ANALYSIS OF WEAR AND TEAR OF DIFFERENT CYLINDER LINERS BY USING ANSYS SOFTWARE

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Abstract: *A Cylinder Liner or also known as Sleeve is a cylindrical component that is placed in an engine block. It is one of the most important functional parts to make up the interior of an engine and it gives a wear protective surface for piston and piston rings. The barrel or bore in which an engine piston moves back and forth may be an integral part of the cylinder block, or it may be a separate liner. It is commonly used in gasoline engines, has the disadvantage of not being replaceable. When excessive wear occurs in a block of this type, the cylinder must be re-bored or honed. Reconditioning of this type cannot be repeated indefinitely and, in time, the entire block must be replaced. Another disadvantage is the inconvenience, especially in large engines, of having to remove the entire cylinder block from a ship in order to recondition the cylinders.*

Key Words: Cylinder Liner, Tungsten and copper alloy, wear resistance, Tear resistance

1. INTRODUCTION

A cylinder liner or also known as sleeve (Figure 1) is a cylindrical component that is placed in an engine block to form a cylinder. It is one of the most important functional parts to make up the interior of an engine and it gives a wear protective surface for piston and piston rings.

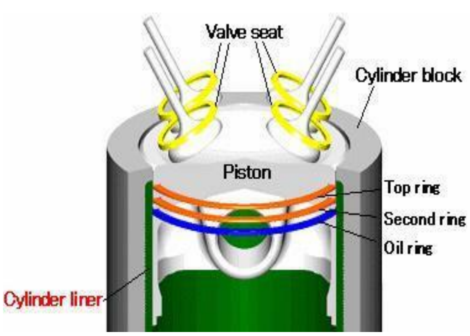

Figure 1

Figure 1. Cross-section of a cylinder in an internal combustion A cylinder wall in an engine is under high temperature and high pressure, with the piston and piston rings sliding at high speeds. In particular, since longer service life is required of engines for trucks and buses, cast iron cylinders that have excellent wear-resistant properties are only used for cylinder parts

Also, with the recent trend of lighter engines, materials for engine blocks have been shifting from cast iron to aluminum alloys. However, as the sliding surface for the inner cylinder, the direct sliding motion of aluminum alloys has drawbacks in deformation during operation and wear-resistance. For that reason, cast iron cylinder liners are used in most cases.

1.1 What is the purpose of Liner :

The barrel or bore in which an engine piston moves back and forth may be an integral part of the cylinder block, or it may be a separate sleeve or liner. The first type, common in gasoline engines, has the disadvantage of not being replaceable. When excessive wear occurs in a block of this type, the cylinder must be re bored or honed.

Reconditioning of this type cannot be repeated indefinitely and, in time, the entire block must be replaced. Another disadvantage is the inconvenience, especially in large engines, of having to remove the entire cylinder block from a ship in order to recondition the cylinders.

For these reasons, diesel engines are constructed with replaceable cylinder liners. The cylinder liners we will discuss are representative of those used in diesel engines
The material of a liner must withstand the extreme heat and pressure developed within the combustion space at the top of the cylinder and, at the same time, must permit the piston and its sealing rings to move with a minimum of friction. Close-grained cast iron is the material most commonly used for liner construction. (Steel, however, is sometimes used.)
Some liners are plated on the wearing surface with porous chromium, because chromium has greater wear-resistant qualities than other materials. Also the pores in the plating tend to hold the lubricating oil and aid in maintaining the lubrication oil film that is necessary for reduction of friction and wear.

2. Formation of sliding surface:

The cylinder liner, serving as the inner wall of a cylinder, forms a sliding surface for the piston rings while retaining the lubricant within. The most important function of cylinder liners is the excellent characteristic as sliding surface and these four necessary points.

1. High anti-galling properties
2. Less wear on the cylinder liner itself
3. Less wear on the partner piston ring
4. Less consumption of lubricant

2.1 Heat transfer:

The cylinder liner receives combustion heat through the piston and piston rings and transmits the heat to the coolant. As shown in figure 2

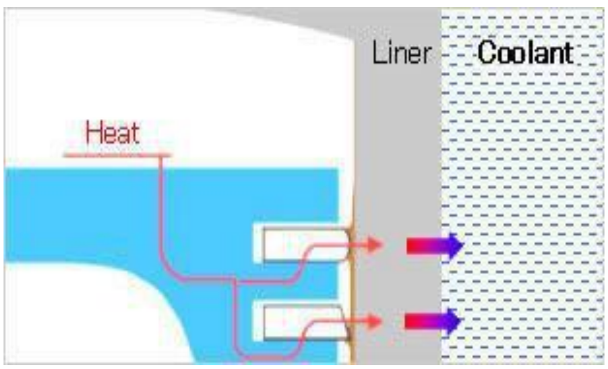

Figure 2

2.2 Compression gas sealing:

The cylinder liner prevents the compressed gas and combustion gas from escaping outside. It is necessary that a cylinder liner which is hard to transform by high pressure and high temperature in the cylinder. As shown in figure 3

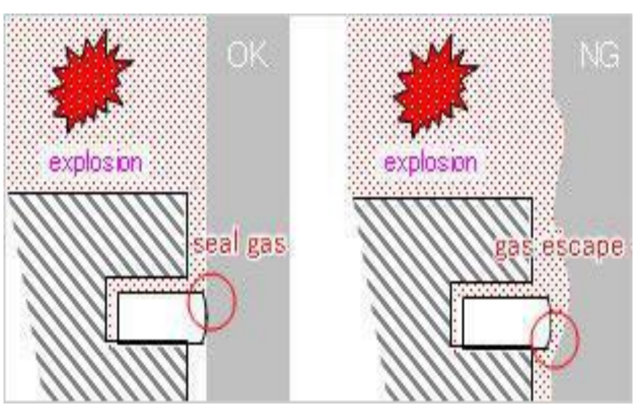

Figure3 Providing air tightness of cylinder liner

3. Types of Liners:

Cylinder liners may be divided into two general classifications or types, they are dry and wet liners. The dry liner does not come in contact with the coolant. Instead; it fits closely against the wall of the cooling jacket in the cylinder block. With the wet liner, the coolant comes in direct contact with the liner. Wet liners may have a cooling water space between the engine block and liner, or they may have integral cooling passages. Liners with integral cooling passages are sometimes referred to as water-jacket liners.

3.1 Dry Liners

Dry liners have relatively thin walls compared with wet liners (fig. 4). Note that the coolant circulates through passages in the block and does not come in contact with the liner

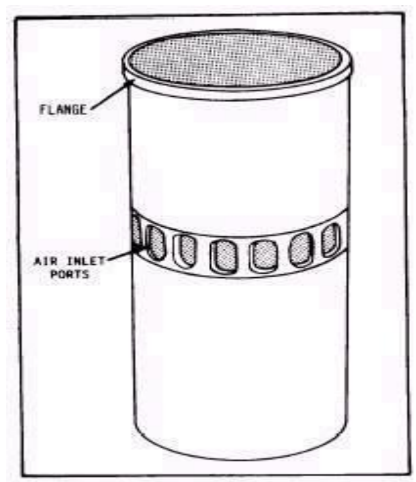

Figure 4—a dry cylinder liner

3.2 Wet Liners

In wet liners that do not have integral cooling passages, the water jacket is formed by the liner and a separate jacket which is a part of the block. (See fig. 3-11.) A static seal must be provided at both the combustion and crankshaft ends of the cylinders to prevent the leakage of coolant into the oil pan sump, or combustion space. Generally, the seal at the combustion end of a liner consists of either a gasket under a flange or a machined fit. Rubber or neoprene rings generally form the seal at the crankshaft end of the liner. Liners of this type are constructed to permit lengthwise expansion and contraction. The walls of a wet liner must be strong enough to withstand the full working pressure of the combustion gases.

4. Coating of Tungsten and Copper Alloy

4.1Tungsten:-

The word tungsten means “heavy stone” in Swedish. The chemical symbol for tungsten is W which stands for wolfram. The name came from medieval German smelters who found that tin ores containing tungsten had a much lower yield. It was said that the tungsten devoured the tin “like a wolf”. Pure tungsten metal was first isolated by two Spanish chemists, the de Elhujar brothers in 1783. Tungsten is a grayish-white lustrous metal, which is a solid at room temperature. Tungsten has the highest melting point and lowest vapor pressure of all metals, and at temperatures over 1650°C has the highest tensile strength. It has excellent corrosion resistance and is attacked only slightly by most mineral acids.

Tungsten belongs to the group of refractory metals. Refractory metals are metals that have a higher melting point than platinum (1 772 °C). In refractory metals, the energy binding the individual atoms together is particularly high. Refractory metals have a high melting point coupled with a low vapor pressure, high modulus of elasticity and good thermal stability. Refractory metals are also typically characterized by a low coefficient of thermal expansion and relatively high density.

Tungsten has the highest melting point of all metals as well as a remarkably high modulus of elasticity. In general, its properties are similar to those of molybdenum. The two metals are located in the same group in the periodic table. However, some of the properties of tungsten are more pronounced than they are in molybdenum.

Table 1.Properties of Tungsten:

S. no	Specification Or Units	Values
1	Atomic number	74
2	Atomic Weight	183.86
3	Group Number	6
4	Density @ 20 ºC (gm/cc)	19.3
5	Melting Point ºC	3410
6	Boiling Point ºC	5530
7	Thermal Conductivity @ 20 ºC (cal/cm/ºC/sec)	0.40
8	Specific Heat @ 20 ºC (cal/gram/ºC)	0.032
9	Temperature Coefficient of Electrical Resistivity Per ºC (0 – 100 ºC)	0.0046
10	Tensile Strength @ Room Temp., psi	100,000 – 500,000
11	Poisson’s Ratio	0.284
12	Hardness (Brinell)	2570
13	Working Temperature, ºC	<1700
14	Recrystallization Temperature, ºC	1300 – 1500

Table 2.Properties of Tungsten and Copper alloy

Chemical Composition on (% by wt.)	Copper	20 ± 2
	Max. Addisivity	0.5
	Tungsten	balance
Density	gr/cc Min.	15.15
Conductivity	IACS % Min.	34
Resistivity	μΩ*cm Max.	5.0
Hardness	HB Kgf/mm^2 Min.	220
Bend Strength	MPa Min.	736

5. DESIGN OF LINER

The model we had use is FORD3600 ,it is an indian based automobile model.

The dimensions of this model are as follows:

Inner diameter: 105.50-105.70 mm

Outer diameter: 112.30-112.50 mm

Collar diameter: 113.70-113.90 mm

Total length : 211-212 mm

Collar width : 8-9 mm

By using this dimension we have drawn the solid 3D model in the ANSYS 13 work bench. The solid model is as follows:

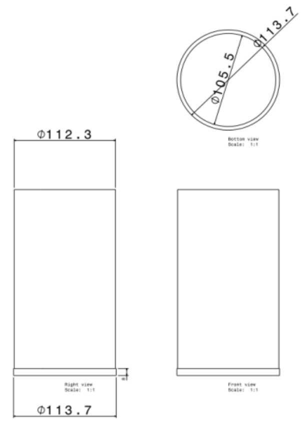

Figure 5 Line Sketch of the Cylinder Liner

5.2 MODELLING OF CYLINDER LINER

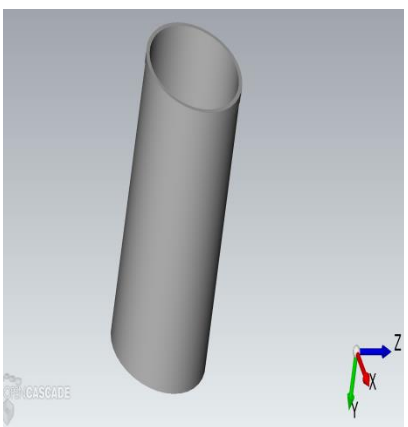

Figure 6 3D Sketch of the Cylinder Liner

5.3 ANALYSIS OF LINER FOR DIFFERENT MATERIALS:

Normally the materials that are use for the liner manufacturing are grey cast iron, steel ,aluminum alloy. Here another material is also is used in our analysis i.e titanium alloy. Here the aim of our analysis is to find out best material for liner i.e. it should have a good durability and withstand the wear and corrosive nature

5.4 Grey cast iron:

Gray iron, or grey cast iron, is a type of cast iron that has a graphitic microstructure. It is named after the gray color of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight.

It is used for housings where the stiffness of the component is more important than its tensile strength, such as internal combustion engine cylinder blocks, pump housings, valve bodies, electrical boxes, and decorative castings. Grey cast iron's high thermal conductivity and specific heat capacity are often exploited to make cast iron cookware and disc brake rotors.

The compassion of grey cast iron is C-2.7-4%,Mn-0.8%,Si-1.8-3%,S-max0.07%,P-max0.2%

Table 3-Physical properties

Density Kg/m^3	Poisson's Ratio	Young's Modulus Mpa	Ultimate Tensile Strength Mpa
7200	0.28	110000	240

Table 4- Thermal Properties

Thermal Conductivity W/m-k	Melting Point °C	Specific Heat J/gm°C
53.3	1090	0.490

6. STRUCTURAL ANALYSIS OF GRAY CAST IRON CYLINDER LINER

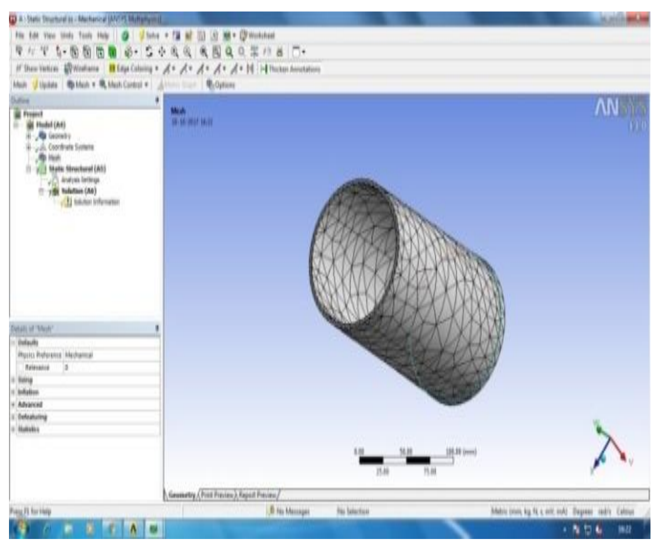

Figure 7 Meshing of Gray Cast Iron

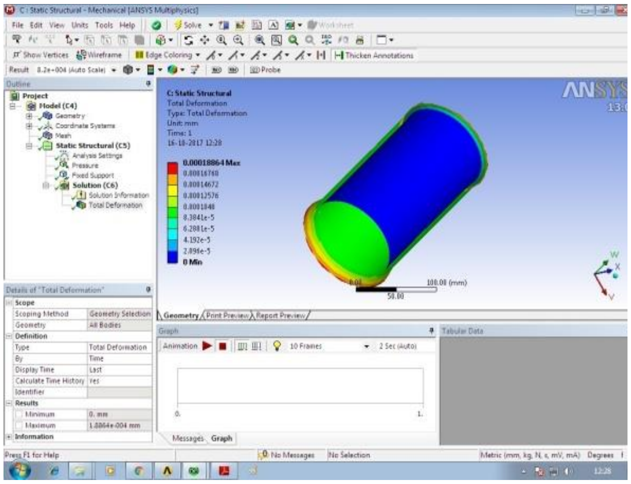

Figure 8 Total Deformation of Gray Cast Iron

In the Fig, the total deformation of **Gray Cast Iron** liner is observed as 0.00018864 mm a maximum.

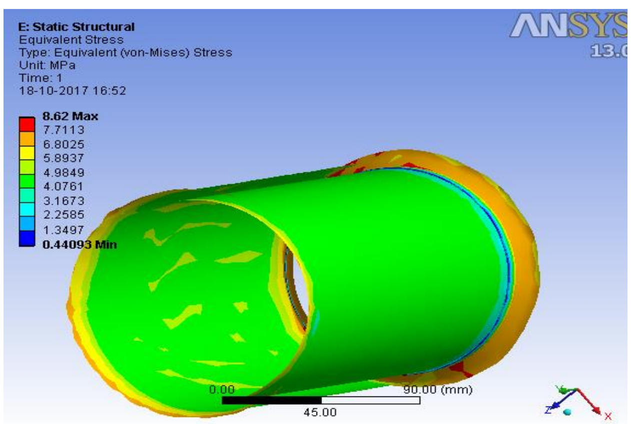

Figure 9 Equivalent Stress

In the Fig , the maximum equivalent stress is found to be 8.62 Mpa

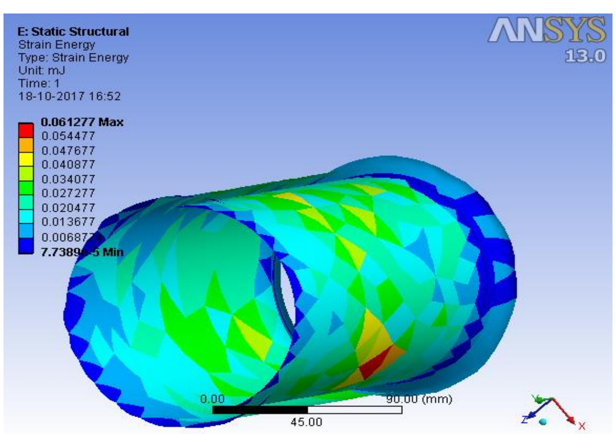

Figure 10 Strain Energy

6.1 THERMAL ANALYSIS OF GREY CAST IRON CYLINDER LINER

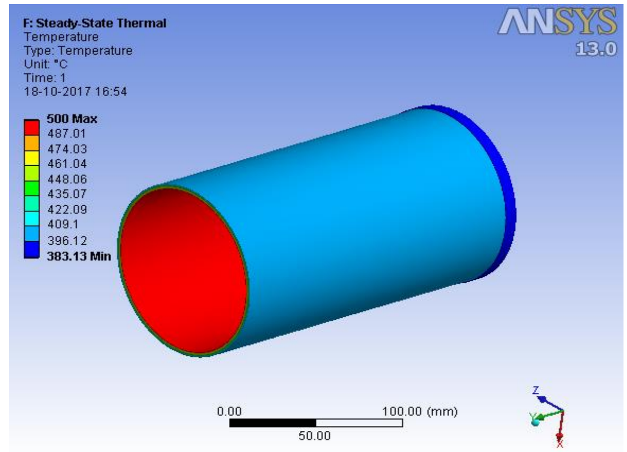

Figure 11 Steady State Thermal Analysis

In the Fig shown the maximum temperature is 500^0C and minimum temperature is 383.13^0C.

6.2 STRUCTURAL ANALYSIS OF TUNGSTEN AND COPPER ALLOY CYLINDER LINERS

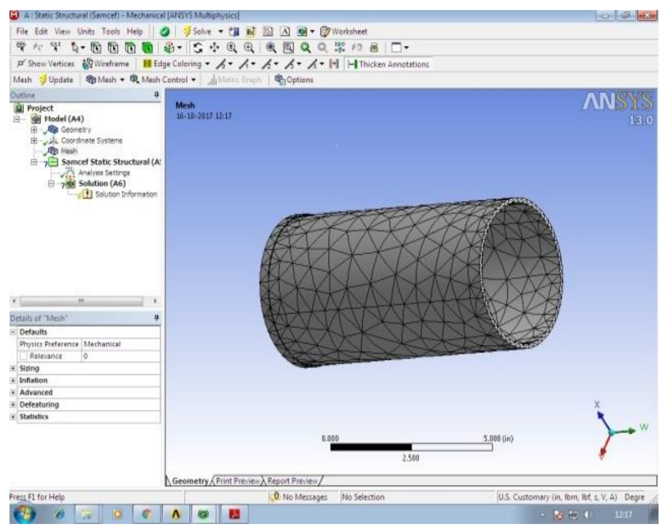

Figure 12 Meshing of Tungsten and Copper alloy

In the Fig, the tungsten and copper alloy cylinder liner meshing is the shown using Ansys software.

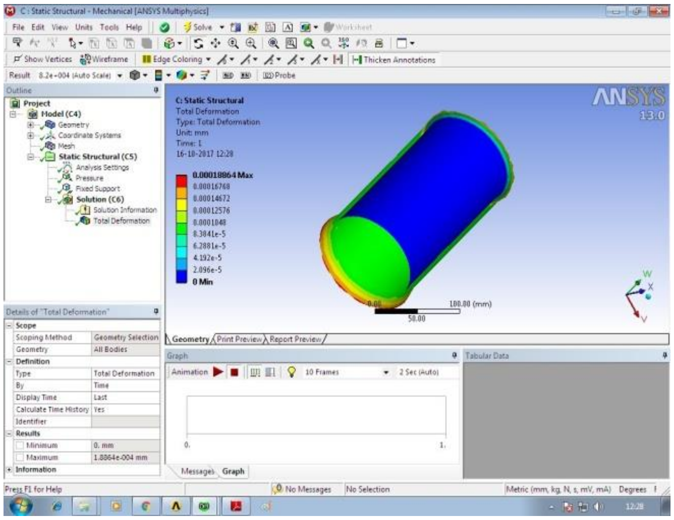

Figure 13 Total Deformation of Tungsten and Copper alloy

In the Fig, the total deformation of tungsten and copper alloy liner is observed as 0.0001678 mm a maximum.

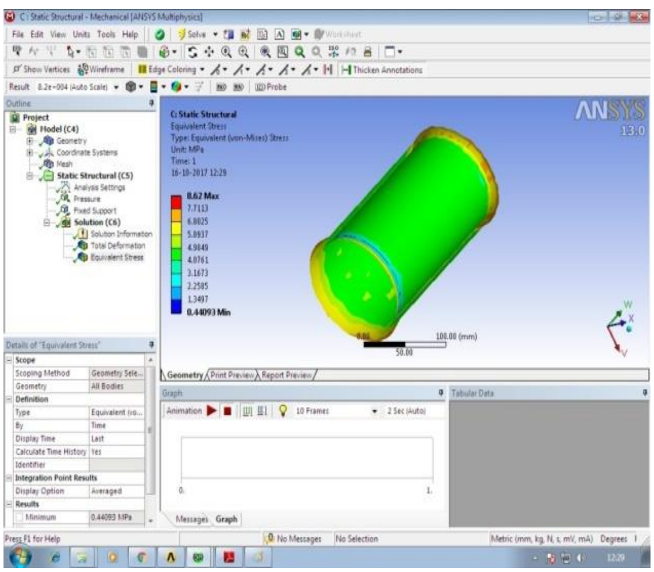

Figure 14 Equivalent Stress of Tungsten and Copper alloy

In the Fig, the maximum equivalent stress is found to be 8.12 Mpa

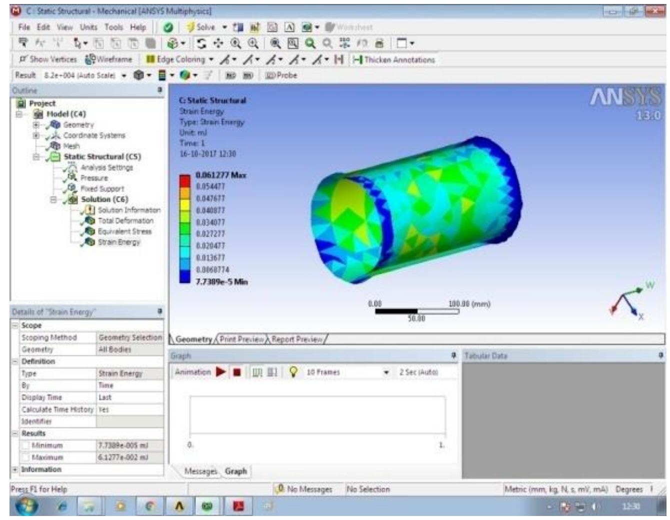

Figure 15 Strain Energy of Tungsten and Copper alloy

The fig shows the maximum strain energy for Tungsten and Copper alloy cylinder liner is 0.061477 MJ

6.3 THERMAL ANALYSIS OF TUNGSTEN AND COPPER ALLOY CYLINDER LINER

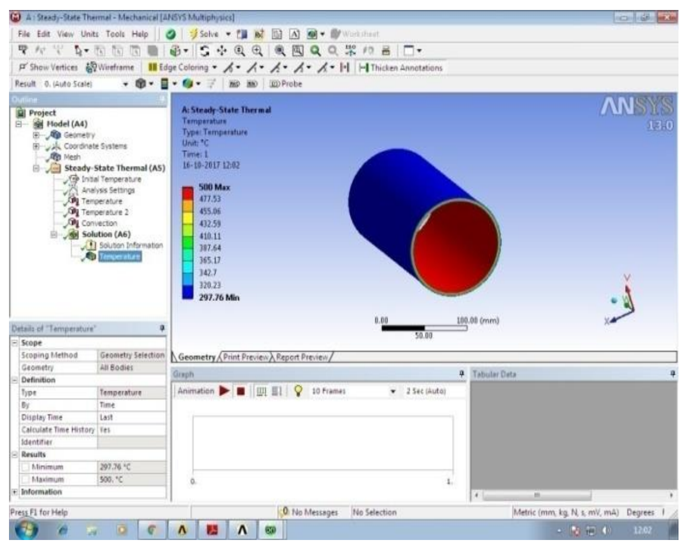

Figure 16 Steady State Thermal Analysis of Tungsten and Copper alloy

In the Fig shown the maximum temperature is 500^0C and minimum temperature is 297.76^0C.

7. RESULTS

Comparison of the results for materials used in the analysis. By tabulating the values we got a brief view can be appears.

Results/ materials	Equivalent stress Mpa	Total Deformation mm	Strain energy MJ
Grey cast iron	8.62	0.00018864	0.061277
Aluminum alloy	9.36	0.0001933	0.06223
Stainless steel	10.2	0.0002038	0.07121
Tungsten Copper alloy	8.12	0.0001678	0.061477

8. CONCLUSIONS:

After studying and analyzing cylinder liner using some materials following conclusions were drawn:

1) The cylinder liner made of tungsten copper alloy is lighter than the existing cylinder liner.

2) ANSYS Equivalent stress for the tungsten copper alloy is slightly less than cast iron alloy which is currently used as cylinder liner.

3) Total deformation of tungsten copper alloy is less than the current material (cast iron alloy).

4) Thus, although the cost of the tungsten copper alloy is high, Tungsten copper alloy is safe to use as cylinder liner.

9. REFERENCES

[1] Internal Combustion Engines ByV.Ganesan, The McGraw-Hill Companies.

[2] JinlinXue, Tony E. Grift, Alan C.Hansen, Effect on engine performance and emissions, Elsevier Journal Renewable and Sustainable Energy Reviews,15(02),2011,1098-1116.

[3] A course in internal combustion engines by M.L.Mathur and Sharma, DhanpatRai& sons publications.

[4] , Ritchie (2012). "'Combustion performance of 2,5-dimethylfuran blends using dual-injection compared to direct-injection in an SI engine'". Applied Energy.

[5] H. S. Yücesu A. Sozen T. Topgül E Arcaklioğlu "Comparative study of mathematical and experimental analysis of compression ignition engine performance"

[6] L. Wei W. Ying Z. Longbao S. Ling "Study on improvement of fuel economy and reduction in emissions for stoichiometric diesel engines" Applied Thermal Engineering vol. 27 no. 17–18 pp. 2919-2923 December 2007