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STRESS ANALYSIS OF SPUR GEAR USING ANSYS

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ABSTRACT

This report presents a comprehensive analysis of the performance and feasibility of using spur gears as an alternative to chain drives in spiral mill machines. The study focuses on assessing the structural integrity, power transmission efficiency, noise and vibration levels, cost considerations,and overall suitability of spur gears for this specific application. Utilizing Creo Parametric and Ansys software, a detailed structural analysis was conducted to evaluate the stress distribution andload-carrying capacity of the gears. The results indicated that the spur gears exhibited sufficient strength and demonstrated effective load distribution. The power transmission efficiency of the gear system was found to be favourable, with smooth gear engagement and minimal energy loss. Furthermore, the spur gears demonstrated lower noise and vibration levels compared to chain drives, contributing to a quieter working environment. Cost considerations favoured the use of spur gears due to their lower manufacturing and maintenance costs. Observations revealed that thegear teeth experienced minimal wear, and safety considerations were highlighted as the transitionto spur gears necessitates assessing potential hazards and implementing appropriate safety precautions. The choice of mild steel as the gear material proved suitable for the given application,but further optimization opportunities exist. In conclusion, the results and observations affirm thatspur gears offer a viable alternative to chain drives in spiral mill machines, providing adequate load capacity, efficient power transmission, reduced noise and vibration, and potential cost savings. Continued monitoring, optimization, and attention to safety considerations are crucial to ensure long-term reliability and success.

CHAPTER – 1

THE INTRODUCTION

In order to distribute torque and match ground speed, a gear can be used alone or in conjunction with other gears. A spur gear is a gear whose teeth run parallel to the shaft axis. One of its main functions is the transmission of power between parallel shafts.

Spur gears typically have high operating efficiency, typically around 90%. However, it is important to note that there are different types of drivetrains. B. Belt drives and chain drives can have slippage. The problem of slippage can be solved by using gears with constant velocity and angular velocity. The primary purpose of any transmission system is to provide powerful and efficient power transmission. It is inexpensive to manufacture and does not generate noise or vibration.

Ideally, spur gears should be commercially viable. Materials like carbon steel are rolled into tubular forms using spiral mill spur gears. Due to their high elasticity, mild steel spiral pipe mill spur gears are being considered for this project.

When dealing with heavy loads, transmission components are often subjected to two types of stress: Contact stress and bending stress.

In this study, spur gears created in an earlier version of his Creo software were used. After loadinginto the Ansys software, the files were subjected to boundary conditions that enabled static structural analysis. It is also important to understand how the spiral mill components respond to stress. The purpose of this study is to analyze the structural stress of connected spur gears. We conducted a research study to compare the operation of chain drives with that of spur gears. Spiralmills use three helical spur gears to test machine noise resistance, load and operating conditions.

The results of this study will help identify suitable gear mechanisms for the stresses experienced by spiral mills. It also helps to see the potential for spur gears to work well with machines.

Gears of various types:

The following are a few kinds of gears:

1. Spur gear
2. Herringbone gear
3. Bevel gear
4. Worm gear
5. Rack and pinion gear
6. Helical gear

SPUR GEARS:

The input and output shafts are parallel to each other. This means that the gears used for power transmission are coplanar. When a spur gear interacts with another gear, the resulting power is transmitted to a shaft arranged parallel to the tooth axis.

When a spur gear is loaded, there are two kinds of load on it.

Bending stress and contact stress. The purpose of this study is to analyze the loads acting on the spur gears of spiral mill machines. This study was conducted using his Ansys software.

- **Pitch Circle:** A virtual circle with evenly spaced teeth is called a pitch circle. It is an important part of gear design as it sets the diameter of the gear and helps in calculating thegear ratio. To calculate the pitch diameter, the ratio of the number of gear teeth to the pitchdiameter or diametral pitch is used. For efficient gear meshing and power transmission, the pitch circle also specifies the distance from centre to centre between two meshing gears.

- **Diametral Pitch:** Dimetral pitch refers to the diameter of the pitch circle. The unit of measurement is the number of teeth per inch of pitch diameter. Higher values for diametralpitch imply smaller teeth and more teeth in the same location, resulting in more accurate and fluid movement.

- **Addendum:** The radial distance between the pitch circle and the top of the tooth is the addendum. It is tooth's length past the pitch circle.

- **Dedendum:** The dedendum serves as a spacer between the teeth of two meshing gears bymeasuring the separation between the bottom of a tooth and its pitch circle. While the machine is running, this area keeps the teeth from binding or jamming. To make sure thereis enough room for the teeth to move about, the dedendum is sometimes a bit bigger thanthe addendum of the mating gear.

- **Diameter Outer:** The outer diameter, not the circumference, is the diameter of the circlegoing through the ends of the spur gear. The length of the circle is the circumference. Theoutside diameter of a spur gear is an important measurement due to application and designconstraints, but it is usually not the maximum size of a spur gear.

PROBLEM FORMULATION (CHAPTER – 2)

2.1. STATEMENT:

The efficiency of the drive system is typically around 90%, with the exception of chain drives andbelt drives, which can cause slippage. This issue can be solved by using a positive drive, which has constant velocity.

2.2. SOLUTION:

In order to determine if the spiral mill can be operated properly with a spur gear system instead ofa chain drive, a stress analysis was performed on the components. The study analyzed the distribution of stress on the gears, their load capacity, and whether or not the spur gear system is ideal for the type of spiral mill. The main objective of this study is to determine if the two systemscan produce the same results.

2.3. OBJECTIVES:

Design: Creating the component designs with the Creo programmer. The developed gears are then loaded into the ansys software.

Equivalent strass: The diagram depicts the equivalent stress that results from connecting threegears. As the wheels turn, the strain is transmitted uniformly throughout the body. Stress is transmitted from one area of the body to the other as a result of contact between the three components.

Results: Evaluate the effectiveness and outcomes produced by the spur gear system. Consider variables like each system's overall efficacy, dependability, accuracy, and precision in running thespiral mill.

Make Recommendations: Provide advice on whether to use the spur gear system for the spiral mill based on the analysis and comparison results. Determine any alterations or adjustmentsneeded for a smooth transition.

Optimize Performance: If the spur gear system turns out to be a workable substitute, look into ways to improve it some more. To maximize effectiveness and lifespan, take into account design adjustments, material upgrades, or lubrication enhancements.

Safety Assessment: Compare the safety implications of utilizing a spur gear system to a chaindrive system in terms of possible risks, noise levels, and any additional safety precautions needed.

2.4. SPIRAL MILLING MACHINE

Spiral milling is a process that does not require the use of small tools. Achieves a good finish evenon a flat part to some extent. Decrease the steps to increase the efficiency of the machine.

The headstock is driven by a lead screw and driven by a timing belt and pulleys. This operation required adjusting the band so that the shaft would rotate in the opposite direction.

Fig1 : Spiral mill picture

MODELLING AND ANALYSIS (CHAPTER – 3)

3.1 .MATERIALS FOR GEAR:

Material selection is important when designing mechanical components. Material properties are important for understanding how materials respond to external stresses. A spur gear of a spiral millwas selected as the object of investigation. In our research, we used mild steel. Mechanical qualities differ from one material to the next. These material qualities are critical in material selection and design.

3.2. THE METHODOLOGY:

In summary, we will test three spur gears that will be used instead of chain drives to check if theycan sustain the load. The machine introduced in this study is used to form sheet metal into tubes or tubular structures. Bend the sheet by rolling it on the machine to give it the correct shape. The weight per sheet is about 30 tons. As seen in the photo above, a gear chain mechanism connectedby sprockets is used to drive the machine. In this case the chain drive is omitted and a transmissionsystem with three spur gears is used. Our research focuses on this disease.

Fig2 : Equipment with a spiral mill's chain drive

Instead of a chain drive, three spur gears were utilized with the same number of teeth and diameteron the first and last gears. The middle gear, on the other hand, is larger and has more teeth than the others. The force acting on these gears when the spiral mill is loaded is spread equally. Thesegears engage and move when a consistent force of 30 tonnes is applied to the device. Our major objective is to monitor and evaluate if the integrated gear mechanism produces the required outcomes and functions well as a chain drive. Along test your capacity to bear the weight.

The spur gears fitted here were manufactured of mild steel and havethe following dimensions:

First Gear:

Dia at the Outside = 396 mmTeeth number = 31

Diameter of shaft = 180mmHeight of key = 14mm Width of key = 45mm **Second Gear:**

Dia at the Outside = 540 mm

Gear width = 130mm Teeth number = 43 Diameter of shaft = 180mmHeight of key = 14mm

Width of key = 45mm

Third Gear:

Dia at the Outside = 396 mmTeeth number = 31

Diameter of shaft = 180mmHeight of key = 14mm Width of key = 45mm **Step: 1**

Create a spur gear for a spiral mill machine and install it in place of the existing chain drive to test the operation of the machine using spur gears instead of chain drives. Then analyze the results anddraw conclusions.

Step:2

3D models of spur gears of various designs were created in Creo Parametric 3.0 software to determine the results between the loads acting on the gears and their ability to withstand those loads.

Step:3

After meshing and boundary conditions were accomplished, the 3D model was exported to AnsysWorkbench for analysis as an IGES file.

Step:4

We may evaluate whether the gear mechanism is adequate for the machine by applying loads to provided gears in Ansys and computing gear stresses.

3.3. Creo design of spur gear:

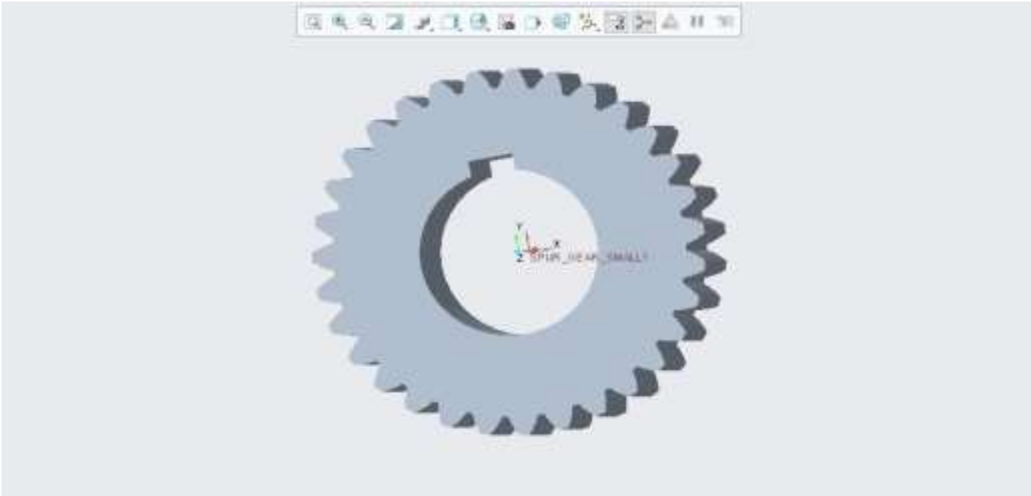


Fig 3: 3D model of Spur Gear1

○ **STEP -1: :** The first step in creating a new template is to create a new template named SPUR-GEAR_SMALL. Next, select various important parameters to use in your model. The pitch parameter is used to determine the number of teeth, and the number of teeth andpressure angle are used to determine the object value.

/*MODULE
MODULE1 = DIAMETER_ PITCH/TEETH

Next, we confirm and press the "OK" button.

○ **STEP -2:** The front face is selected, and three circles are drawn. Those are

1) dia_ Pitch_sketch
2) dia_ Root_sketch
3) dia_ Outside_sketch
4) Circle_center
5) lock_ Inner_key

By implementing the equation

/*MODULE

MODULE1 = DIA_ PITCH/TEETH

/* CIRCLE DIAMETERd0= DIA_ PITCH

d1= DIA_ PITCH – 2.5*MODULE1d2 DIA_ PITCH + 2*MODULE1

○ **STEP -3:** To generate the gear key, we must first create a curve, and the curve equation is as follows:

DP= DIA_ PITCH

AP= ANGLE_PRESSURECR=(DP/2) * COS(AP) THETTA = T*90

THETTA_RD=THETTA*(PI/100)

A= CR*COS (THETTA)+CR* THETTA_RD*SIN(THETTA)B= CR*SIN (THETTA)+CR* THETTA_RD*COS(THETTA)

C=0

○ To see a preview regarding the curve, click OK. Then use the "Trim" command to removeunwanted parts of the curve. The curvature is then mirrored. The next step is to link the two separate curves using the same line to the base circle. It is created with the name key_Teeth_sketch.

○ **STEP -4:** The Extrude command lets you create geometry by first extruding a drawing.Start with the root circle. After that add a tooth and rename the sketch to "teeth".

○ **STEP -5:** The Pattern section allows you to create a series of teeth around the root of theround component. You can specify the number of teeth to use and his 360 degree angle between teeth. To create the pattern, draw the teeth relative to the pitch_dia_sketch and thecircle axis.

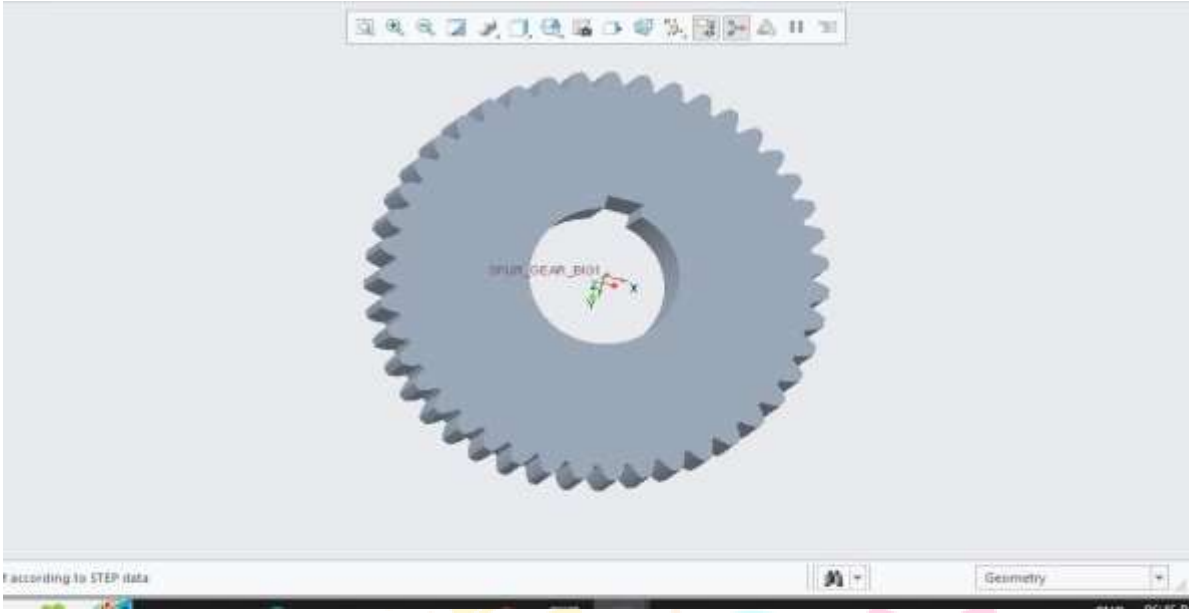


Fig 4: 3D model of spur gear2

○ **STEP -1:** The first step in creating a new template is to create a new template named SPUR-GEAR_BIG1. Next, select various important parameters to use in your model. Thepitch parameter is used to determine the number of teeth, while the number of teeth and pressure angle are used to determine the object value.Used to determine property values.

/*MODULE

MODULE1 = DIAMETER_ PITCH/TEETH

Next, we confirm and press the "OK" button.

○ **STEP -2:** The front face is selected, and three circles are drawn. Those are

6) dia_ Pitch_sketch
7) dia_ Root_sketch
8) dia_ Outside_sketch
9) Circle_center
10) lock_ Inner_key

By implementing the equation

/*MODULE

MODULE1 = DIA_ PITCH/TEETH

/* CIRCLE DIAMETERd0= DIA_ PITCH

d1= DIA_ PITCH – 2.5*MODULE1d2 DIA_ PITCH + 2*MODULE1

○ **STEP -3:** To generate the gear key, we must first create a curve, and the curve equationis as follows:

DP= DIA_ PITCH

AP= ANGLE_PRESSURECR=(DP/2) * COS(AP) THETTA = T*90

THETTA_RD=THETTA*(PI/100)

A= CR*COS (THETTA)+CR* THETTA_RD*SIN(THETTA)B= CR*SIN (THETTA)+CR* THETTA_RD*COS(THETTA)C=0

To see a preview regarding the curve, click OK. Then use the "Trim" command to removeunwanted parts of the curve. The curvature is then mirrored. The next step is to link the two separate curves using the same line to the base circle. It is created with the name key_Teeth_sketch.

○ **STEP -4:** Use the Extrude command to create geometry. The first step is to select the root circle. And the extruded part is called a tooth.

○ **STEP -5:** The Pattern section allows you to create a series of teeth rotating around a circular path. Place multiple teeth on each part and between them he should create a 360 degree angle. The axis serves as the circle's center, and the pitch circle diameter drawing serves as the reference. A tooth is created by selecting the appropriate tooth.

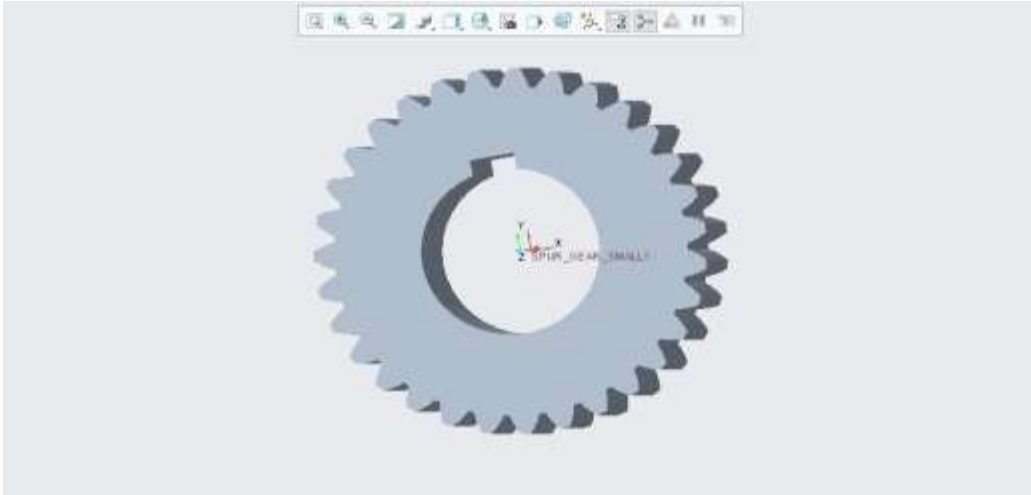


Fig 5: 3D model of spur gear3

We didn't mention it since the dimensions of this gear 3 sketch design are the same as spur gearsmallgear-1.

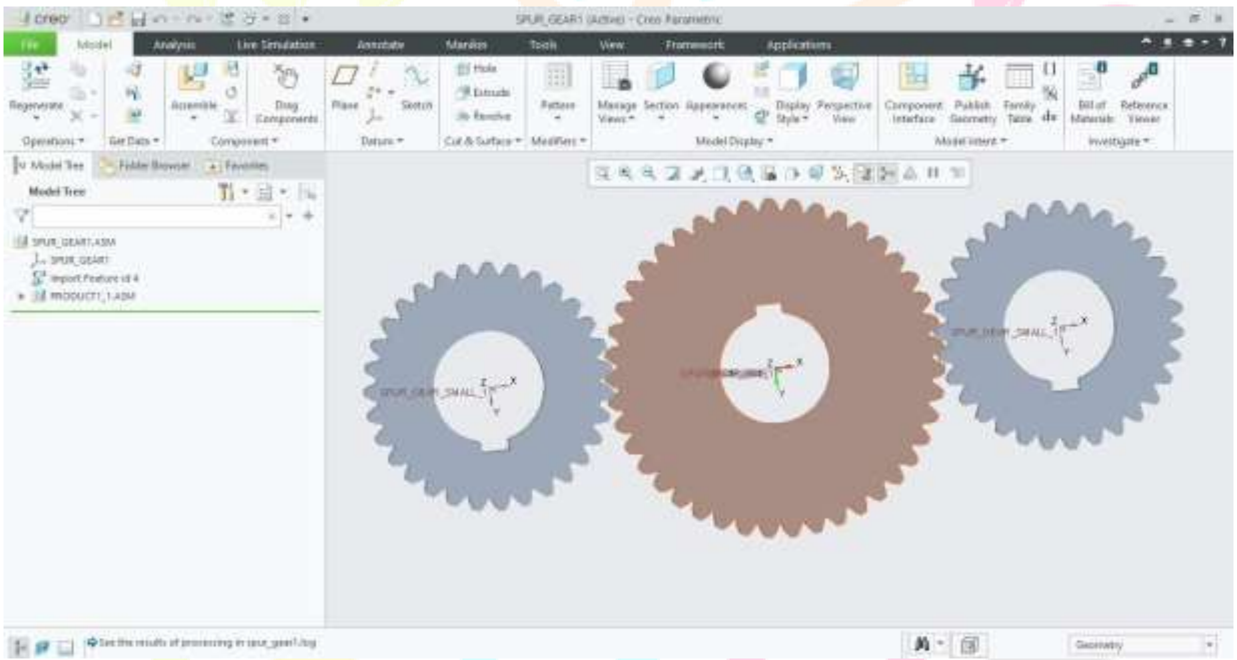


Fig 6 Gears are assembled.

To determine whether the three Gears complement one another well, they are assembled in a fresh Creo template.

- The three drawings must be imported as a first step.
- The primary gear is placed in the center, while the other two are placed on either side.
- The alignment was then double-checked to make sure everything was in place. went on tothe following

3.4. FEA-BASED STRESS ANALYSIS

The concept of finite element analysis is a method that can be used to describe a model or physicalassembly. This includes applying constraints to the geometry and ensuring that the material properties of the components are correct. This method would not have been possible without the appropriate software and computers.

An evaluation of the device's structural reliability is possible through the use of stress analysis, fatigue analysis, and accelerated durability testing. On powerful computer systems, stress analysisis often carried out using a technique called finite element analysis (FEA). The highest possible stresses and strains in a device under specific constraints and loading circumstances during the course of the device's manufacture, delivery, and service history may be determined using the numerical approach known as finite element analysis (FEA). Material constitutive properties should be determined using similar materials and processing conditions as the finished device. Furthermore, verification and validation are critical parts of FEA for demonstrating the correctness and dependability of stress analysis findings. The ASME Standards Committee's General Guidelines for FEA Verification and Validation are a helpful resource to utilise when building his FEA verification and validation strategy for equipment.

After obtaining the major stresses from the output database, the mean stress and cyclic stress amplitude may be computed using ASTM E1823, Standard Terminology for Fatigue and FractureTesting. The mean stress σm and stress amplitude σa were calculated from the maximum principalstress using the following formulas:

A finite element evaluation typically consists of three main phases in practice.:

Preprocessing: An analysis-related portion is modelled by the user. The geometry is split intoa number of discrete "elements" or sub-regions in this model, which are linked by discrete "nodes."A specified load is applied to some of these nodes, while a set displacement is applied to others. Given how time-consuming it is to prepare these models, commercial software is competing to develop the graphical "pre-processors" that are the most user-friendly and facilitate this laboriousprocess. In the course of computer-aided drawing and design, several of these preprocessors mayoverlay meshes on top of already-existing CAD files, making them helpful for finite element analysis.

Analysis: To create and solve systems of linear or nonlinear algebraic equations, the finite element code itself uses the data set created by the preprocessor as input. where u and f representnodal displacements and external forces, respectively. Depending on how the problem is being approached, the K matrix is formed. The methods for linear elastic stress analysis and truss analysis are described in this module. Commercial programming may provide huge element collections with parts suitable for a wide range of applications. a few the primary advantages of FEA is that itenables a single piece of code to tackle a range of problems by picking the appropriate element type from a library.

Postprocessing: In the early days of finite element analysis, the user would sift through reams of statistics generated by the algorithm, detailing the stresses and displacements at discrete locations inside the model. Modern programmes use graphical representations to assist users visualise the information, however this makes it easier to miss important patterns and hotspots. A typical postprocessor display overlays coloured outlines that represent the model's stress levels, resulting in a full-field visual that resembles the results of tests using photo flixble or other materials.

The function of a certain code is often outlined in the documentation provided with the programme,and suppliers of more costly codes frequently provide seminars or training sessions to assist customers learn the subtleties of code functioning

However, users may still encounter problems with the code after completing this training. Even after this training, users could still encounter issues because the code is frequently a "black box" whose inner workings are unknown. The ideas behind the majority of the most recent finite elementstress analysis algorithms will be discussed in this subject, with the focus for the time being on linear elastic analysis. Understanding this theory makes the "black box" myth go away and clarifiesthe analytical underpinnings of solid mechanics.

Ansys is popular for its adaptability and ability to perform well on a wide variety of technicaltasks. That makes it an ideal choice to analyze and deliver effective results.

3.5. PROCESS OF STATIC STRUCTURAL ANALYSIS

Pictorial representation of analysis of spur gear

Before using the Ansys software, the planning and assembly tasks for spur gear were carried out in the software using precise measurements. To make it easier to import the model files, the boundary conditions and meshing criteria were first checked. The gears were then evenly distributed with a load of 30 tonnes.

Ansys software is what we're using here. Working steps

- We begin by launching "workbench". hear, we develop 3 static structural blocks.

A. Spur_Gear_Big

B. Spur_Gear_Small

C. Assembled Gears

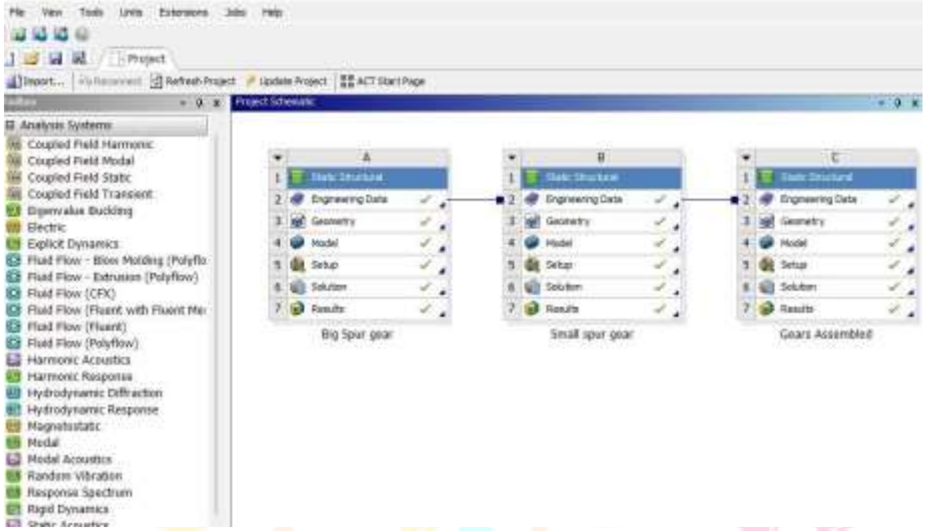


Fig -7 : Setup of 3 gears Static Structural

- Each block comprises technical information that has been submitted. Parametric Creo software-created designs and parameters are saved. At that moment, the initialization is complete, and the results are logged in results.

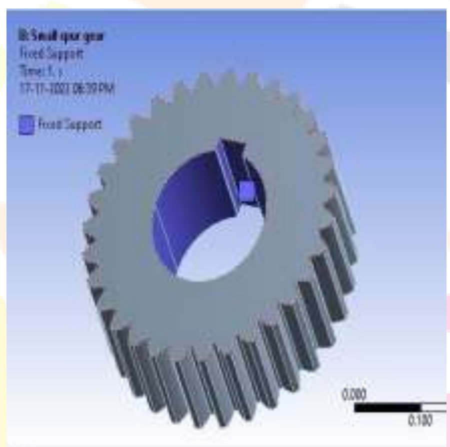


Fig 8 : Fixed support on gear1

- The figure shows the shape of a small gear. Although the illustration shows the post attached tothe inner locking point, this component remains fixed and helps align the gear properly. This allows Gear and its companions to move together.

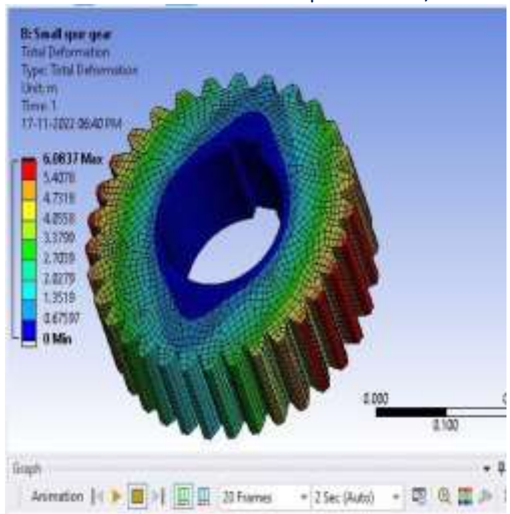


Fig 9 : Deformation in Gear1 in Ansys

The distortion in the image above is the result of the deformation of the small gear. Listening to this deformation, we know that it can withstand minimum pressure and maximum deformation. The gear has a maximum deformation of 7.5872Mpa and a minimum deformation of 0Mpa.

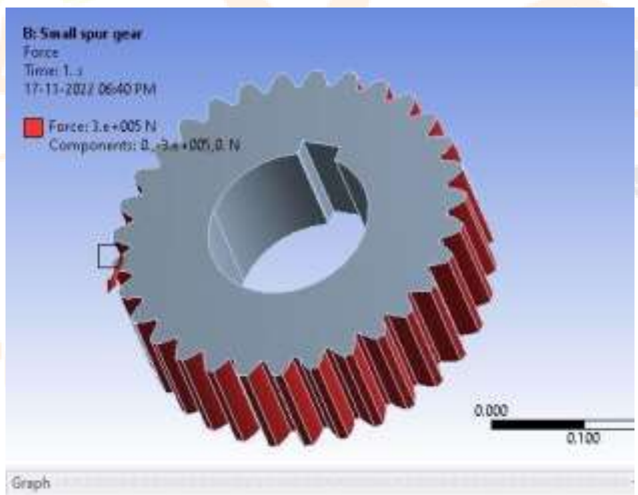


Fig 11: Gear1 force exerted

The diagram above depicts the forces acting on the gear's body. In practice, forces are transmittedto the edges or surfaces of the gear during rotation. Gear rotation is caused by a force transmittedfrom one part of the body to another. When two gears are engaged, they both rotate counterclockwise.

Force applied on gear

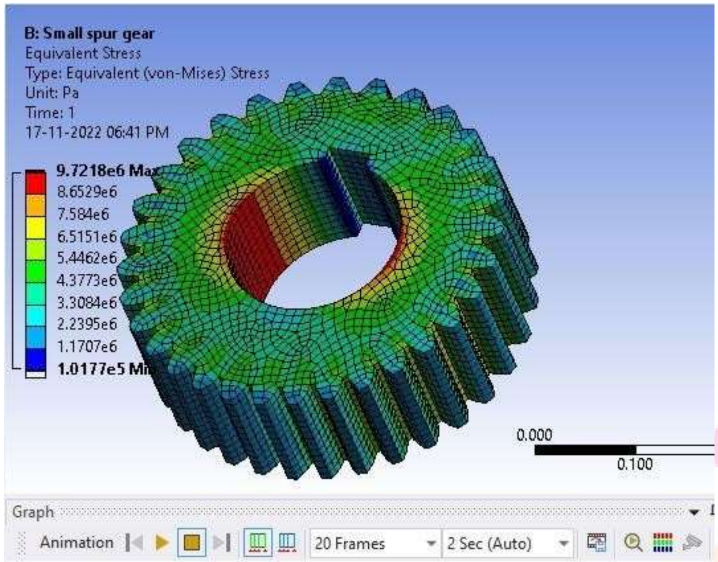
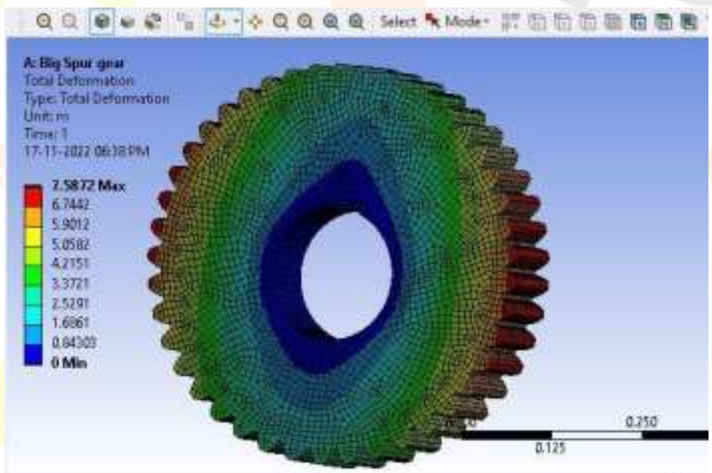


Fig 11: Von mises stress of gear1&3

This figure shows the equivalent stresses experienced by three gears when meshed. The 3-gear movement distributes the load evenly. This transfers stress from one part of the system to another.This behavior sets the minimum and maximum voltages to 1.0177Mpa and 9.7218Mpa, respectively.

Fig(12):Deformation in gear2 in Ansys



The image above shows the complete distortion of a small gear. It can withstand the minimum andmaximum pressures that can be felt throughout the body. In this case, the maximum deformation is 7.5872Mpa.

Deformation

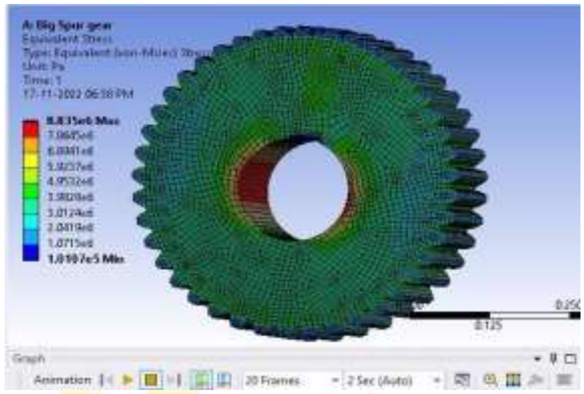


FIG (13) : Equivalent von mises stress of gear2

The graphic shows the equivalent tension when three gears are joined. The tension is distributed evenly across the body as the wheels spin. Due to the contact between the three components, the stress is transferred from one part of the body to the other. The highest and lowest stresses occur at 8.835Mpa and 1.0107Mpa respectively.

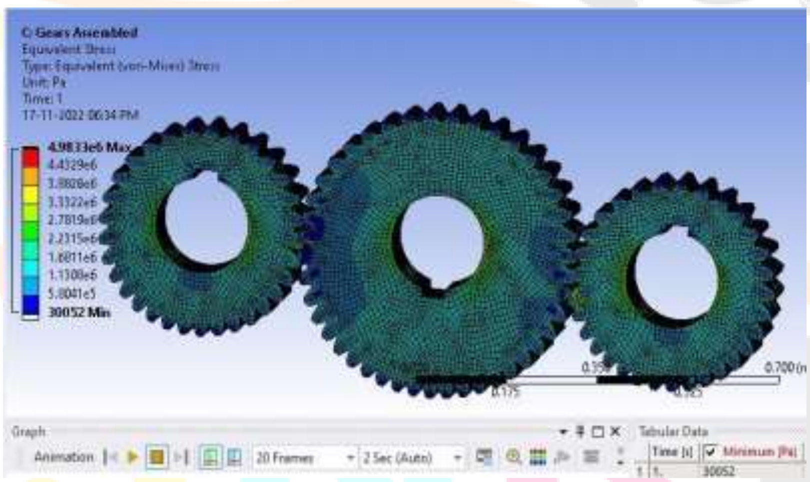


Fig 14: The stress equivalent of the assembled item.

The graphic depicts the tension between the three components as they rotate in succession. Whenone of the gears moves, the other two will follow suit, and the resulting contact causes the stress to be transferred from one part to the other. This procedure has a maximum stress of 4.9833Mpa and a minimum stress of 3.0053Mpa.

RESULT & DISCUSSION (CHAPTER – 4)

RESULT

Following a thorough examination of the spiral mill's gear action, Three spur gears were chosen to replace the chain drive. This change was made after the initial stages of spiral mill operation were completed.

Before starting the static structural analysis, the spiral mill gear design was created according to the gear specifications. In addition, the operating conditions and life parameters of spur gears wereanalyzed. The purpose of the study was to analyze whether using a spur gear structure instead ofa chain drive would yield the desired results. The spur gear design withstands the stresses the machine experiences and resists deformation during stress periods. The findings will be analyzedand published after the project is completed. The spur gear design is also suitable for short shaft spacing and translation of spiral mills. A spiral mill gear design was created according to Creo Parametric specifications before performing a static analysis using the spur gear .

The study boundary conditions were then defined and the operating conditions and service life ofthe spiral mill spur gear were tested with a load of 30 tons. Research results show that using helicalgears instead of chain drives yields desirable results, and the images show full deflection and loading of these components.

The maximum stress and deflection of the spiral mill component. The data collected during the investigation allowed us to produce drawings showing the design components of the spiral mill spur gear. The image also shows the von Mises stress level of the assembled section. Research results show that spiral mill spur gears can withstand the stresses they experience.

The spur gear design of the spiral mill is also better suited for short shaft spacing and translation,allowing for efficient operation.

CONCLUSION:

In this study, we examined spur gears used in spiral mill machines to determine their appropriateness as a replacement for chain drives. The major goal was to see if the spur gear system could give equivalent performance to the chain drive system while withstanding the weight and stress encountered during spiral milling operations.

Through the use of Creo Parametric and Ansys software, we designed 3D models of the spur gearsand subjected them to structural analysis. The gears were made of mild steel and had specific dimensions and properties. The analysis focused on examining the distribution of stress on the gears, their load capacity, and their ability to transmit power effectively.

Based on our analysis and evaluation, we draw the following conclusions:

1. Spur gears are suitable for power transmission in spiral mill machines. They can effectivelydistribute torque and match ground speed between parallel shafts.
2. The designed spur gears demonstrated sufficient load capacity and were able to withstandthe forces applied during spiral milling operations. The stress analysis indicated that the gears could handle the required loads without failure.
3. The spur gear system showed promise as a replacement for chain drives in spiral mill machines. It provided efficient power transmission and exhibited low noise and vibration levels.
4. The use of spur gears in spiral mill machines can lead to cost savings in manufacturing andmaintenance compared to chain drives. Spur gears are inexpensive to manufacture and donot require frequent adjustments or lubrication.
5. The material selection of mild steel for the spur gears proved to be suitable for the given application. However, further research and experimentation with different materials may be beneficial to optimize performance and durability.
6. An overall deformation of 1.3091 MPa and a highest stress result of 4.9833 MPa, Design 3 can effectively withstand heavy loads while maintaining structural integrity and shape.

7. Safety implications should be carefully considered when transitioning from a chain drive system to a spur gear system. It is important to assess the potential risks, noise levels, andany additional safety precautions required.

In conclusion, the analysis and evaluation of the spur gear system for spiral mill machines indicatedthat it is a viable alternative to chain drives. The spur gears demonstrated satisfactory load capacity, efficient power transmission, and potential cost savings. However, further testing and optimizationmay be necessary to fine-tune the gear design and ensure long-term performance and reliability.

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