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CFD Analysis Of Gear Oil For Oil Temperature In Helical Gearbox

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Abstract — *A gearbox is a set of gears for transmitting power from one rotating shaft to another. They are used in a wide range of industrial, power plant, automotive and home machinery application. A gear heads are available in different sizes, capacities and speed ratios. Mostly their main function is to convert the input provided by an electric motor into an output of lower r.p.m and higher torque or high r.p.m and lower torque. This continuous transmission of the torque in gearbox increase the wear and temperature between to rubbing surface of gear teeth due to friction. The gear oil which is used to reduce this friction loss has high viscosity. This viscosity of gear oil will increase power losses of gear box. So this work is consent for find out power loss for same viscosity index gear oil. Finally we conclude that Power loss of Caster oil is less compared to other gear oil. The results of the experiments confirm that the CFD represent a valid method to predict temperature of oil, CFD proves to be valid tool to investigate the parameters.*

***Keywords* - CFD** *Analysis of Gear, Gear Oil for Power Loss, Oil Temperature in Helical Gearbox.*

I. INTRODUCTION

EFFECTIVE FACTORS ON GEARBOX EFFICIENCY

Total system efficiency (motor plus gearbox) is neither clearly understood nor easily calculated. This makes gearbox efficiency specifications unreliable because they typically provide only a single efficiency rating. Efficiency depends on a number of factors, especially gearbox loading, but most manufacturers do not list efficiency tolerances, or the difference in efficiencies between a heavily loaded gearbox and one running under normal loads. The electrical input power to a gearbox (the product of voltage and current to the motor) multiplied by motor efficiency is the input power to the gearbox. Output power is the gearbox speed and load torque. The ratio of output power to input power equals efficiency. Power loss in the gearbox is mostly due to friction, which generates heat. In miniature gearboxes, heat is not much of a problem because the power losses (and absolute amounts of power involved) are relatively small. However, large gearboxes use oil coolers and pumps to compensate for gearbox inefficiency. Gearbox friction in turn depends on the quality of the gearing, the number of tooth engagements (how many times one gear drives another).

GEAR OIL

Gear oil is a fluid lubricant used in gears (gearboxes) for reduction of friction and wear of the gear tooth surfaces, removal of the heat generated by the operating gear and corrosion protection of the gear parts. The following properties of gear oils are important.

- Proper viscosity
- Ability to withstand extreme pressures (Ep)
- Thermal and oxidation stability
- Corrosion and rust protection
- Compatibility with seal materials.

VISCOSITY OF GEAR OILS

Viscosity of gear oil is a compromise between the gear parameters requiring low viscosity and those requiring high viscosity. Low viscosity is favorable for high speed, low loaded gears with a good tooth surface finish. Low viscosity provides thin oil film, low friction (high mechanical efficiency), good cooling (heat removal) conditions. High viscosity is favorable for low speed, highly loaded gears with a rough tooth surface. High viscosity provides thick 13 oil film, high wear resistance and low galling even at high pressure (Ep). Viscosity of gear oil depends on the temperature therefore oil selected for a particular gear should provide its reliable operation within the expected temperature range. The low temperature limit of gear oil is 9°f (5°c) higher than its pour point (the lowest temperature, at which the oil may flow). Mineral oils possess relatively high pour point about 20°f (-7°c). Pour point of synthetic oils may reach 50°f (-46°c). The highest operation temperature in spur gears is about 130°f (54°c). In the worm gears the temperature may reach 200°f (93°c).

DESIGNATION OF GEAR OILS BY PERFORMANCE

American petroleum institute (API) established a performance grading system for gear oils.

Gl-1:- Gl-1 gear oil has rust and oxidation protection effect but it does not contain extra pressure (Ep) additives. The oil is used in low load applications only.
Gl-2:- Gl-2 gear oil contains more additives than Gl-1, but without Ep effect. It is used in medium loaded worm gears.
Gl-3:- Gl-3 gear oil possesses light Ep effect.
Gl-4:- Gl-4 gear oil possesses moderate Ep effect. It is most widely used oil.
Gl-5:- Gl-5 gear oil possesses high Ep effect. It is used in hypoid and other highly loaded gears.

Choosing the right gearbox lubricant provides the benefits of lower wear rates, lower operating temperatures and greater energy efficiency. Viscosity index is important because it indicates how the oil's viscosity varies at high temperatures. The higher the viscosity index, the less the oil viscosity change has to be considered. The pressure viscosity coefficient is defined by how the oil changes viscosity under load. The pressure is increases at that time the viscosity increase. Plant professionals need to understand that gear oil affects several design considerations, including reliability. Gearbox energy efficiency increase can be achieved by using high-quality oil depends on the gear type. Depending on specific plant operating conditions, lubricants might perform a variety of wide ranging functions. There are several additional elements to consider when selecting an appropriate lubricant. These include operating speed, type of friction, load and environmental conditions, and industry standards. Depending on the machine, component or application, the plant engineer should look at different fluid properties by considering factors like the load, speed, type of gearing, number of stages and the combination of metals in the gearbox.

TYPES OF GEAR OILS

Combinations of additives impart special functions to gear oils

Rust and oxidation preventive gear oils rust and oxidation preventive oils are mainly mineral base. They contain rust and oxidation inhibitors. The viscosity of rust and oxidation oils according to the ISO grading system is between 32 to 320.

Compounded gear oils

Compounded oils are mineral base. They contain rust and oxidation inhibitors, demulsifies and up to 10% of fatty oils for better lubricate. Compounded oils are used mainly in worm gears. The viscosity of compounded oils according to the ISO grading system is between 460 to 1000.

Extreme pressure (Ep) gear oils

Ep oils may be either mineral or synthetic base. They contain Ep additives, rust and oxidation inhibitors, anti-foaming agents and demulsifies. The viscosity of Ep oils according to the ISO grading system is between 68 to 1500.

Synthetic gear oils

Synthetic gear oils may be based on poly alpha olefins, esters oils or poly glycols. They may contain Ep additives, rust and oxidation inhibitors, anti-foaming agents and demulsifies. The viscosity of synthetic oils according to the ISO grading system is between 32 to 6800. Synthetic gear oils are used for gears operating under extreme conditions.

II. CFD ANALYSIS

CFD may be used to determine the performance of a component at the design stage, or it can be used to analyses difficulties with an existing component and lead to its improved design. For example, the pressure drop through a component may be considered excessive: The first step is to identify the region of interest: The geometry of the region of interest is then defined. If the geometry already exists in CAD, it can be imported directly. The mesh is then created. After importing the mesh into the pre-processor, other elements of the simulation including the boundary conditions (inlets, outlets, etc.) and fluid properties are defined. The flow solver is run to produce a file of results which contain the variation of velocity, pressure and any other variables throughout the region of interest. The results can be visualized and can provide the engineer an understanding of the behaviour of the fluid throughout the region of interest.

Procedure of CFD Analysis for Gear Box

- The procedure of CFD analysis is divided in three parts;
  1. Pre processer
  2. Solution
  3. Post Processer

Pre Processer

The pre process for doing CFD analysis of Caster oil in gear box is divided in following four steps.

- Prepare modal for gearbox.
- Meshing
- Material Property
- Boundary condition

Prepare Modal Gearbox

The assembly modal of gearbox made in solid works 2012 converted in to STEP file and imported in ANSYS workbench is shown in figure.

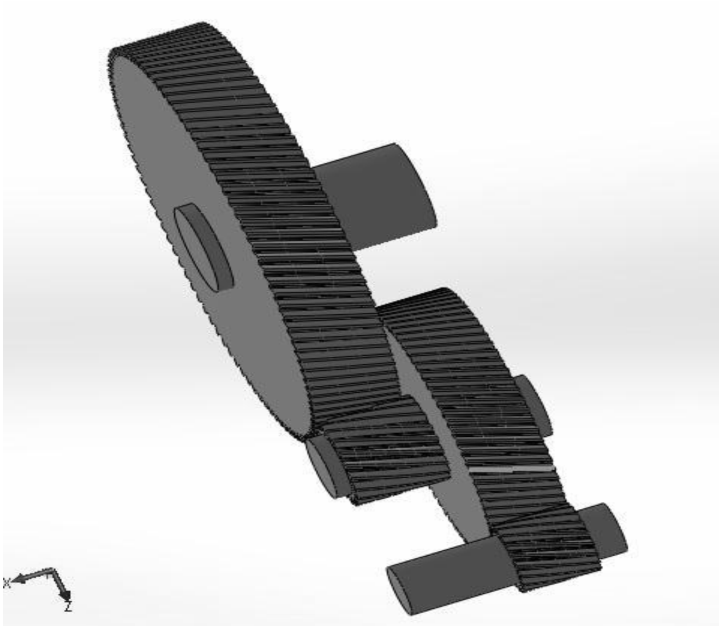

Figure 1. Assembly modal of gearbox.

Meshing

FEA software typically uses a CAD representation of the physical model and breaks it down into small pieces called finite “elements” (think of a 3-D puzzle). This process is called “meshing”. The higher quality of the mesh (collection of elements), is a better mathematical representation of the physical model. ANSYS workbench simulation provides two forms of automated meshing: Fully automatic and manually directed automatic. Both forms employ a fault-tolerant philosophy and it meaning that, if a problem occurs, at least 12 attempts of automatic trouble-shooting are made before the meshed fails and tags the area of difficulty with a label. The Manual directed means that the user may specify meshing over rides on specific areas of a part or the baseline mesh density on entire parts that differ from other parts within the assembly, either for accuracy or efficiency purposes. Here in current work the fully automatic meshing of gearbox is done. The element chose for meshing by ANSYS is ten nodes tetrahedral shown in fig.2 this element is good for meshing in curvature area.
Numbers of node and element use for meshing are listed in table1 below.

Domain	Nodes	Elements
Gear	5347	23913
Castor oil	23680	124330
All Domains	29027	148243

Table 1. Mesh Information for CFX

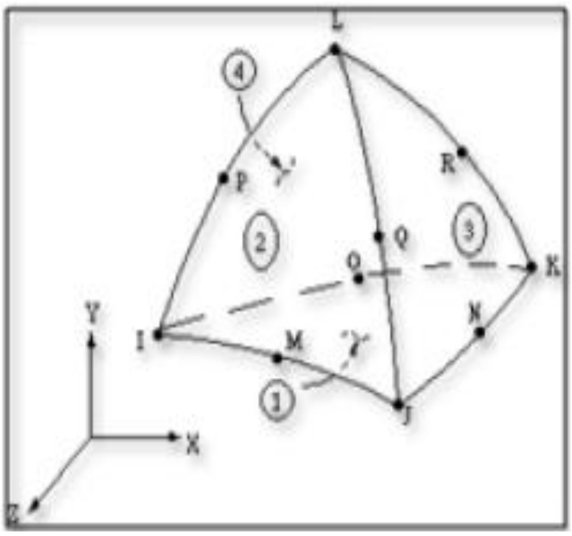

Figure 2. Ten Nodes Tetrahedral.

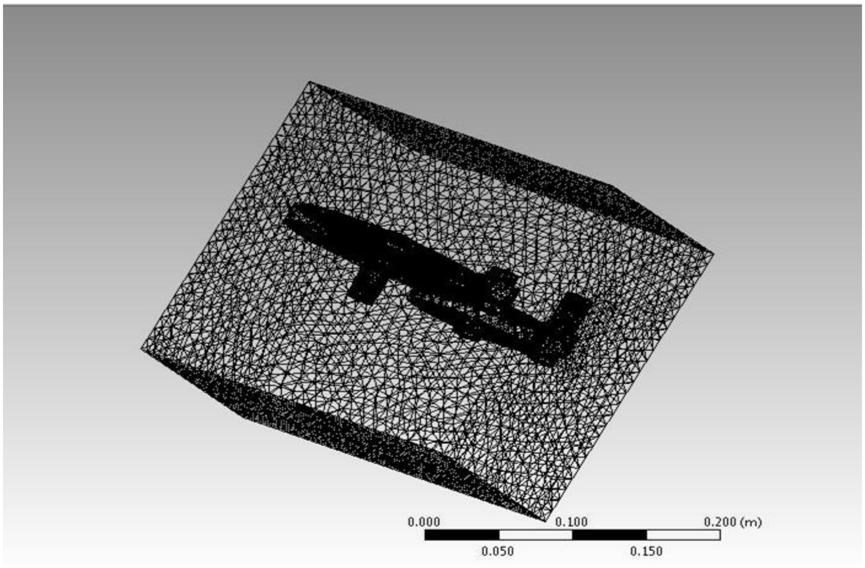

Figure 3. Meshing modal of gearbox.

Material Property

Materials in the Workbench are imported from material library available in ANSYS database. If the material is not available in material library then it is required to define manually. Here in this work for doing CFD analysis of Castor oil in gear box the property of Castor oil is imported manually as shown in fig 4.

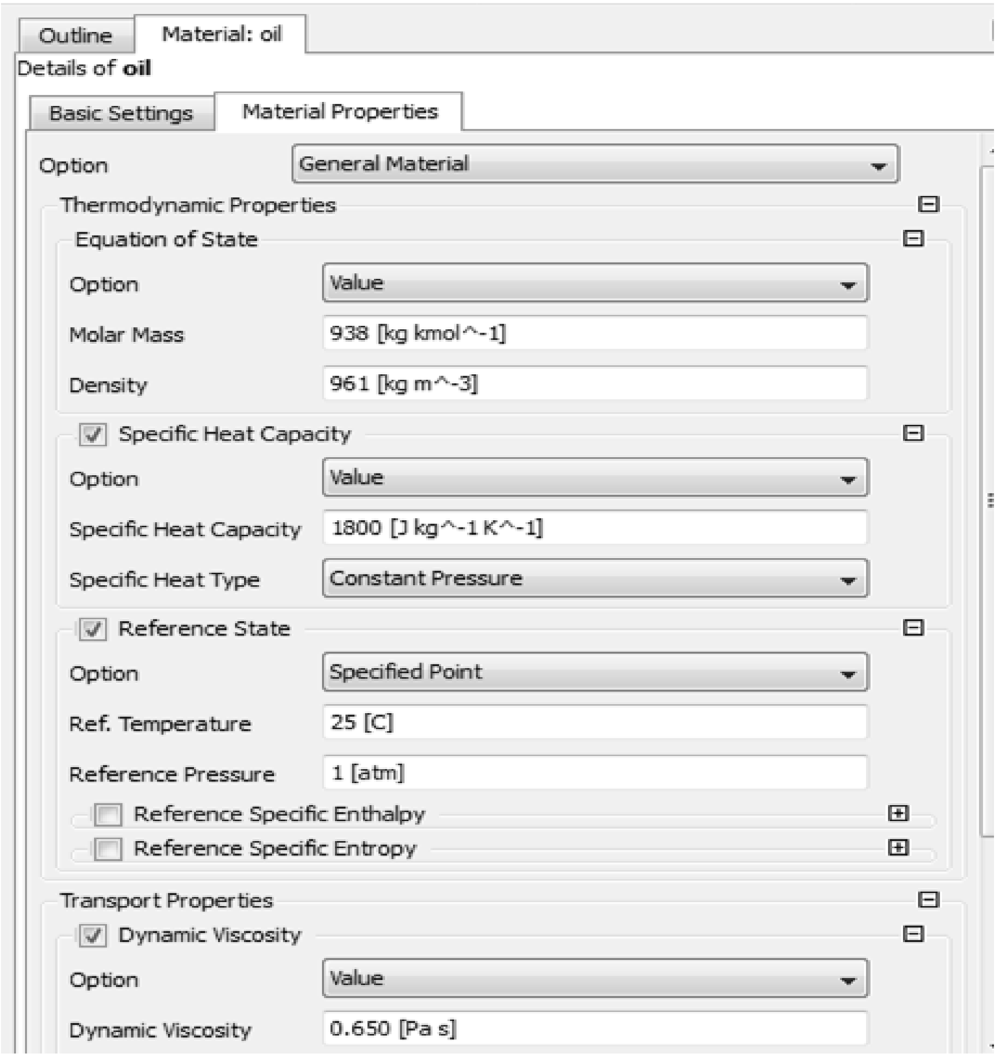

Figure 4. Castor oil material property

Boundary condition

The boundary condition in Pre processor is very important for getting approximate result nearer to actual condition. In present work the boundary condition is define as domain in pre processer. The first domain is defined as gear oil and second is a gear. The gear is a rotating 60 domain and speed of rotation is 1450 rpm. This rotation effect of gear domain is transferring to the gear oil so it is also working as rotating domain.

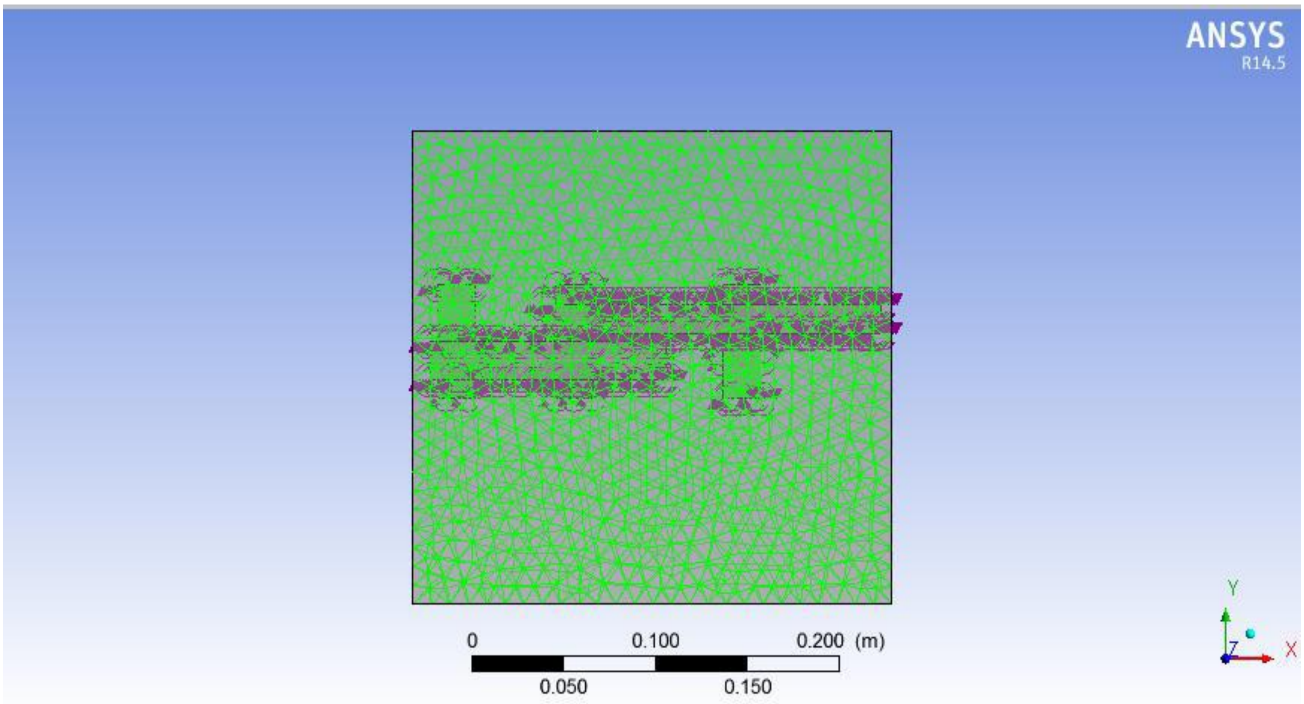

Figure 5. Domain of oil

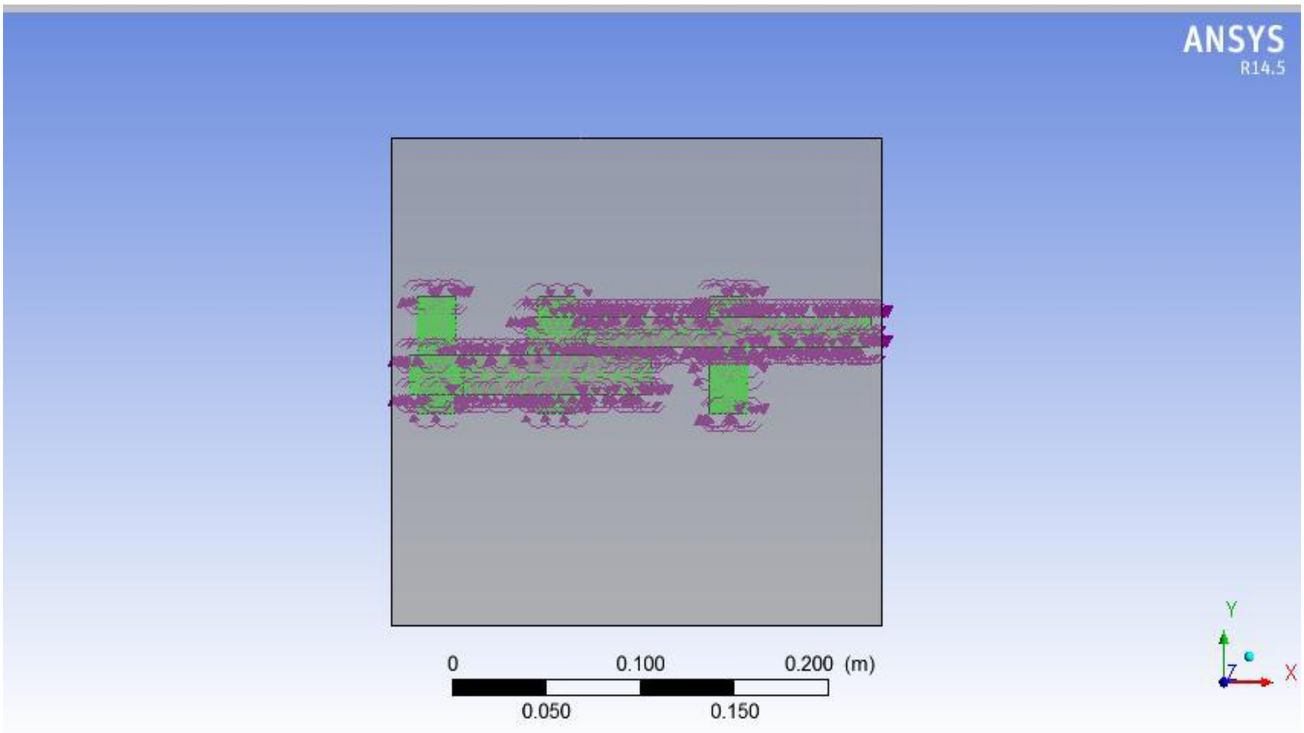

Figure 6. Domain of gear.

Solution

The solution is the processer in which the problem is solve for given boundary condition.

Post Processor

The post processor is the process of getting result for given problem. The result for temperature distribution in gear box for castor oil is shown in below fig.7. The maximum 61 and minimum temperatures for CFD analysis of the Castor oil in reduction helical gear box are 58°C and 55°C respectively.

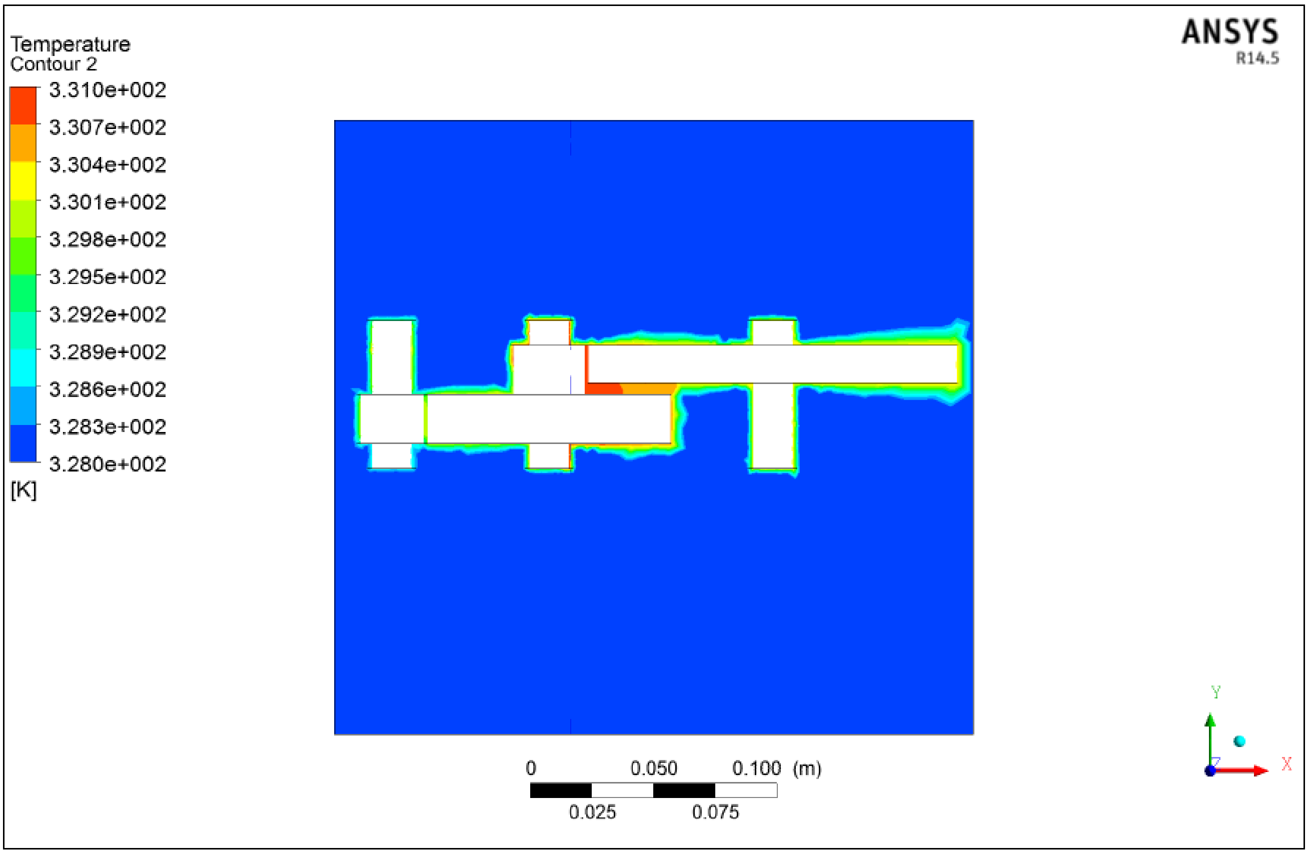

Figure 6. Temperature distribution for castor

III. CONCLUSION

The CFD analyses of Castor oil in reduction helical gear box is done for 100 min with same geometrical model and operating condition, and it is conclude that the maximum and minimum temperature in gear box are 58°C and 55°C respectively which is nearly about experiment result. Also from the literature survey and experimental analysis it found the input current, input power and output power is depends on viscosity of the oil. This viscosity of the oil is directly depends on increase of temperature so the CFD analysis tool is very good for finding the power losses by finding temperature.

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