ISSN: 2581-3404 (Online)
International Journal of Innovative Research in Technology and Management, Vol-5, Issue-3, 2021.

Thermal Transient Analysis of a Diesel Engine Piston with Different Materials by Using FEM

Gaurav Kumar[1], Padmakar Pachorkar[2]

[1]PG, Research Scholar of ME, Department of Mechanical Engineering

[2] Assistant Professor, Department of Mechanical Engineering

[1,2]IES College of Technology, Bhopal, MP, India, Bhopal, (M.P.), India.

Abstract- *Typical, most frequently found failures of pistons used in 06 cylinder internal combustion engines. Typical piston failures caused by the poor quality of fuel, the maladjustment of the engine feed system or wrong engine operation have been discussed. The most common cause of piston failures is an incorrectly performed repair of the engine or its improper operation. Here take two material like that AL 6061 without coating and another material is Al 6061 with coating 1 mm layer of beryllium aluminium material. Here take thermal boundary condition is 42 ^{0}C and piston crown temperature put-up 420 0C and film coefficient 5e-006 w/m²C .Then here find out temperature results for exiting material AL6061 is 377.78 ^{0}C and Magnesium Alloy 377.78 0C when take another beryllium aluminium coated material used then find out less temperature results like 375.75 ^{0}C. Then here find out heat flux results for exiting material AL6061 is 9.2 w/mm² and Magnesium Alloy 7.60 w/mm² when take another coated material used then find out less heat flux results like 14.028 w/mm². So it is clear that Al 6061 with beryllium aluminium coated material is best for exiting material AL 6061 and Magnesium Alloy on the basis on more heat transferred and less temperature value.*

Keywords:- Piston Alloys, beryllium aluminium material, AL6061 , 6 cylinder, heat flux, coating, piston failures.

I. Introduction

The current design of the internal piston fire engines has contributed to improved performance and reliability of the piston-cylinder assembly components. Many research and development centers and sciences at home and abroad conduct studies aimed at increasing net energy and torque and reducing fuel consumption, while meeting EU standards for effective emissions of fire hazards [1, 2]. One of the main objectives of car manufacturers is to ensure the highest durability and reliability of the engine [7, 9]. The piston is a feature of the crankshaft assembly, which participates in the conversion of heat energy into a working machine [6, 10]. The piston head forms the moving part of the fire chamber. Piston grooves hold piston rings that enclose the cylinder working space, while individual piston pin holders have a piston pin bear-mounted on them, which transmits electrical energy to the crankshaft. The main function of the piston is to absorb the piston head-space pressure by the piston head. This force, increased by the inertia force, is transmitted to the piston, the piston pin and, through the connecting rod, to the crankshaft. The design of the piston must withstand high thermal and mechanical loads [8]. It is necessary to: - take heat from the head of the hot piston, heated by high temperature gas, to the walls of the cool cylinders, - lead the piston to the cylinder sleeve and take the pressure of the lateral piston on the cylinder bearing above, - cause very low friction loss, and - confirm the use of engine oil lubricant. The materials used for pistons in internal combustion engines include: - aluminum alloys, - alloy steels, and cast iron. The most commonly used materials for making pistons include: stainless steel, alloy steel and aluminum alloys, aluminum-silicon alloys (Al-Si) and aluminum-copper alloys (Al-Cu) These alloys are characterized by low density, being useful due to the small weight of the piston, and the large coefficient of thermal conductivity [5]. Aluminum alloys are distinguished by good posture during dispersion and mechanical efficiency (machine cutting). The main disadvantages of these alloys include: large coefficient of thermal elasticity, low hardness and low power indicators at high temperatures. Cast-iron pistons are rarely used. They are available in low-speed exercise engines. They are characterized by good slide structures, which maintain good mechanical properties at high temperatures, and a small coefficient of thermal expansion. The main disadvantages of using cast-iron pistons in modern high-speed engines are: the coefficient of low thermal conductivity and high magnitude leading to a large number of pistons and high inertia potential.

II. **Problem Formulation**

Typical, most frequently found failures of pistons used in four-stroke internal combustion engines. Typical piston failures caused by the poor quality of fuel, the adjustment of the engine feed system or wrong engine operation have been discussed. The most common cause of piston failures is an incorrectly performed repair of the engine or its improper operation.

III. Methodology

3.1 Finite Element Model

Establish a balanced and accurate element model that is the most important part of piston finite element analysis, thus marking the grid elements to get accurate results in the end. According to the piston structure symmetry, to facilitate calculation and reduce the workload, cut the established piston model to save 1/4 and import the model into the limited element analysis software to the piston according to good interface between modeling software and limited analytics software. During the import process, some details are left out, such as the chamfer and the snap ring of the piston pin etc. The geometric model of the piston is shown in Figure 1. The Body Structures of the Piston are shown in table1. During the production of piston model space, based on experience.

IV. Modeling & Simulation

4.1 Aluminum 6061 Alloy Materials

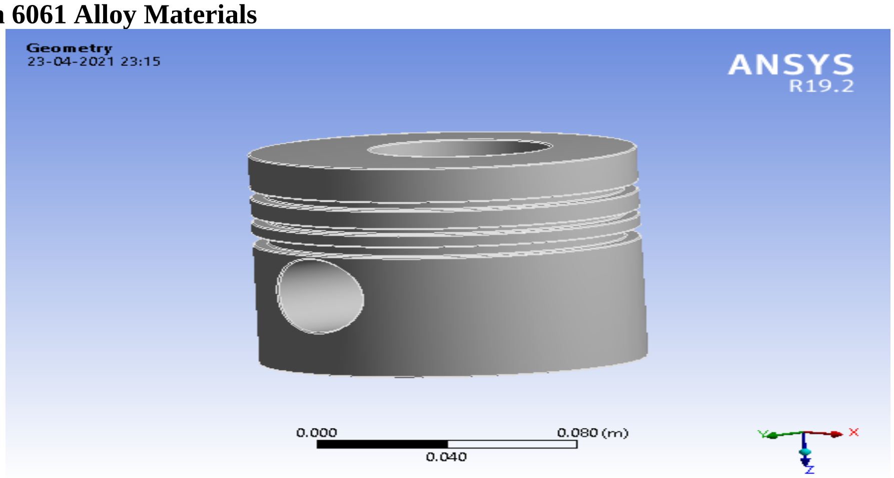

Fig.4.1: Diesel engine Al 6061 piston model import into Piston model generate on Solid work software and import in ANSYS.

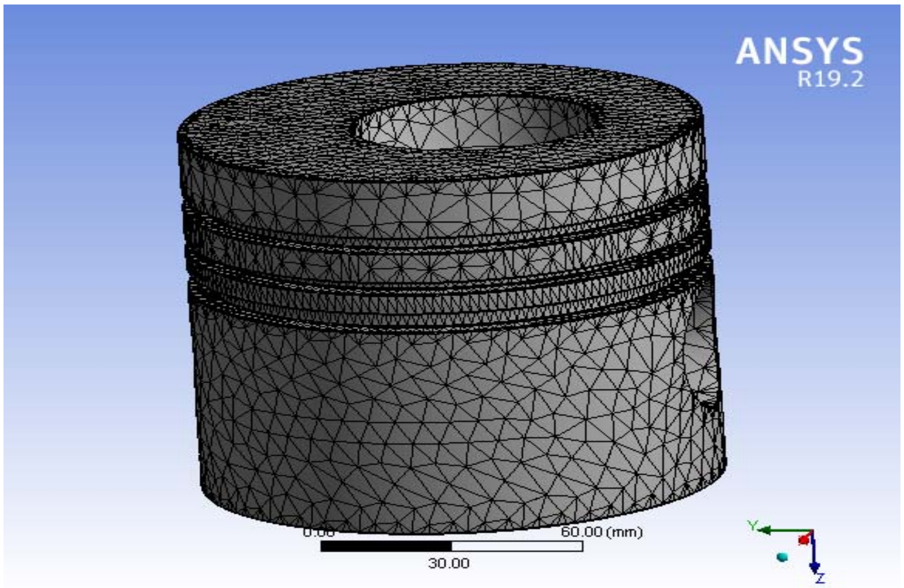

Fig. 4.2: Diesel engine Al 6061 piston meshing model.

Piston model generate on Solid work software and import in ANSYS and meshing generate by tetrahedral with medium meshing.

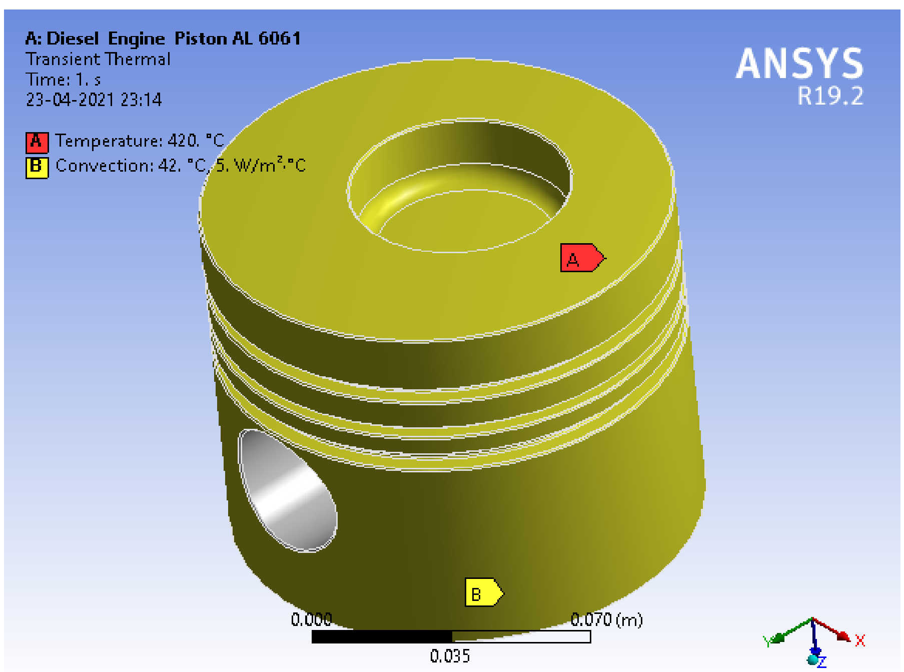

Fig.4.3: Diesel engine Al 6061 piston thermal convection boundary condition Piston model generate on Solid work software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition.

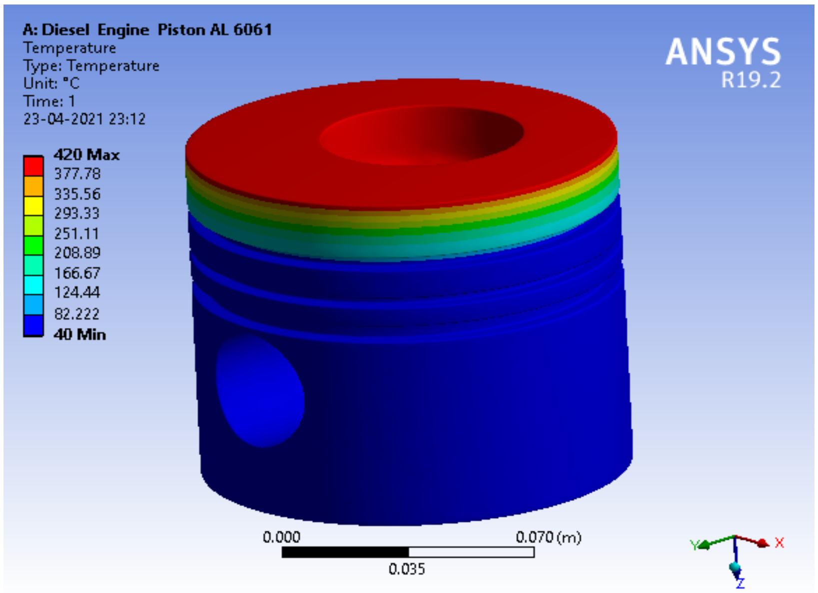

Fig.4.4: Diesel engine Al 6061 piston temperature results.

Al 6061 piston:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition and find out temperature value 377.78 ^{0}C

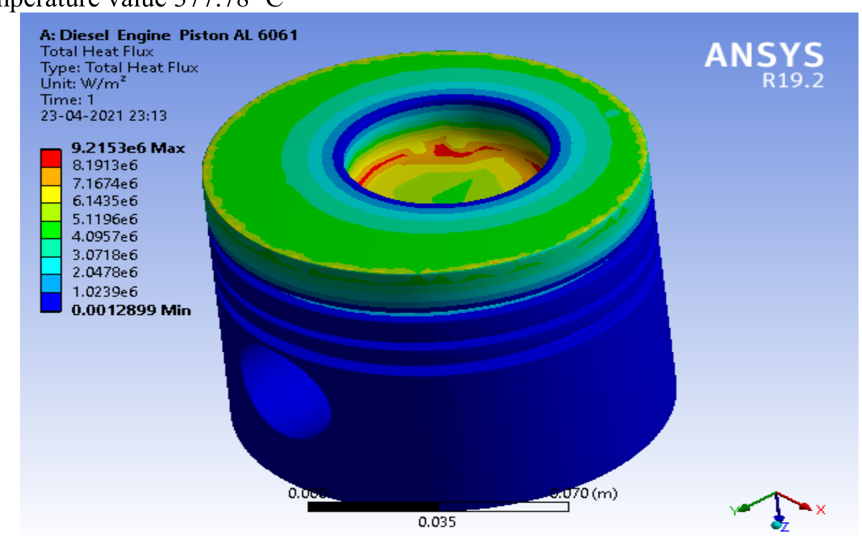

Fig.4.5: Diesel engine Al 6061 piston heat flux results.

Al 6061 piston:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition and find out heat flux 9.21 w/mm^2.

4.2 Magnesium Alloy Materials

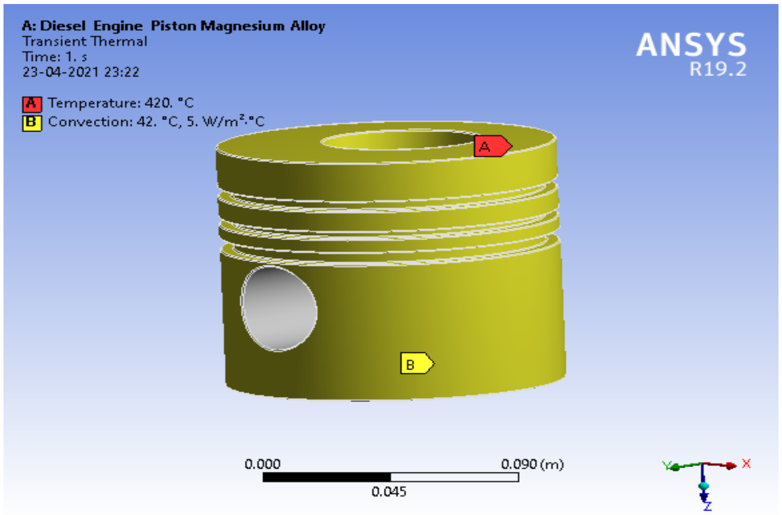

Fig.4.6: Diesel engine Magnesium Alloy piston convection boundary condition.

Magnesium Alloy piston:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition.

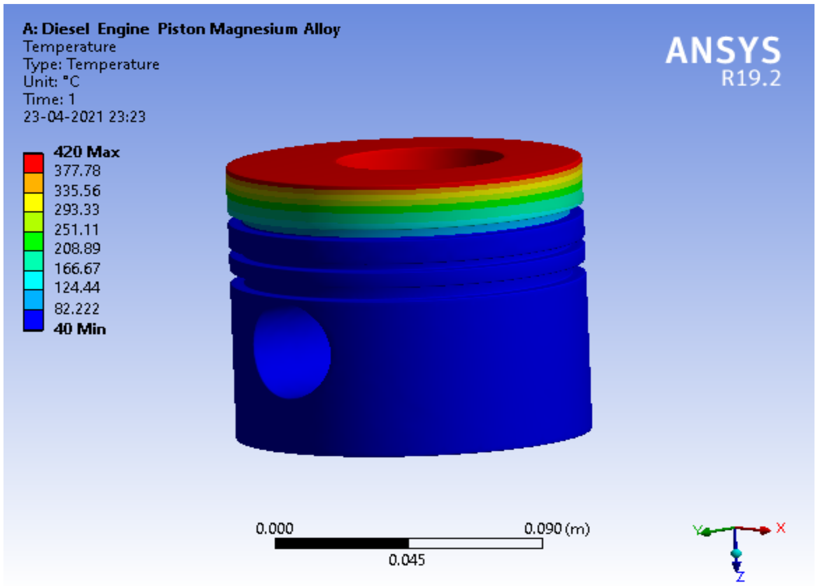

Fig.4.7: Diesel engine Magnesium Alloy piston temperature results.

Magnesium Alloy:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition and find out temperature value 377.78 ^{0}C

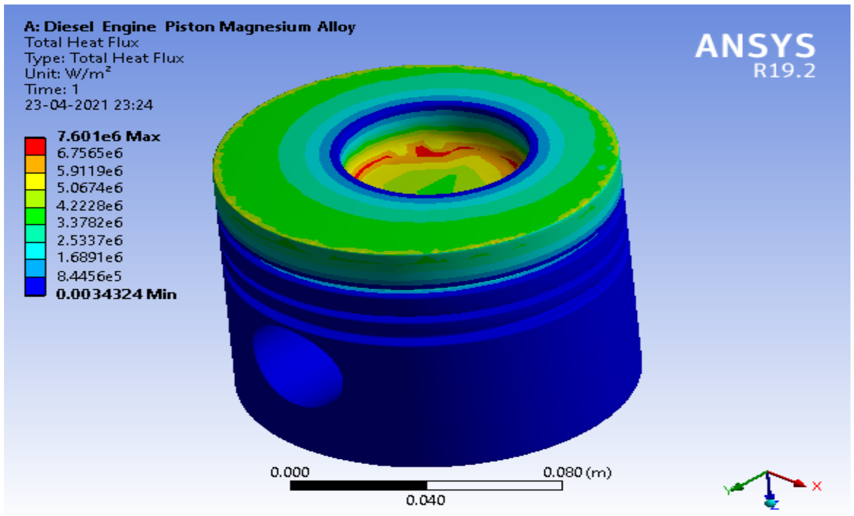

Fig.4.8: Diesel engine Magnesium Alloy piston heat flux results.

Magnesium Alloy piston:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition and find out heat flux 7.6 w/mm^{2}

4.3 Aluminum Beryllium Alloy Materials

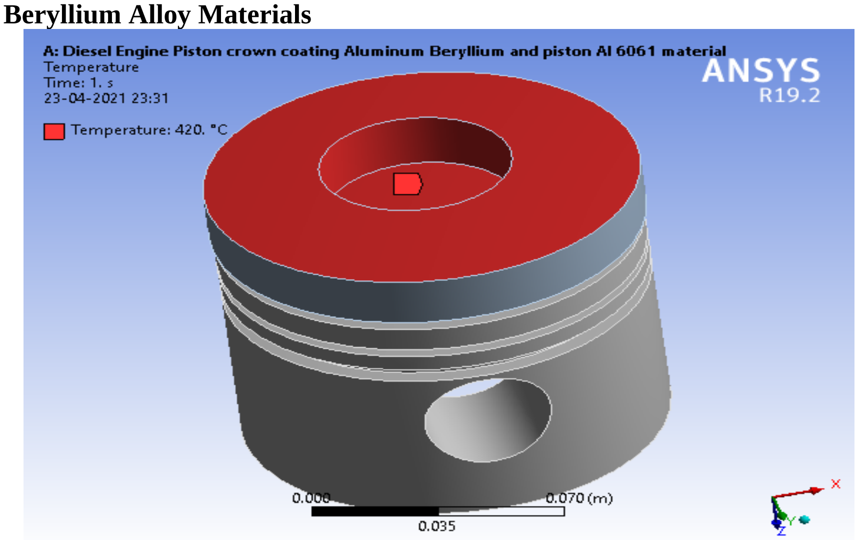

Fig.4.9: Diesel engine Aluminum Beryllium Alloy piston thermal boundary.

Aluminum Beryllium Alloy:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C put up

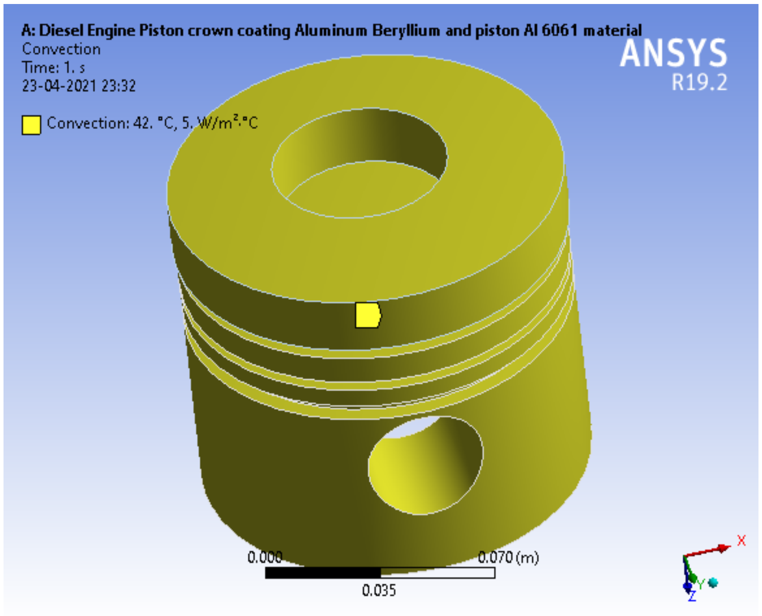

Fig.4.10: Diesel engine Aluminum Beryllium Alloy piston convection boundary.

Aluminum Beryllium:- Piston model generate on Solidwork software and import in ANSYS and piston atmospheric temperature 42 ^{0}C put up

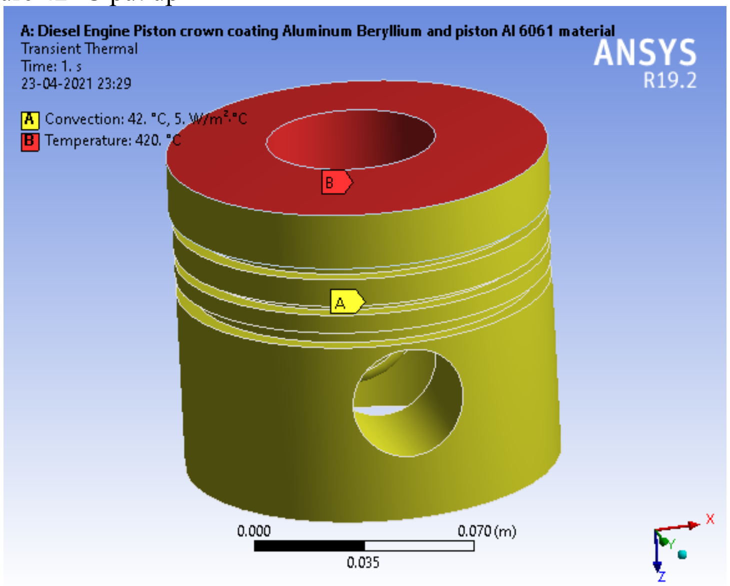

Fig.4.11: Diesel engine Aluminum Beryllium Alloy piston thermal boundary.

Aluminum Beryllium Alloy piston:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition.

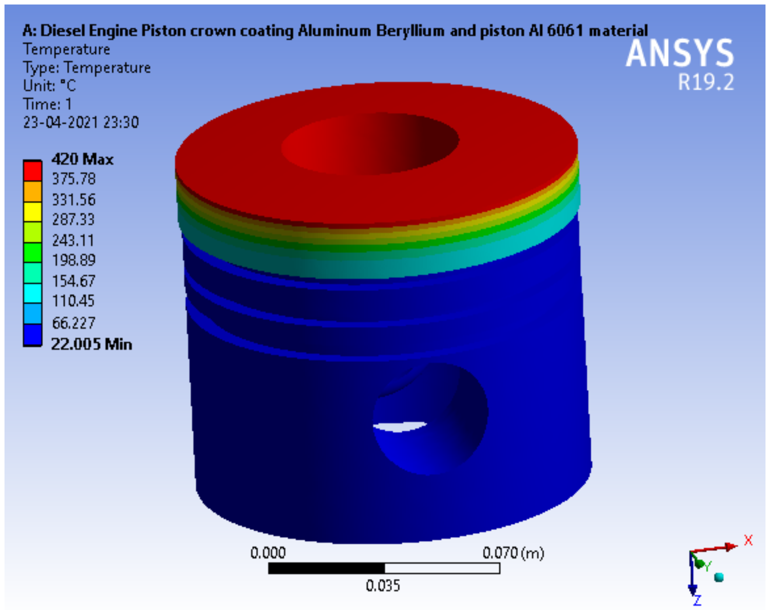

Fig.4.12: Diesel engine Aluminum Beryllium Alloy piston temperature results.

Aluminum Beryllium Alloy:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition and find out temperature value 377.78 ^{0}C

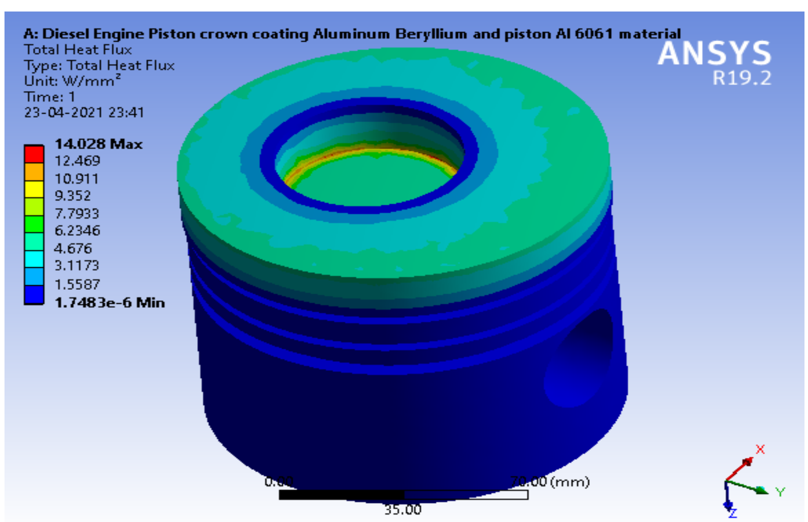

Fig.4.13: Diesel engine Aluminum Beryllium Alloy piston temperature results.

Aluminum Beryllium Alloy piston:- Piston model generate on Solidwork software and import in ANSYS and piston crown temperature 420 ^{0}C and piston atmospheric temperature 42 ^{0}C put up with overall thermal boundary condition and find out heat flux 14.028 w/mm^{2}

V. Results & Discussion

Here it is cleared about diesel engine piston for 6 cylinder vehicle. here using NX software for 2D and 3D modeling purpose and simulation have performed on ANSYS workbench at thermal transient analysis platform. So here find out two results basis on thermal boundary condition. Like that temperature and heat fluxes.

Here take three material like that AL 6061 without coating and another material is Al6061 with coating 1 mm layer of beryllium aluminium material and **Magnesium Alloy.**

Here take thermal boundary condition is 42 ^{0}C and piston crown temperature put-up 420 ^{0}C and film coefficient 5e-006 w/m²C

Then here find out temperature results for exiting material AL6061 is 377.78 ^{0}C and **Magnesium Alloy** 377.78 ^{0}C when take another beryllium aluminium coated material used then find out less temperature results like 375.75 ^{0}C

Then here find out heat flux results for exiting material AL6061 is 9.2 w/mm² and **Magnesium Alloy 7.60** w/mm² when take another coated material used then find out less heat flux results like 14.028 w/mm²

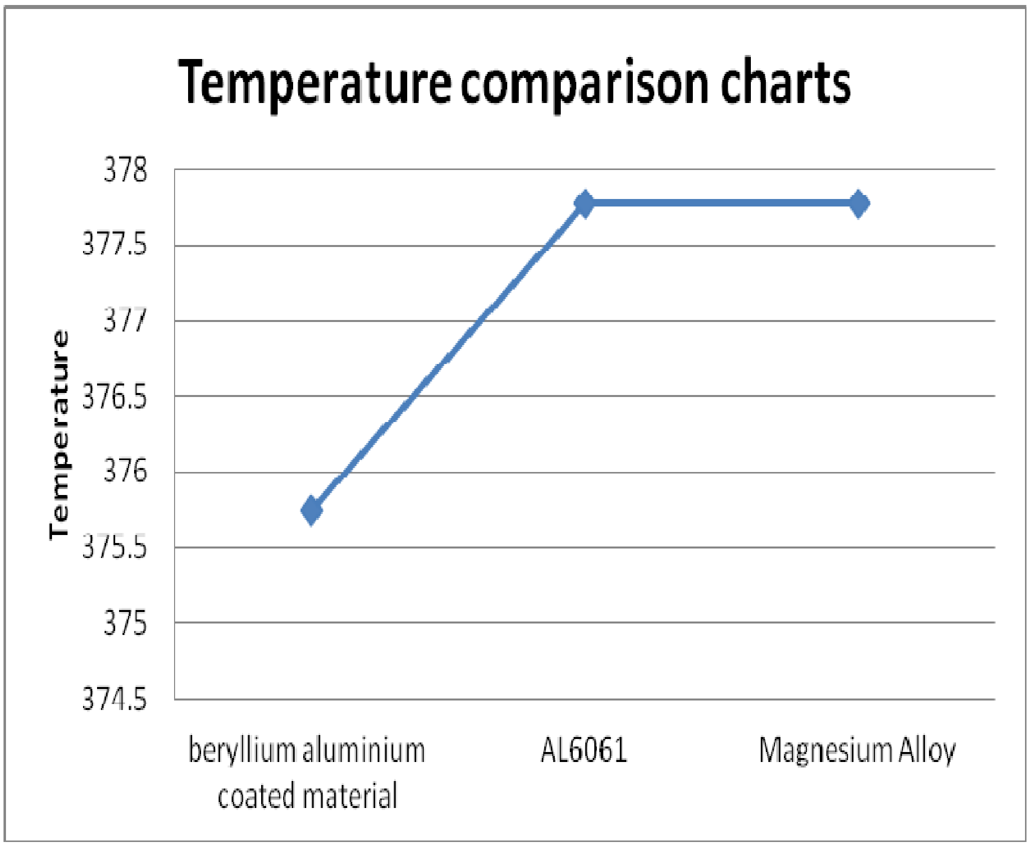

Fig. 5.1: Temperature comparison charts (C).

In this graph here find out temperature results for exiting material AL6061 is 377.78 ^{0}C and **Magnesium Alloy** 377.78 ^{0}C when take another beryllium aluminium coated material used then find out less temperature results like 375.75 ^{0}C

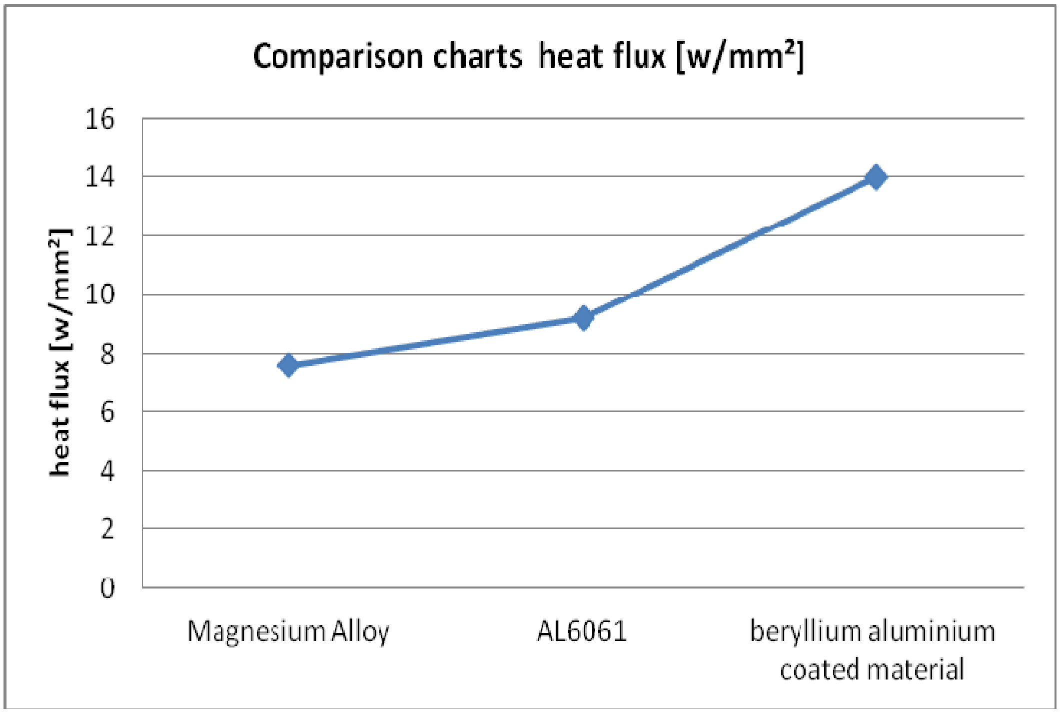

Fig 5.2: Comparison charts heat flux [w/mm²].

In this graph here find out heat flux results for exiting material AL6061 is 9.2 w/mm² and **Magnesium Alloy 7.60** w/mm² when take another coated material used then find out less heat flux results like 14.028 w/mm²

VI. Conclusion

In order to find the surrounding temperature at design stage, Thermal transient analysis is applied in the prediction of heat transfer rate.

This FEA calculation technique improves the accuracy of the piston temperature prediction and the optimization of the piston cooling is realized at the design stage.

(1) The accuracy of piston temperature prediction is improved significantly.

(2) By using this technique, find out heat transferred results.

References

[1] Qin Zhaoju, Li Yingsong, Yang Zhenzhong , Duan Junfa, Wang Lijun "Diesel piston thermo-mechanical coupling simling and multidisciplinary design ptimization" Case Studies in Thermal Engineering 15, (2019).

[2] Leilei Xu, Xue-Song Bai, Ming Jia, Yong Qian, Xinqi Qiao, Xingcai Lu "Experimental and modeling studies of hydraulic and fire injection in diesel engines with a standard I njection system" Applied Energy, November 2018.

[3] S Pal, A Deore, A Choudhary, V Madhwani and D Vijapuri "Analysis and probe testing of ceramic powder coating on aluminum piston" IOP Conf. Series: Materials Science and Engineering 263, 2017.

[4] Z. Khatir, K. J. Kubiak, P. K. Jimack, T. G. Mathia Hot engineering was used, in 2016.

[5] Maloth Heeralal, Thurai Sai Sharat, Guguloth Ravi Design Design Evaluation of Diesel Engine piston Using Materials CI and Aluminum Alloy International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value, 2015.

[6] Elisa Carvajal Trujillo, Francisco J. Jiménez-Espadafor, José A. Becerra Villanueva, Miguel Torres Garcí How to measure the internal temperature of a cylinder in an air- cooled engine. Application of Thermal Engineering, Vol. 31, page. 1474-1481,2011.

[7] Sook-Ying Ho, Allan Paull has undergone a thermal, structural and vibrational analysis of the hypersonic aircraft test engine. Aerospace Science and Technology, Vol. 10, page. 420-426, 2006.

[8] Bao-Lin Wang, Yiu-Wing Mai Transient three-degree heat dissipation is solved with a small object. International Journal of Mechanical Sciences, Vol. 47, page. 303-317, 2005.

[9] Benz U. A., RencisJ. J. Coupling with two limitation features and axisymmetric zone zones for temporary heat transfer applications. Engineering and Boundary Elements Analysis, Vol. 26, page. 455-467., 2002.

[10] Hidehiko Kajiwaraa, Yukihiro Fujiokab, Tatsuya Suzukia, Hideo Negishia "An Analytical Method of Predicting the Distribution of Piston Temperature in Diesel Engine" science.

[11] Ambrozik Andrzej, Ambrozik Tomasz, Łagowski Piotr: The impact of Fuel emissions on CI engines during the onset of the cold, Eksploatacja i Niezawodność - 2015 maintenance and reliability; 17 (1): 95-99, 2015.

[12] Ambrozik Tomasz: Wybrane uszkodzenia silników gaźnikowych, Logistyka 6/2014, p. 1428- 1435.

[13] UDroździel P., Ignaciuk P.: Classical technology technologies in the real world - the cylindrical cylindrical spacecraft, Technological and automated automation, 3/2002, pp. 64-68.

[14] Droździel P., Ignaciuk P.: Wpływ luzów na zużycie tulei cylindrowej podczas docierania eksploatacyjnego silnika, Technology 38-40. R. 10, May 1-2, 2003.