Design of Pneumatic Rotary Actuator Spur Pinion in Worst Loading Condition with Different Material

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ABSTRACT

In pneumatic rotary actuators widely use in valve operating opening and closing system the rack and pinion are use for valve operation in that failure in spur pinion observed for maximum pressure of 8 bar due to this failure causes actuators to be stop current operation this failure is high due to higher pressure load acting on pinion. This failure can be changed by assuming different material to existing design of spur pinion this modification minimizes failure in pinion and optimize the weight of application. In This first drawing the 3-d model with help of solid edge software and then with help of ANSYS software also the stresses And Deflection in the spur pinion must be analyzed under worst conditions in order to prevent its failure. as material changes doing for different loading condition.

Keywords*: Spur Gear, Fea, Steel, Aluminum, Bending Strength*

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1. INTRODUCTION

Gears are Essential used mechanical components in power transmissions and are frequently responsible for gearbox failures. Two kinds of tooth damage can occur under repeated loadings that cause fatigue; namely, the pitting of gear teeth flanks and tooth fracture in the tooth root. Gear is one of the most critical component in a mechanical power transmission system, and most industrial rotating machinery. A pair of spur gear teeth in action is generally subjected to two types of cyclic stresses: bending stresses inducing bending fatigue and contact stress causing contact fatigue. Both these types of stresses may not attain their maximum values at the same point of contact fatigue.

Spur gear is The simplest types of gears are those that connect parallel shafts. They are generally relatively easy to manufacture and are capable of transmitting large amounts of power with high efficiency. Parallel axis gears transmit power with greater efficiency than any other type or form of gearing. The spur/helical gear have teeth on the outside of a cylinder and the teeth are parallel to the axis of the cylinder. The shape of the tooth is that of an involute form. These gears having about a 3.8:1 ratio for optimum design. The teeth are 20° involute tooth form. The most common pressure angles used for spur gears are 14.5°, 20°,and 25°. In general, the 14.5° pressure angle is not used for new designs (and has, in fact, been withdrawn as an AGMA standard tooth form); however, it is used for special designs and for some replacement gears.

In this mostly focus on only pinion but pneumatic rotary actuator having pneumatic rack and pinion actuators that can be used to control valves in pipeline transport. The actuators in the picture on the right are used to control the valves of large water pipeline. In the top actuator, a gray control signal line can be seen connecting to a solenoid valve (the small black box attached to the back of the top actuator), which is used as the pilot for the actuator. The solenoid valve controls the air pressure coming from the input air line (the small green tube). The output air from the solenoid valve is fed to the chamber in the middle of the actuator, increasing the pressure. The pressure in the actuator's chamber pushes the pistons away. While the pistons are moving apart from each other, the attached racks are also moved along the pistons in the opposite directions of the two racks. The two racks are meshed to a pinion at the direct opposite teeth of the pinion. When the two racks move, the pinion is turned, causing the attached main valve of the water pipe to turn.

2. LITERATURE SURVEY

1. Mrs, Shinde S.P. et.al The parametric model is capable of creating spur gears with different modules and number of teeth by modifying the parameters and regenerating the model.by taking the reference this in our project the parametric model of spur gear

is created in Creo 3.0.The Sets of gears having the same module and pressure angle can be created and assembled together. It is possible to carry out finite element analysis such as root bending stress and contact stresses between gear teeth pair and effect of root fillet radius on the root stresses. The 3D deformable-body (model) of spur gears is developed. The result is checked with theoretical calculation data. The simulation results have good agreement with the theoretical results, which implies that the deformable-body (model) is correct. With reference to these results a sound foundation for future studies on contact stresses. The model is applied onto commercial FEA software ANSYS. Simulation results were compared and confirmed by the theoretical calculation data. By applying same methodology for the project the FEA calculation is carried out with Pro-mechanica.

2. Daniela Ristić, MSc (Eng):- An efficient and Reliable numerical model for the determination of tooth root phenomena caused by geometrical discontinuity understatic and cyclic loads is studied from his paper, Critical tooth root stress Concentration is caused, in the first place, by an inner contact point load of a single mesh and then by an outer contact point of double mesh. These loads are the main Cause of crack initiation and they are only investigated. The most important one is tooth root stress caused by load in the inner contact point of the mesh since it is the highest and the most dangerous for failure appearance. Reduction of stress concentration acts directly on gear service life elongation because it deflects the danger of crack initiation and increases the safety factor SF at that place. Although the stress on the pressured side is higher than on the tensile one, the stress concentration on the tensile side is more important for initial crack appearance. It is supposed that two fillet radii (“two level approach” in a root) act as a “disencumber notch” for stress and that the tooth root stress concentration will be lower. Nevertheless, the analyses show that is not always correct and that it is possible to get higher tooth root stress with two fillet radii than only with one radius for the same determined gear. The Von Mises stress values, for gears with only one fillet radius, are always higher than the normal stress values.

3. V .Raja prabakaran, et.al -The main objective of this study is to add different shaped slot to reduce stress attention. A finite factor type of Spur gear with a segment of three teeth is known for evaluation and stress concentration minimizing holes of numerous sizes will be introduced on gear tooth at various locations. Evaluation revealed that aero-fin designed hole introduced along the stress flow direction produced better results

4. Machine design by R.S.khurmi gear tooth strength calculation, this standard specifies a method for rating the pitting resistance and bending strength of spur and helical involutes gear pairs. A detailed discussion of factors influencing gear survival and calculation methods is provided. as per standard the calculation of gear tooth safety is carried out in our project.

3. PROBLEM STATEMENT

In this spur pinion are widely used for closing and opening valve.The failure are observed in pinion are due to various reasons like worst condition of loading, improper lubrication, corrosion etc. in the pinion failure generally start at root fillet radius .and the cracks may observed at fillets. This teeth failure may lead to failure in entire transmission system .this problem can be minimize by a selection of different material to a spur pinion. In the higher weight of part also lead problem in opening and closing pneumatic rotary actuators to such the weight reduction can be achieved by changing the material of spur pinion.

4. OBJECTIVE

In spite of the number of investigations devoted to gear research and analysis there still remains to be developed, a general numerical approach capable of predicting the effects of variations in gear geometry, bending stresses and Von-Mises stresses. The objectives of this thesis are to use a numerical approach to develop theoretical models of the behavior of gears in mesh, to help to predict the effect of gear tooth stresses and transmission error. The main focus of the current research as developed here is to analyses the failure of spur pinion.

1. Model of baseline of spur pinion by solid edge software.
2. Analyses the baseline spur pinion design by ansys and evaluate deflection and stress for different material as steel and aluminium.
3. Compare the deflection and stress for both.

5. FINITE ELEMENT ANALYSIS

Finite element analysis (FEA) is a fairly recent discipline crossing the boundaries of Mathematics, Physics, and Engineering and computer science. The method has wide application and enjoys extensive utilization in the structural, thermal and fluid analysis areas. Finite element analysis (FEA) is a computer based numerical technique for calculating strength and behavior of engineering structure. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. It also can be uses to analyze either a small or large scale deflection under or applies displacement. It uses a numerical technique called the finite element analysis method (FEA). In finite element method, the actual continuum is represented by the finite element. These elements are considered to be joined at specified joints called nodes or nodal solution. As the actual variation of the field variables (like displacement, temperature and pressure or velocity) inside the continuum is not known, the variation of

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field inside a finite element is approximately by a simple function. The approximating functions are also called as interpolation models and are defined in terms of field variables at nodes. When the equilibrium equations for the whole continuum are known, the unknowns will be the nodal values of the field variable. In this dissertation work fatigue analysis was carried out using FEA software ANSYS.

5.1 Methodology:

A FEA always involves a number of uncertainties that impact the accuracy or reliability of each stage of a FEA and its results. The book, Building Better Products with Finite Element Analysis by Adams and Ashkenazi gives an outstanding detailed description of most of the real world uncertainties associated with solid mechanics FEA. All engineers conducting stress studies should read it. That book also points out how poor solid modeling skills can adversely affect the ability to construct meshes for any type of FEA. Here, the most important FEA uncertainties are highlighted.

5.2 Preprocessing*:*

As the name indicates, preprocessing is something before processing analysis. The Preprocessing involves the preparations of data, such as nodal coordinates, connectivity, boundary conditions and loading and material information.

The preparation of data require considerable effort if all data are to be handled manually. If the model is small, the user can often just write a text file and feed it into the processor, but as the complexity of the model grows and the number of elements increase, writing the data manually can be very time consuming and error-prone. It's therefore necessary with a computer preprocessor which help with mesh plotting and boundary conditions plotting.

For an example of a simple preprocessor, see the Java-applet on these pages. Here you can change loads, boundary conditions, mesh and element properties and material. All this is done graphically to minimize the chance of error. The only limitation is that you cannot draw your own geometry; you have to select one of the pre-generated geometries. Processing or finite element analysis: This stage produces an output visual file.

6. CAD MODEL

Cad geometry was prepared as per machining conditions by using Solid Edge ST7.In that pinion cad drawing is below:

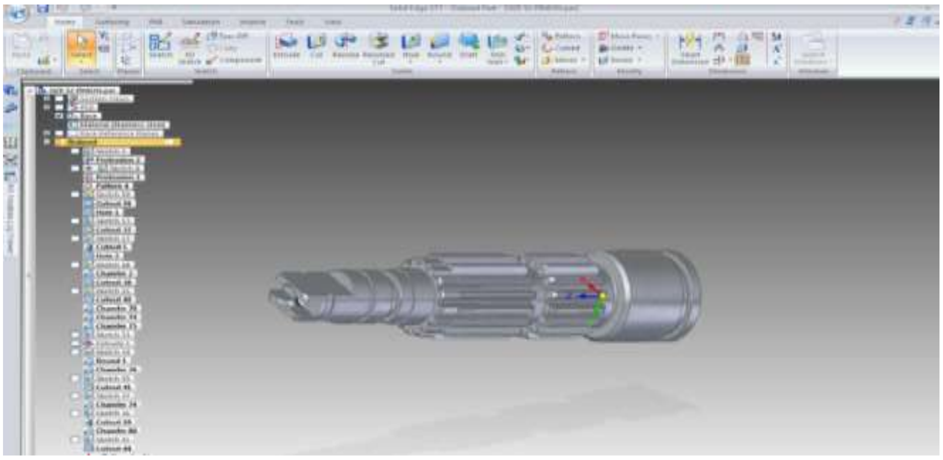

Fig.1 Actual Model in Solid Edge ST7

6.1 Meshing:

Meshing is probably the most important part in any of the computer simulations; because it can show drastic changes in results (have a first-hand experience of this). Meshing means you create a mesh of some grid-points called 'nodes'. It's done with a variety of tools & options available in the software. The results are calculated by solving the relevant governing equations numerically at each of the nodes of the mesh. The governing equations are almost always partial differential equations, and Finite element method is used to find solutions to such equations. The pattern and relative positioning of the nodes also affect the solution, the computational efficiency & time. This is why good meshing is very essential for a sound computer simulation to give good results. The meshing types are described below,

A Tetrahedron Meshing is has 4 vertices, 6 edges, and is bounded by 4 triangular faces. In most cases a tetrahedral volume mesh can be generated automatically. A Pinion Tetrahedron Meshing Figure As Below:

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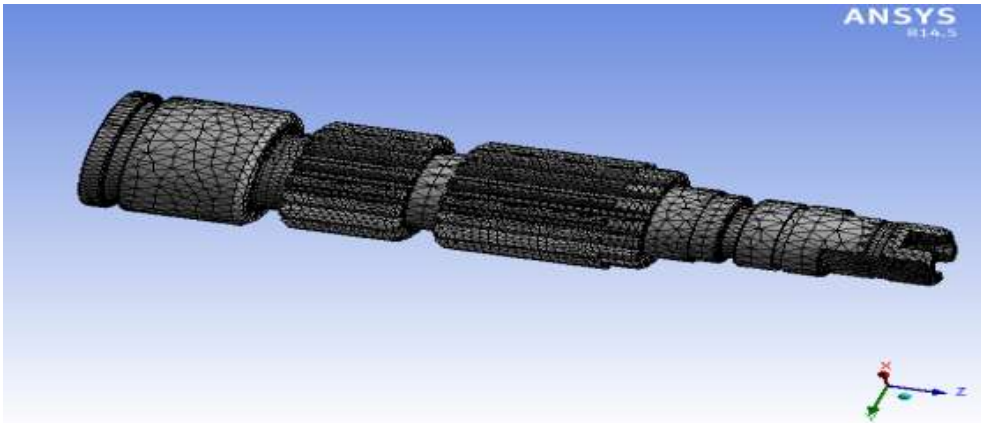

Fig.2 - Meshing of Spur Pinion

No. of nodes in model	124622
No. of elements in model	75846

Table No1-Meshing Details

6.2 Loading and Boundary Conditions:

Different sets (contact, fix, slave surface) were defined to apply boundary conditions. Boundary conditions applied for Spur Pinion Fix support applied on both sides of the gear as shown in the Figure Below:

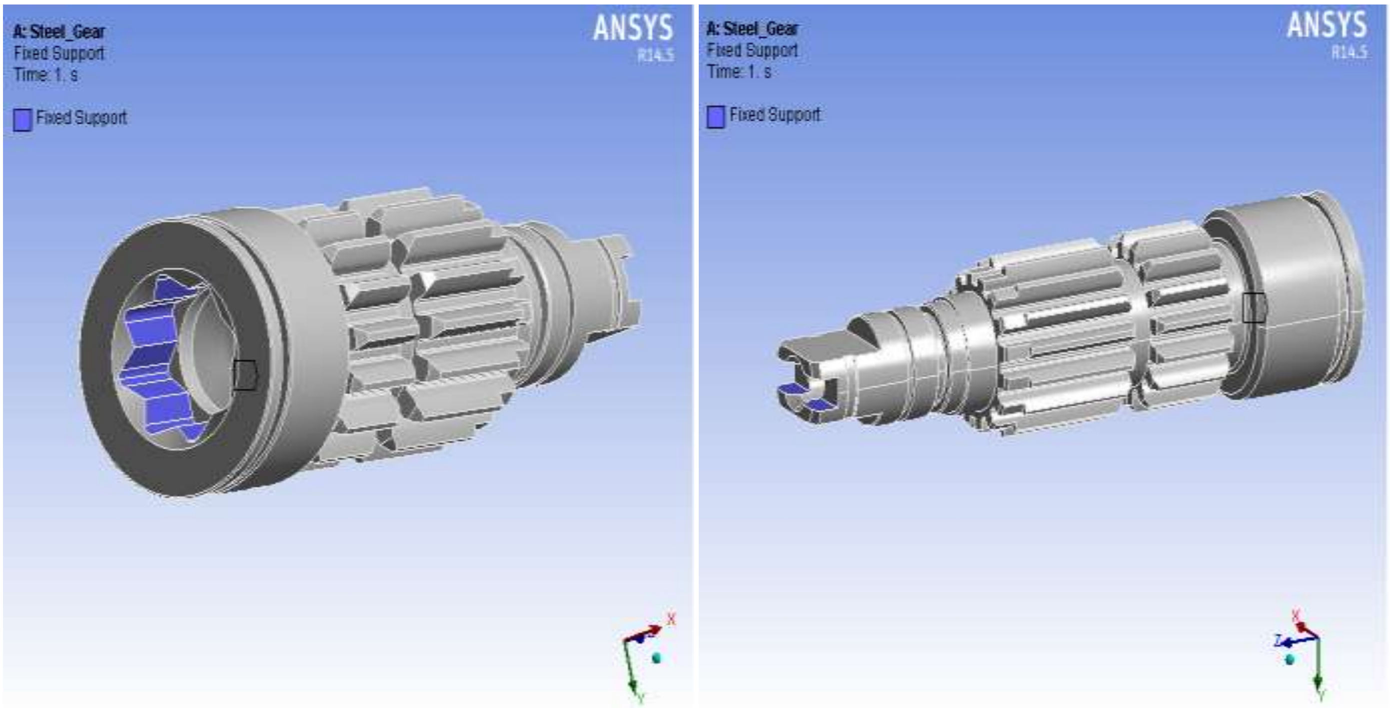

Fig 3- Loading And Boundary Conditions

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7. MATERIAL PROPERTIES

Properties of Outline Row 3: Structural Steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7850	kg m^-3		
3	Isotropic Secant Coefficient of Thermal Expansion				
6	Isotropic Elasticity				
7	Derive from	Young's ...			
8	Young's Modulus	2E+11	Pa		
9	Poisson's Ratio	0.3			
10	Bulk Modulus	1.6667E+11	Pa		
11	Shear Modulus	7.6923E+10	Pa		
12	Alternating Stress Mean Stress	Tabular			
16	Strain-Life Parameters				
24	Tensile Yield Strength	250	MPa		
25	Compressive Yield Strength	250	MPa		
26	Tensile Ultimate Strength	460	MPa		
27	Compressive Ultimate Strength	0	MPa		

Fig 4- Steel Material Detail

Properties of Outline Row 3: Aluminum Alloy

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	2770	kg m^-3		
3	Isotropic Secant Coefficient of Thermal Expansion				
6	Isotropic Elasticity				
7	Derive from	Young's ...			
8	Young's Modulus	7.1E+10	Pa		
9	Poisson's Ratio	0.33			
10	Bulk Modulus	6.9608E+10	Pa		
11	Shear Modulus	2.6692E+10	Pa		
12	Alternating Stress R-Ratio	Tabular			
16	Tensile Yield Strength	280	MPa		
17	Compressive Yield Strength	280	MPa		
18	Tensile Ultimate Strength	310	MPa		
19	Compressive Ultimate Strength	0	Pa		

Fig 5-Aluminum Material Detail

8. RESULTS OF FEA

Details	Steel	Aluminium
Deformation	0.014mm	0.04mm
Von-Mises Stress	103Mpa	102 Mpa

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Equivalent elastic strain	0.00091	0.0025
Weight	181.32gm	63.82gm

Table 2-Results of FEA

9. CONCLUSION

In this it is observed that the aluminum gear is most feasible than the steel in steel material spur pinion in a loading condition. In this analysis is to find out the total amount of stresses and deformation of gear tooth. also observed by the help of ansys higher stress observed in steel is higher than the aluminum spur pinion. after comparing of behavior of gear set by considering steel and aluminum as gear material, aluminum provides reliability because of strength of in loading condition also.

By analysis it can be found that no more stress changes for different material.fos is Aluminum is greater than the steel material. Stress occurs is within safety limits. So aluminum is selected as the best material for less corrosion resistance, less weight and less cost than steel material.

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