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ANALYSIS OF MECHANICAL PROPERTIES OF HELICAL GEARS

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ABSTRACT

Gear is the important member for transmission of power. Different types of gears are used for this power transmission, and helical gears are used in power transmission of Permanent Magnet DC Motors. The main reason for the failure of the gears are bending and surface strength, thus the analysis of these parameters become the most popular filed of interest for the researchers to minimize this failure.

In aim of this paper is to different types of stresses occurring in the helical gears of permanent magnet DC motor with analytical solutions as well as FEM solution with the help of ANSYS 14.0. The modeling of the helical gear sets is done by using the modeling software CATIA V5 R20.The different types of stresses were found out by using ANSYS 14.0 software. The stress of the gears is analyzed for different materials like aluminum, structural steel, and steel EN 19 and results are compared. The analysis can be further extended for different types of gears such as spur, bevel, rack and pinion, etc... By varying different parameters like face width, gear ratio and many more parameters.

KEY WORDS: Helical gear, bending stress, finite element analysis.

1. INTRODUCTION

A gear is a round shaped component that has teethes on the outer surface and is used as contagion device for shifting rotational force into some other devices or some other gears, for this we will use gears. A gear is somewhat similar to pulley in that we have a gear as a round wheel to which we have linkages called as teethes or "cogs" that connects with other gear teethes which allow some force to be shifted without slippage. A gear looks very simple machines and they have large number of application in our day to day life. A PMDC motor is alike an average DC shunt motor exclude that its

Field is furnished by permanent magnets rather than of salient-pole wound-field structure. All of earliest discoverers of electrical rotating machines utilized PM's in their designs. But these "automobile" were not motors in the sense we realize them today. Michael Faraday was one the earliest individuals in the pullulating field of electricity and electromagnetism. He worked up a rotating electrical machine that is commonly knighted as the first electric motor.

S.Jyothiram.et.al [1] they conducted their study by designing a helical gear model with the help of modeling software and after modeling the helical gear they took the modeled gear in iges format and imported it into ansys software for finite element analysis purposes. In fem analysis they analyzed the gear for structural, fatigue, and contact analysis. They used AGMA standards for theoretical calculation and used the Mat lab software for the analysis purpose.

B.Venkatesh.et.al [2] in their work they studied one of the most important stresses in gear i.e. bending stress by keeping the parameters like helix angle, speed, face width and module as constant and then they increased the gear ratio as a result the bending stress will be constant. Later they adjusted the parameters like helix angle, modules and speeds and observed that the bending stress was linearly decreasing as they increased the parameters. Finally they worked by combining the effect of gear ratio, face width and helix angle they calculated bending and compressive stresses for high speed helical gears, for alloy steel they carried out the same process.

A.Sathyanarayana.et.al [3] they used NX CAD 8.5 version software for the creation of helical gear model and later they used the NX Nastran8.5 analysis software for analyzing the previously modeled gear. The contact and bending stresses were analyzed at the root of the helical gear tooth's with the use of NX nastran8.5. The theoretical as well as FEM analysis were carried out for the helical gear and theoretically contact stresses were calculated by using AGMA standards. For finding the bending stress at the tooth root Lewis equation was used. The results obtained by both the methods were finally equated with each other.

Lot of research scholars worked on the design and analysis of helical gears both theoretically and experimentally. Some of them worked on bending stresses and some on both bending and contact stresses, and studied characteristics of a helical gear in dynamic condition involving meshing stiffness.

METHODOLOGY

In order to accomplish the set of objectives, a process flow chart is shown in the figure 1 was formulated. This gives a broad view of the methods involved in modeling & analysis conducted to study the different parameters of En 19 steel helical gear.

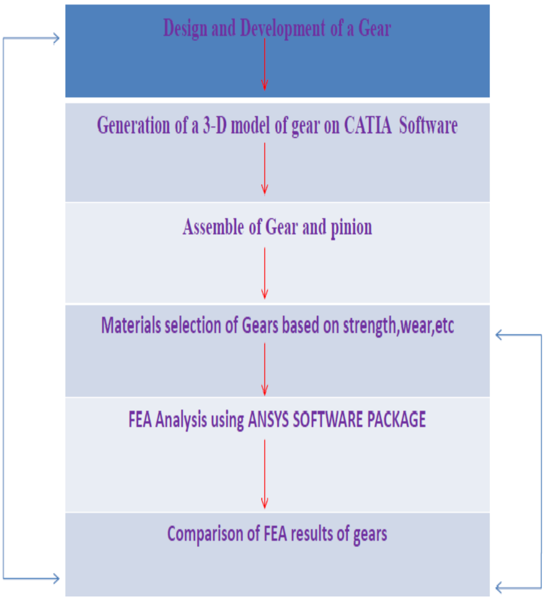
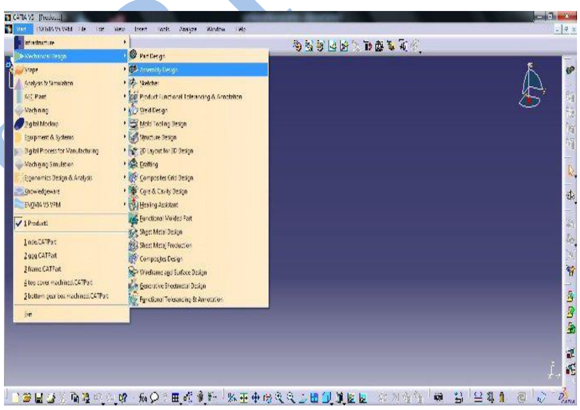


Figure 1. Project Methodology Flow Chart

The above flow chart is briefly explained as:
CAD models of the helical gear set are modeled by using the CATIA V5 R20 package.
The assembly of different parts of PMDC Motor such as frame. Shaft, helical gear and pinion etc are done by Catia V5.
Results are obtained by using the ANSYS 14.0 Software package.

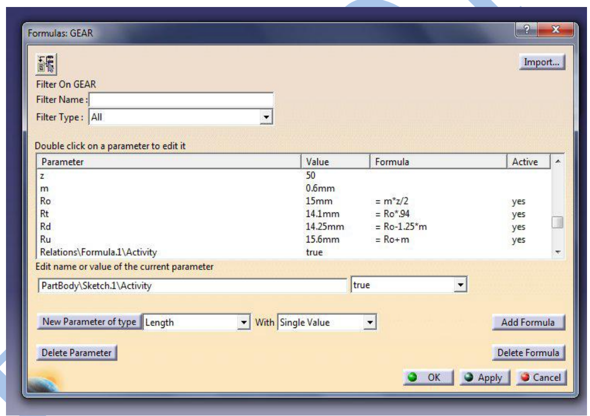
Procedure for creating Gear Model Geometry:

1. Select start-----Mechanical Design----Part Design.

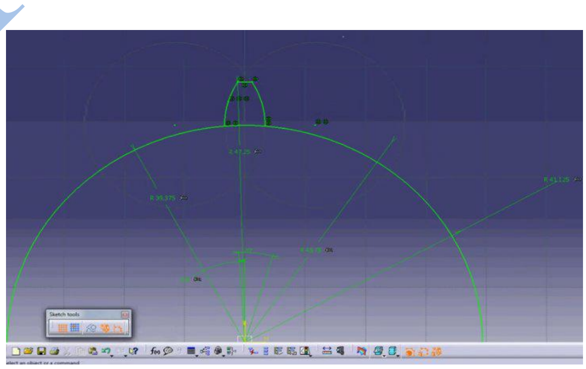


2. Select formula icon on the knowledge tool bar.

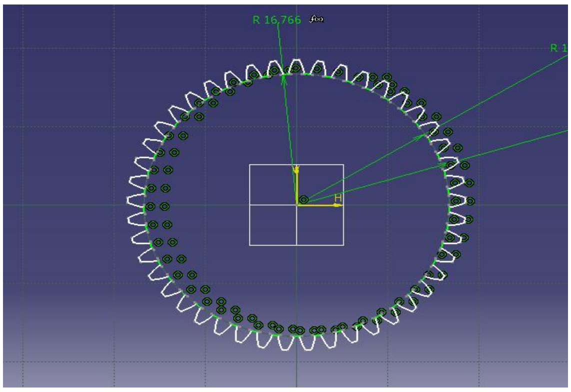
3. Feed all the values like no. Of teeth, module, also feed the formulae's in the following manner.



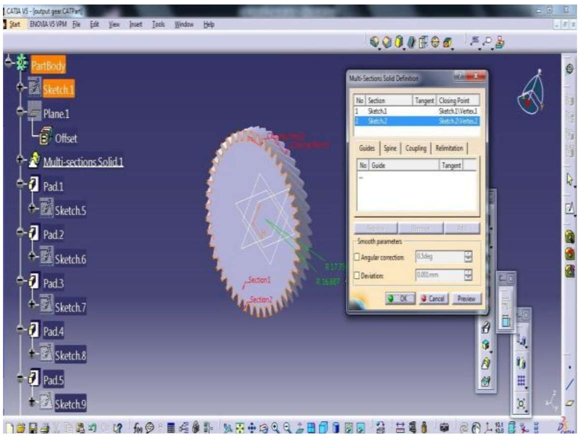
4. After feeding all the values draw the respective circles and design the tooth profile by trimming unwanted lines.

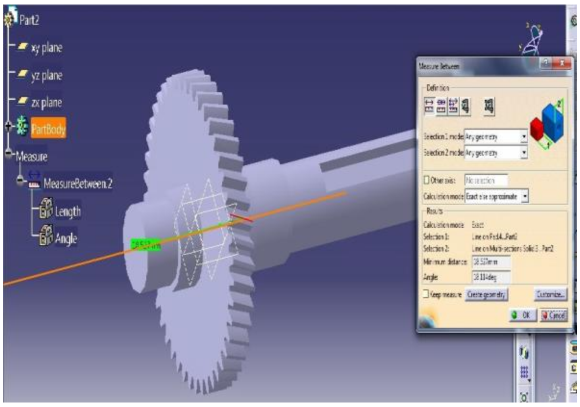


5. Copy the teeth profile and duplicate on the circumference of the circle.



6. Now perform the multi section solid option and the gear will be modeled in this manner.





Parameters of gear and pinion.
The parameter of first stage gear, output gear, and pinion are as shown on following table.

Sl.No.	Parameters	First Gear	Second pinion	Output Gear
1.	Number of teeth	50	18	45
2.	Module (m_n)	0.6mm	0.789mm	0.789mm
3.	Helix angle (α)	33.5 RHS	18 LHS	18 RHS
4.	Pressure angle (ϕ)	20^0	20^0	20^0
5.	Face width	6mm	9mm	7mm
6.	Pitch circle diameter	30.01mm	14.20mm	35.49mm
7.	Material used	Steel EN 19	Steel EN 19	Steel EN 19

Material Properties of Steel EN 19
Steel EN 19 is an eminent quality alloy steel which will be supplied with as a higher grade tensile steel grade of EN19T or EN19U. The grade of EN 19T or EN19U will provides the good resistance to wear properties, good ductility, good shocking resistance properties and many more properties. By having these good properties this kind of steels provide good features which will made this material as a good tensile EN steel with tensile strength ranging in between 850N/mm2 to 1000N/mm2. EN 19 steel exhibits fairly best impact properties when they are at low temperatures. Chemical composition of steel EN 19 given in Table 1.

Table 1. Chemical composition of steel EN 19.

Element	Min	Max
Carbon	0.36%	0.44%
Silicon	0.10%	0.40%
Manganese	0.70%	1.00%
Phosphorus	---	0.035%
Chromium	0.90%	1.20%
Molybdenum	0.25%	0.35%
Sulphur	___	0.040%

RESULTS AND DISCUSSION

The static non linear analysis is carried out for the helical gear made of Steel EN 19 material, material data, boundary condition, tangential load, are inputs. Stress analysis is carried out on non linear geometry.

MESHING

The CAD model of the helical gear is taken from the Catia V5 which has been saved in IGES format before and imported into ANSYS. The meshing is one of the major tasks of the FE analysis, solid element mesh is generated using AUTOMESH feature in ANSYS.
Basically there are three kind of solid elements namely four faced tetrahedral element, five faced penta elements and six faced hexahedral element, of these hexahedral elements invariably offers better results.

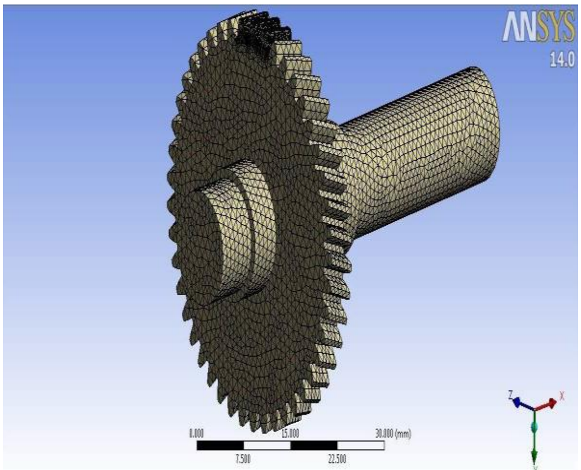


Fig. Meshed model using tetrahedral elements.

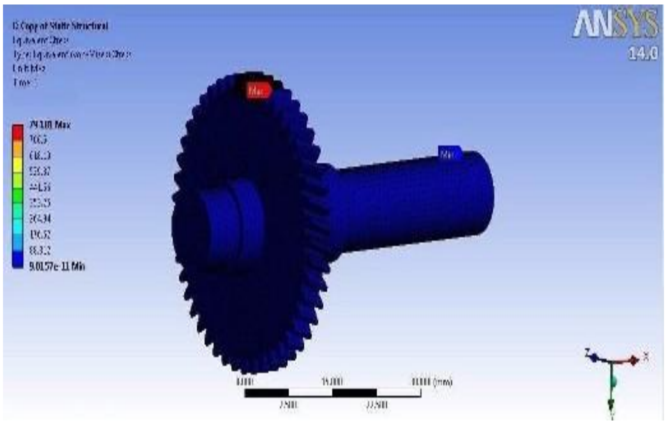


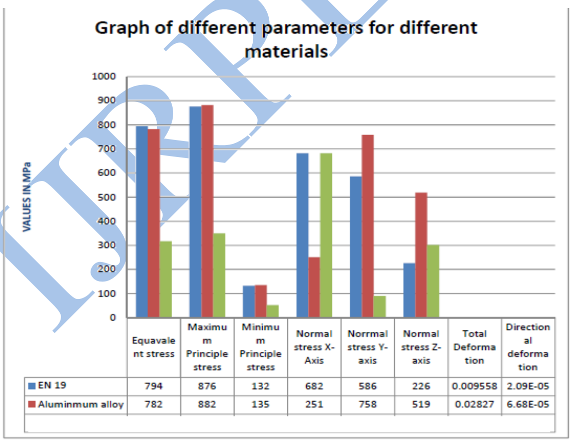
Fig. Von – mises acting on the gear.

The theoretical design is carried out using standard design formulae as per AGMA procedure and analysis is carried out using ANSYS results and these two values will be compared with each other. The following table shows the comparison between theoretical design values and ANSYS value.

ANSYS RESULTS:

Sl. NO.	PARAMETER FOR EN 19 STEEL	MAXIMUM VALUE	MINIMUM VALUE
1.	Equivalent (von-misses) stress	794.81MPa	9.01E-11MPa
2.	Directional deformation	2.096E-6	-0.0094
3.	Normal stress in X-direction	682MPa	-561MPa
4.	Normal stress in Y-direction	586MPa	-526MPa
5.	Normal stress in Z-direction	226MPa	-200MPa
6.	Shear stress	53MPa	-80MPa

Comparison for different materials:



The above graph shows the different parameters obtained by the software ansys for different materials like aluminum, structural steel en 19 etc…

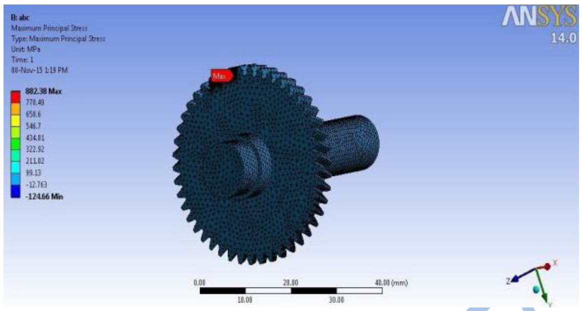


Fig . Maximum principle stress

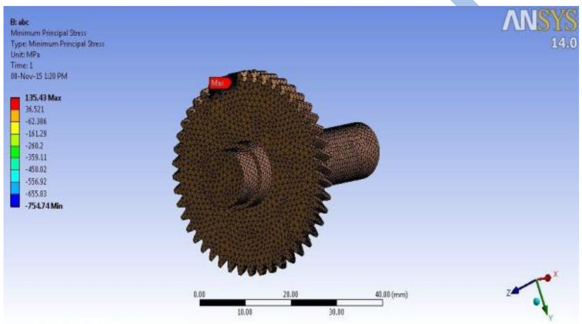


Fig Minimum principle stress

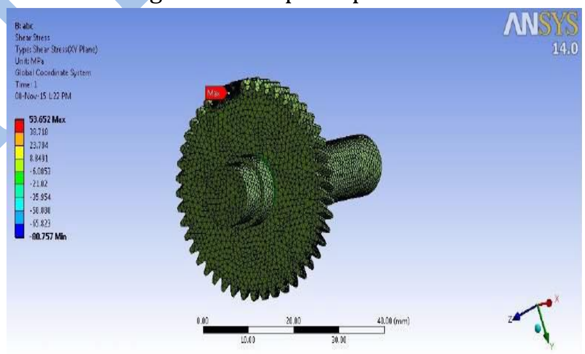


Fig shear stress

Above figures shows the different types of stresses obtained by inputting the load on the teeth of a gear. The stresses which are obtained are maximum principle stress, minimum principle stress, shear stress, etc.. From ANSYS14.0 Software package.

CONCLUSION

In our study we found that the stress due to the bending i.e. bending stress will be exhibiting maximum in the upper half portion of the helical gear. But in actual theory of helical gears the load will be act at one point only at that point we are interested to find out the value different stresses. Intensity of the tooth of helical gear is an important parameter to avoid failure. In this thesis, it is explained that the good method to evaluate the root bending stress. We have employed a 3-D model of helical gear in CATIA V5 and the model is analyzed for total deformation, directional deformation, max .principle stress, minimum principle stress, in X, Y, Z directions respectively are found by using the analysis software ANSYS 14.0.

FUTURE SCOPE OF WORK

The following areas are very important for future research in the gear analysis field.

For all types gears such as spur, bevel, rack &pinion, and other tooth forms the analysis of bending and contact stress can be investigated by 3 – D numerical method.

The gears which are under dynamic conditions and are in mesh with crack

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6) ANSYSV14.0 User Manual
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