoms slipping past one another, and so pure iron is quite ductile, or soft and easily formed. In steel, small amounts of carbon, other elements, and inclusions within the iron act as hardening agents that prevent the movement of dislocations that are common in the crystal lattices of iron atoms.

The carbon in typical steel alloys may contribute up to 2.14% of its weight. Varying the amount of carbon and many other alloying elements, as well as controlling their chemical and physical makeup in the final steel (either as solute elements, or as precipitated phases), slows the movement of those dislocations that make pure iron ductile, and thus controls and enhances its qualities. These qualities include such things as the hardness, quenching behavior, need for annealing, tempering behavior, yield strength, and tensile strength of the resulting steel. The increase in steel's strength compared to pure iron is possible only by reducing iron's ductility.

Steel was produced in bloomery furnaces for thousands of years, but its large-scale, industrial use began only after more efficient production methods were devised in the 17th century, with the production of blister steel and then crucible steel. With the invention of the Bessemer process in the mid-19th century, a new era of mass-produced steel began. This was followed by the Siemens-Martin process and then the Gilchrist-Thomas process that refined the quality of steel. With their introductions, mild steel replaced wrought iron.

Further refinements in the process, such as basic oxygen steelmaking (BOS), largely replaced earlier methods by further lowering the cost of production and increasing the quality of the final product. Today, steel is one of the most common man-made materials in the world, with more than 1.6 billion tons produced annually. Modern steel is generally identified by various grades defined by assorted standards organizations.

Heat treatment

There are many types of heat treating processes available to steel. The most common are annealing, quenching, and tempering. Heat treatment is effective on compositions above the eutectoid composition (hypereutectoid) of 0.8% carbon. Hypoeutectoid steel does not benefit from heat treatment.

Annealing is the process of heating the steel to a sufficiently high temperature to relieve local internal stresses. It does not create a general softening of the product but only locally relieves strains and stresses locked up within the material. Annealing goes through three phases: recovery, recrystallization, and grain growth. The temperature required to anneal a particular steel depends on the type of annealing to be achieved and the alloying constituents.

Quenching involves heating the steel to create the austenite phase then quenching it in water or oil. This rapid cooling results in a hard but brittle martensitic structure. The steel is then tempered, which is just a specialized type of annealing, to reduce brittleness. In this application the annealing (tempering) process transforms some of the martensite into cementite, or spheroidite and hence it reduces the internal stresses and defects. The result is a more ductile and fracture-resistant steel

HASTE ALLOY C276

Haste alloy C276 is a nickel-molybdenum-chromium super alloy with an addition of tungsten designed to have excellent corrosion resistance in a wide range of severe environments. The high nickel and molybdenum contents make the nickel steel alloy especially resistant to pitting and crevice corrosion in reducing environments while chromium conveys resistance to oxidizing media. The low carbon content minimizes carbide precipitation during welding to maintain corrosion resistance in as-welded structures. This nickel alloy is resistant to the formation of grain boundary precipitates in the weld heat-affected zone, thus making it suitable for most chemical process application in an as welded condition.

Although there are several variations of the Haste alloy nickel alloy, Haste alloy C-276 is by far the most widely used.

Alloy C-276 is widely used in the most severe environments such as chemical processing, pollution control, pulp and paper production, industrial and municipal waste treatment, and recovery of sour natural gas.

Corrosion Resistant Haste alloy C276

Considered one of the most versatile corrosion resistant alloys available, Hastelloy C-276 exhibits excellent resistance in a wide variety of chemical process environments including those with ferric and cupric chlorides, hot contaminated organic and inorganic media, chlorine, formic and acetic acids, acetic anhydride, seawater, brine and hypochlorite and chlorine dioxide solutions. In addition, alloy C-276 resists formation of grain boundary precipitates in the weld heat affected zone making it useful for most chemical processes in the as-welded condition. This alloy has excellent resistance to pitting and stress corrosion cracking.

Characteristics of Haste alloy C276

Excellent corrosion resistance in reducing environments

Exceptional resistance to strong solutions of oxidizing salts, such as ferric and cupric chlorides

High nickel and molybdenum contents providing good corrosion resistance in reducing environments

Low carbon content which minimizes grain-boundary carbide precipitation during welding to maintain resistance to corrosion in heat-affected zones of welded joints

Resistance to localized corrosion such as pitting and stress-corrosion cracking

One of few materials to withstand the corrosive effects of wet chlorine gas, hypochlorite and chlorine dioxide

Composition

Ni	Mo	Cr	Fe	W	Co	Mn	C
Remainder	15.0-17.0	14.5-16.5	4.0-7.0	3.0-4.5	2.5 max	1.0 max	.01 max
V	**P**	**S**	**Si**				
.35 max	.04 max	.03 max	.08 max				

Applications

Pollution control stack liners, ducts, dampers, scrubbers, stack-gas reheaters, fans and fan housings

Flue gas desulfurization systems

Chemical processing components like heat exchangers, reaction vessels, evaporators, and transfer piping

- Sour gas wells
- Pulp and paper production
- Waste treatment

Pharmaceutical and food processing equipment

Haste alloy C-276 alloy can be forged, hot-upset and impact extruded. Although the alloy tends to work-harden, you can have it successfully spun, deep-drawn, press formed or punched. All of the common methods of welding can be used, although the oxyacetylene and submerged arc processes are not recommended when the fabricated item is for use in corrosion service.

Stainless Steel Alloy 440c

Stainless steels are high-alloy steels which have high corrosion resistance compared to other steels due to the presence of large amounts of chromium. Based on their crystalline structure, they are divided into three types such as ferritic, austenitic, and martensitic steels. Another group of stainless steels are precipitation-hardened steels. They are a combination of martensitic and austenitic steels. Grade 440C stainless steel is a high carbon martensitic stainless steel. It has high strength, moderate corrosion resistance, and good hardness and wear resistance. The following datasheet gives an overview of grade 440C stainless steel.

Chemical Composition

the chemical composition of grade 440C stainless steel is outlined in the following table.

Element	Content (%)
Iron, Fe	79.15
Chromium, Cr	17
Carbon, C	1.1
Manganese, Mn	1
Silicon, Si	1
Molybdenum, Mo	0.75

Fabrication and Heat Treatment

Machinability

Grade 440C stainless steel can be machined in the annealed condition. Chip breakers can be used to handle tough and stringy chips. Carbide or ceramic tooling is preferred for this alloy.

Welding

Grade 440C stainless steel is not welded because it can be easily air hardened. To weld this alloy, it should be preheated to 260°C (500°F) and post weld treated at 732-760°C (1350-1400°F) for 6 h followed by slowly cooling in the furnace to prevent cracking.

Hot Working

Grade 440C stainless steel is pre-heated at 760°C (1400°F). Temperature can be increased up to 1038-1204°C (1900-2200°F). It should not be heated below 927°C (1700°F). It is then slowly cooled at room temperature and fully annealed.

Cold Working

Grade 440C stainless steel is slightly cold workable using common practices.

Annealing

Grade 440C stainless steel is annealed at 843-871°C (1550-1600°F) followed by slowly cooling in the furnace.

Tempering

Grade 440C stainless steel can be tempered by soaking at 148°C (300°F).

Hardening

Grade 440C stainless steel can be hardened by heating at 760°C (1400°F). Temperature can be increased up to 1010°C (1850°F) followed by cooling in air or oil.

Applications

Grade 440C stainless steel is used in the following applications:

Gage blocks

Cutlery

Ball bearings and races

Molds and dies

Knives

Valve components

Measuring instruments

Conclusion

CAD combines the characteristic of designer and computer that are best applicable made CAD such as popular design tool. CAD Has allowed the designer to bypass much of the Manuel drafting and analysis. Simulation tools enable us to be creative and to quickly test new ideas that would be much more difficult, time-consuming, and expensive to test in the lab. (Jeffrey D. Wilson, Nasa Glenn Research Center) It also help us reduce cost and time-to-market by testing our designs on the computer rather than in the field. Many of the individual tasks within the overall design process can be performed using a computer. As each of these tasks is made more efficient, the efficiency of the overall process increases as well. The computer is well suited to design in four areas, which correspond to the latter four stages of the general design process; Computers function in the design process through geometric modeling capabilities, engineering analysis calculations, testing procedures, and automated drafting, From the result of the testing and the affordability in terms of cost, it can be concluded that the project is successful. Therefore software design should be encouraged in our institution of higher learning base on the following facts, long product development, countless trial and error, and accountability and limited profitability

In this project both design and calculation and material selection process discussed, in steel composition material, steel 440c material has high yield limit values, so that by using this steel 440c material object durability can increases and the total contact stress values will be reduces overall

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