Performance analysis of Diesel Engine with crown coated & Non-coated alloy materials

M. Srinivasnaik[1] D Srinivas[2], B. Kavitha[3], Srinivas Banothu[4], S.Raju[5].

[1] Associate Professor in the Department of Mechanical Engineering Chaitanya Deemed to be University Warangal

[2]Senior Lecturer in Mechanical, S.G.Govt.Polytechnic Adilabad

[3]Lecturer in mechanical engineering, Government polytechnic Warangal,

[4]Lecturer in Mechanical Engineering, Govt.Polytechnic,Kataram, Jayashanker Bhupalapally District

[5]Assistant Professor in the Department of Mechanical Engineering Chaitanya Deemed to be University Warangal

Abstract: The vitality request worldwide is expanding at quick rate, in this way it is fundamental as better and compelling usage of accessible vitality by utilization of suitable innovation at least cost. The internal combustion engine has discovered wide application in transportation. In the present paper, near investigation on Engine utilizing two diverse better combination materials is finished. Impressive endeavours were made to create progress adiabatic motor and mean to lessen warm lost. Logical examination is done under various temperature and warmth transition condition on a cylinder for diesel engine ignition chamber. The amalgams, for example, Titanium composite and Nimonic are utilized to locate the best performance. The outcomes were contrasted and base motor and two distinctive LHRE. The TITANIUM improved Piston is discovered having best performance and discharge qualities. The commotion level was discovered palatable without thumping in Engine. The analysis has been carried out by using ANSYS work bench 15.0.

Keywords: Engine performance, Emission, Thermal analysis.

Introduction: Research for diminishing expenses and expended fuel in internal combustion engines and technological development thinks research about have been proceeding. Engine efficiency change endeavours through constructional adjustments are expanded today; for example, parallel to improvement of cutting edge innovation pottery, clay covering applications in interior ignition motors develop quickly. To enhance engine performance, fuel vitality must be changed over to mechanical vitality and no more conceivable rate. Non Coted burning with low warmth directing artistic materials prompts expanding temperature and weight in interior burning motor chambers. Subsequently, an expansion in engine efficiency ought be watched [1]. The main focus areas of today's in IC engine are higher thermal efficiency with minimum emission. The amount of total energy developed during combustion in I.C. engine is not fully converted in to useful work. In I. C. engine about one-third of the total energy use in brake power while about 30-33 % energy is lost in cooling water and the rest in exhaust gases. The heat lost from engine boundaries due to radiation, convection and conduction. Further in case of auto vehicle only about 10-15 % of energy is effectively use to propel the vehicle out of about 33% available energy. Hence in overall there is a large amount of energy loss from engine. A key role is performed by lubricant oil in diesel engine to improve mechanical efficiency. Many research development programs have been arranged in world during the 40-years to improve the efficiency of the IC engine, particular diesel engine. The adiabatic engine is one of the programs to develop an engine with higher efficiency. [2]

Objectives of study

1. To enhance the design of I.C engine piston.
2. To study the applications of I.C engine piston.
3. To understand the properties such as mechanical, electrical and thermal properties of Coated & Non-Coated alloys.
4. To study the usage of Coated & Non-Coated alloys.

LITERATURE REVIEW:

Recently, much attention has been focused on TBCs for turbine engines. However, the service environment of the coating in the turbine is markedly different than in the diesel engine. In the former, the service temperature is high (1000-1100°C). The super alloy substrate's maximum ser-vice temperature is about 800°C. The thickness of coating is a few hundred microns and is applied to protect against oxidation, hot corrosion, thermo-mechanical fatigue and creep. Due to the high substrate temperature, oxidation of the bond coat plays a major role in coating failure. On the other hand, in the diesel engine the gas temperature, currently less than 750°C, would ideally approach 900°C. The substrate temperature is limited to approximately 200°C, and therefore a thick coating (at least 1mm) is required which leads to a high thermal gradient. In a thick thermal barrier coating (TTBC) the bond coat temperature is too low for severe oxidation and creep [3]. In a thick TBC, a low TEC is desirable for the hot surface to minimize thermally derived stresses and sensitivity to thermal shock. A large TEC mismatch with the metallic substrate limits coating adhesion. A multi-layer system may permit these opposing requirements to be satisfied. A set of chemically compatible materials have been identified which offer a range of TECs and acceptable thermal conductivities. Coupled analysis of the temperature and stress distribution through the thickness of the multi-layer coating is underway to evaluate stress levels in the coating during and after deposition and under service conditions. The goal is to optimize the thickness of each layer to minimize the stress in the coating under service conditions [4, 5].The details of insulated piston, insulated liner and ceramic coated cylinder head employed in the experimentation are discussed. LHR diesel engine contains a two part piston, the top crown made of low thermal conductivity material, superni90 screwed to aluminium body of the piston, providing a 3mm air gap in between the crown and the body of the piston. The optimum thickness of air gap in the air gap piston is found to be 3mm. [6, 7] for better performance of the engine with supernal inserts with diesel as fuel. A superni90 insert is screwed to the top portion of the liner in such a manner that an air gap of 3mm is maintained between the insert and the liner body. At 500 o C the thermal conductivity of superni90 and air are 20.92 and 0.057 W/m K respectively. Partially stabilized zirconium (PSZ) of thickness 500 microns is coated by means of plasma coating technique. Experimental setup used for the investigations of LHR diesel engine with pure diesel is shown [8].A zero dimensional, multi zone model is attempted to predict the performance of LHR diesel engine, with air gap insulated piston and liner. However, there are certain assumptions suck as

i) There is no interaction between two elements,

ii) Pressure is uniform over the entire combustion chamber,

iii) Fuel jet breaks into droplets right at the exit plane of the nozzle and

iv) Injection pressure and injection rate are constant over a cycle.

The concept of dividing spray is similar to that of Hiroyasu [9, 10]

The motivating force behind the low heat rejection (LHR) engine has been the prospect to decrease of cooling load. Cooling system is there to keep engine-operating tempera-tures down to levels tolerated by currently used constructional materials and lubricants. If the energy normally rejected to the coolant could be recovered instead on the crankshaft as useful work, then a substantial improvement in fuel economy would be obtained. Increased thermal efficiency and elimination of the cooling system are the major promises of the LHR engine [11]. On the other hand, the LHR engine designs promise to meet the increasingly stringent regulations in the areas of fuel economy and permissible emissions levels [12, 13]. At the same time, exhaust energy rise, which accompanies this, can be effectively used in turbocharged engines. Higher temperatures in the combustion chamber can also have a positive effect on diesel engines, due to the self-ignition delay drop [14, 15]. Can Hasimoglu at al [16] conducted various experiments on a turbocharged direct injection diesel engine coated with CaZrO3 using diesel and biodiesel fuels and reported that with the LHR diesel and STD diesel conditions the brake thermal efficiency was increased approximately 3%, 4% and 6.5%, respectively as shown Fig.1, compared to STD diesel condition. This can be explained as follows: although there is a difference between fuels lowers heating values of approximately 14%, the engine power and torque decrease to a maximum of 4.5%. It is estimated that these circumstances increased the brake thermal efficiency in STD biodiesel condition. In LHR biodiesel and LHR diesel conditions due to the reduction of specific fuel consumption, the brake thermal efficiency was increased. [17, 18]. Volumetric efficiency is an indication of breathing ability of the engine. It depends on the ambient conditions and operating conditions of the engine. Reducing heat rejection with the addition of ceramic insulation causes an increase in the temperature of the combustion chamber walls of an LHR engine. The volumetric efficiency should drop, as the hotter walls and residual gas decrease the density of the inducted air. [19, 20]

Materials: A steady state thermal analysis is done for the piston with a crown and materials such as Titanium Alloy and Nimonic Alloy are used for finding the performance and emission in the engine.

Material:	Titanium Alloys - Ti6Al4V Grade 5		
Property	**Minimum Value (S.I.)**	**Maximum Value (S.I.)**	**Units (S.I.)**
Density	4.429	4.512	Mg/m^3
Bulk Modulus	96.8	153	GPa
Compressive Strength	848	1080	MPa
Elastic Limit	786	910	MPa
Hardness	3370	3730	MPa
Modulus of Rupture	786	1080	MPa
Shear Modulus	40	45	GPa
Tensile Strength	862	1200	MPa
Young's Modulus	110	119	GPa
Latent Heat of Fusion	360	370	kJ/kg
Melting Point	1878	1933	K
Specific Heat	553	570	J/kg.K
Thermal Conductivity	7.1	7.3	W/m.K
Resistivity	168	170	10^{-8}ohm.m

Meshing: The model has been mesh with tri mesh of surface 2d element after importing the model to Ansys work bench.

NON COATED MATERIAL AS TITANIUM ALLOY:

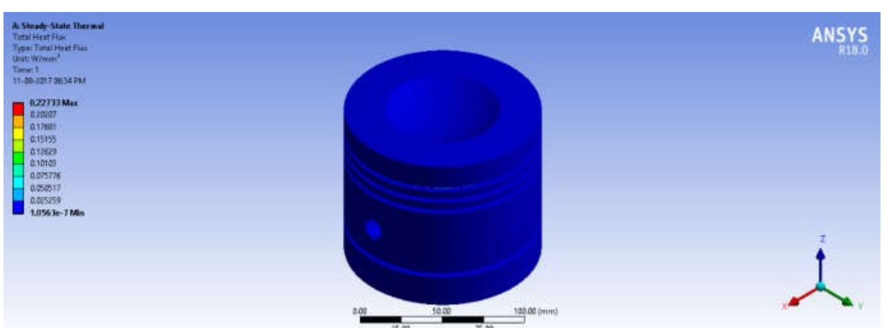


Figure 1 shows total heat flux piston with TITANIUM ALLOY

In this it is observed that when the piston with crown is subjected to heat flux the minimum value obtained is $1.056e^{-7}$ W/mm^2 and the maximum of 0.22733 W/mm^2

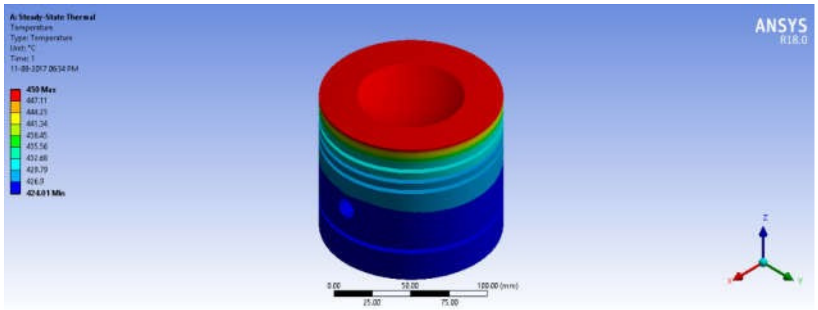


Figure 2 shows temperature variance piston with TITANIUM ALLOY

In this it is observed that when the piston with crown is subjected to temperature the minimum value obtained is 424.01^{0}C and the maximum of 450^{0}C.

NON COATED MATERIAL AS NIMONIC ALLOY:

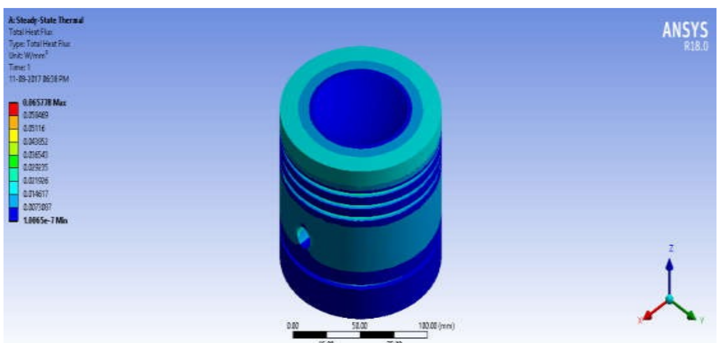


Figure 3 shows total heat flux piston with NIMONIC ALLOY

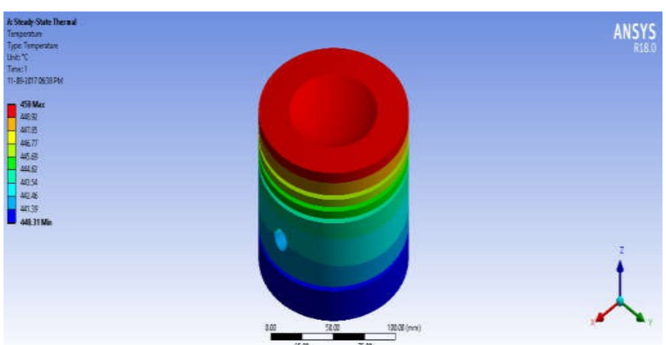


Figure 4 shows temperature variance piston with NIMONIC ALLOY

COATED MATERIAL AS TITANIUM ALLOY

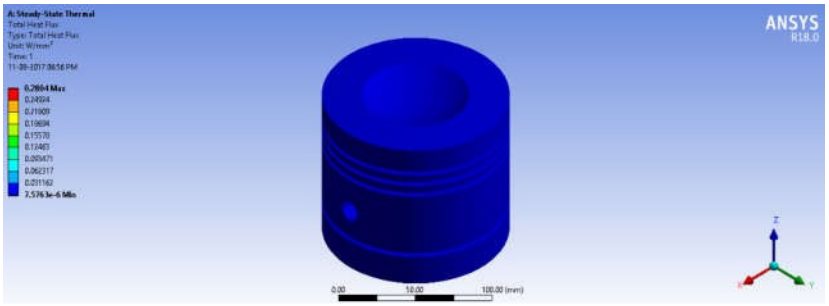


Figure 1 shows total heat flux piston with crown of TITANIUM ALLOY

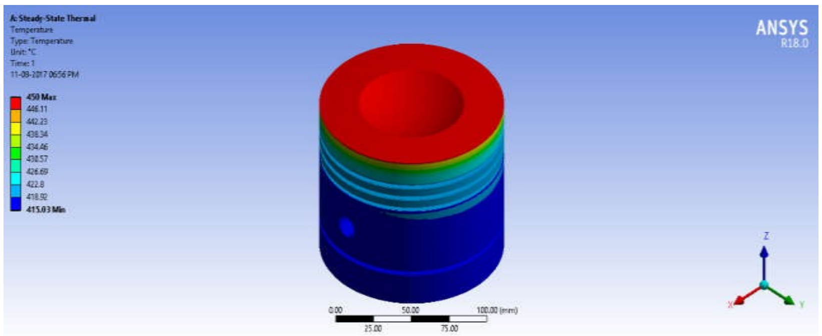


Figure 2 shows temperature flux piston with crown of TITANIUM ALLOY

COATED MATERIAL AS NIMONIC ALLOY:

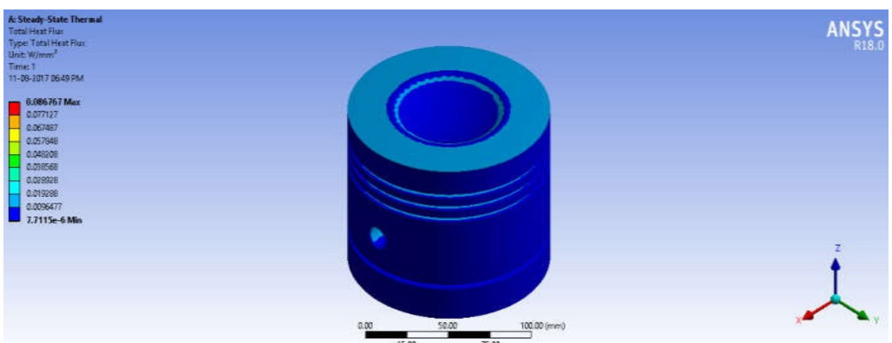


Figure 3 shows total heat flux piston with crown of NIMONIC ALLOY

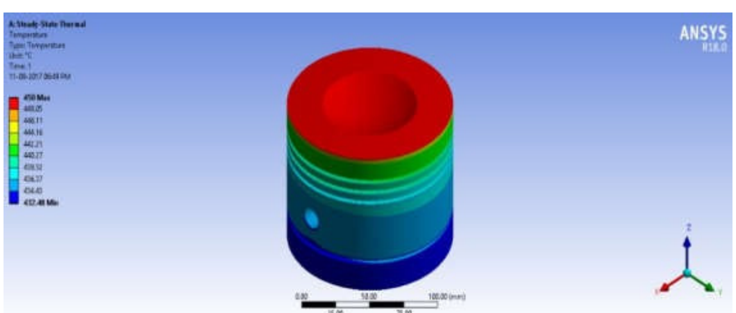
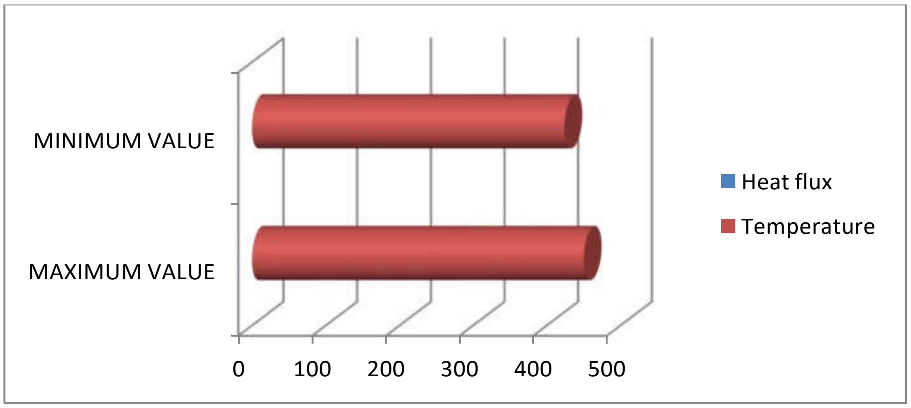


Figure 4 shows total temperature piston with crown of NIMONIC ALLOY

Table 4.1 piston with non coted material as titanium alloy

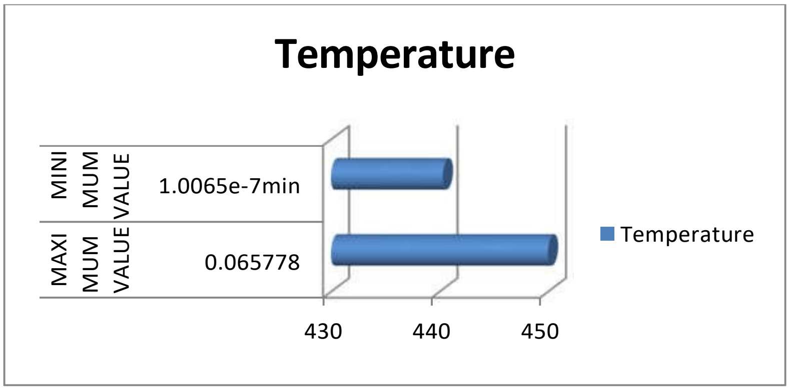
PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE
Heat flux	0.22333	1.0563e-7
Temperature	450	424.01



Graph 4.1 Piston with non coated material as titanium alloy variations

TABLE 4.2 PISTON WITH NON COTED MATERIAL AS NIMONIC ALLOY

PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE
Heat flux	0.065778	1.0065e-7min
Temperature	450	440.31

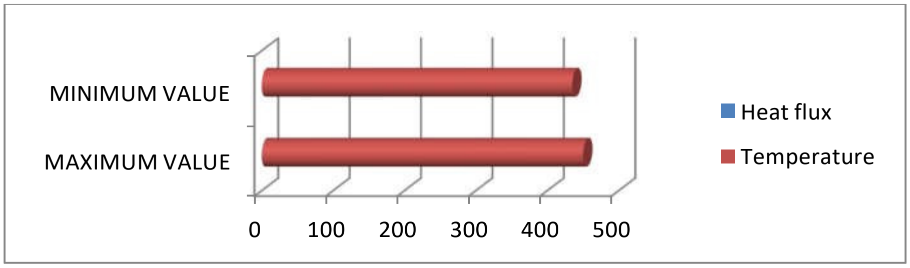


GRAPH 4.2 PISTON WITH NON COTED MATERIAL AS NIMONIC ALLOY VARIATIONS

TABLE 4.3 PISTON WITH COATED MATERIAL AS TITANIUM ALLOY

PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE

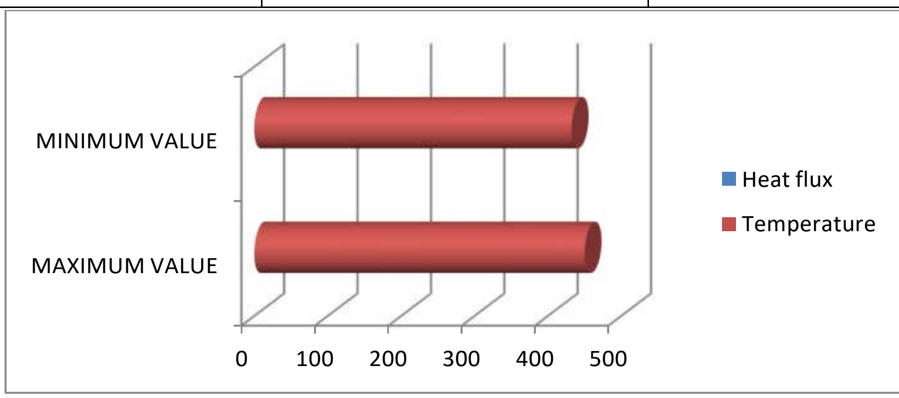
Heat flux	0.2904	7.536E-6
Temperature	450	435.03



GRAPH 4.3 PISTON WITH COATED MATERIAL AS TITANIUM ALLOY VARIATIONS

TABLE 4.4 PISTON WITH COATED MATERIAL AS NIMONIC ALLOY VARIATIONS

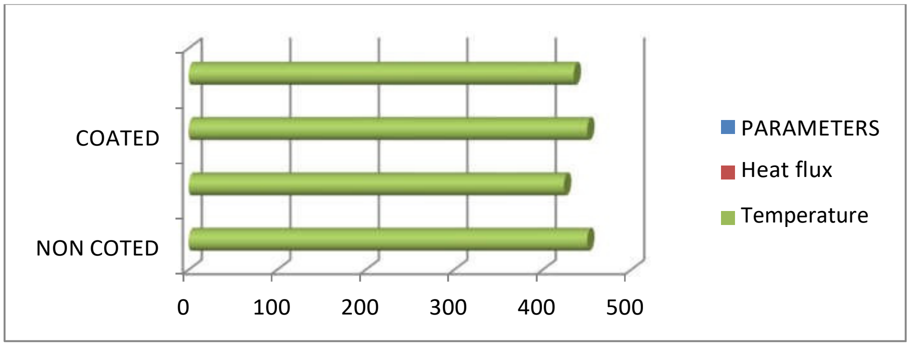
PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE
Heat flux	0.086763	7.7115e-6
Temperature	450	432.48



GRAPH 4.4 PISTON WITH COATED MATERIAL AS NIMONIC ALLOY VARIATIONS

TABLE 4.5 COMPARISON OF PISTON WITH NON COATED TITANIUM ALLOY AND COATED TITANIUM ALLOY

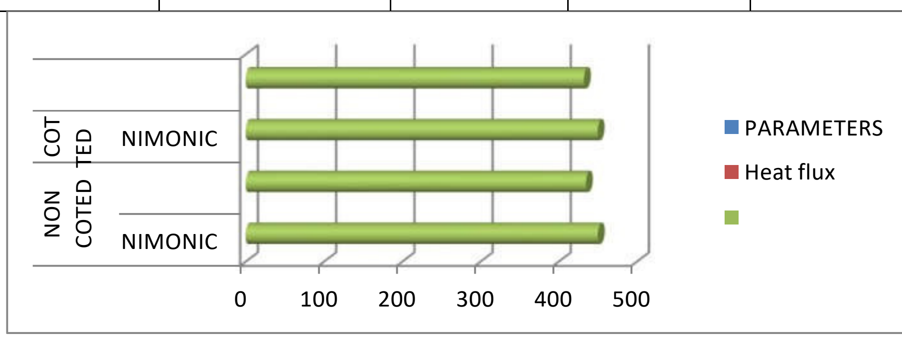
	NON COTED TITANIUM		COATED TITANIUM	
PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE	MAXIMUM VALUE	MINIMUM VALUE
Heat flux	0.22333	1.0563e-7	0.2904	7.536E-6
Temperature	450	424.01	450	435.03



Graph 4.5 comparison of piston with non coated titanium alloy and coated titanium alloy

Table 4.6 comparison of piston with non coated nimonic alloy and coated nimonic alloy

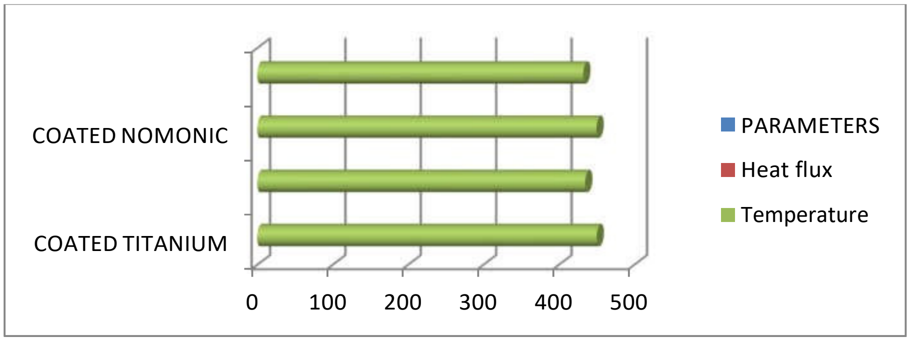
	NON COTED NIMONIC		COTTED NIMONIC	
PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE	MAXIMUM VALUE	MINIMUM VALUE
Heat flux	0.2904	7.536E-6	0.086763	7.7115e-6
Temperature	450	435.03	450	432.48



Graph 4.6comparison of piston with non coated nimonic alloy and coated nimonic alloy

Table 4.7 comparison of piston with coated titanium alloy and coated nimonic alloy

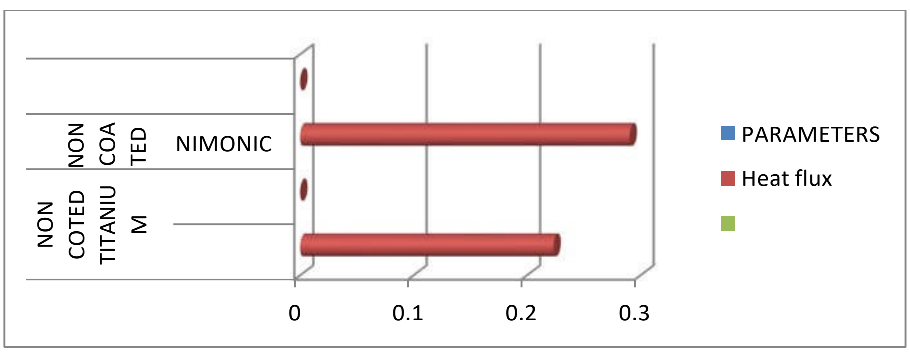
	COATED TITANIUM		COATED NOMONIC	
PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE	MAXIMUM VALUE	MINIMUM VALUE
Heat flux	0.2904	7.536E-6	0.086763	7.7115e-6
Temperature	450	435.03	450	432.48



GRAPH 4.7 Comparison of piston with coated titanium alloy and coated nimonic alloy variations

TABLE 4.8 COMPARISON OF PISTON WITH NON COATED TITANIUM ALLOY AND NON COATED NIMONIC ALLOY

	NON COTED TITANIUM		NON COATED NIMONIC	
PARAMETERS	MAXIMUM VALUE	MINIMUM VALUE	MAXIMUM VALUE	MINIMUM VALUE
Heat flux	0.22333	1.0563e-7	0.2904	7.536E-6
Temperature	450	424.01	450	435.03



GRAPH 4.8 Comparison of piston with non coated titanium alloy and non coated nimonic alloy

DISCUSSIONS:

It is observed that the titanium alloy which is coated has a better performance results as compared to coated Nimonic alloy as well the non coated titanium alloy is also having the better performance than the non coated Nimonic alloy so here we had observed that

Material	Heat flux maximum($W{\cdot}m^{-2}$	Heat flux minimum	Temperature max	Temperature min

COATED TITANIUM:	0.2904	7.536E-6	450^0c	435.03^0c
NON COATED TITANIUM	0.2233	1.0563e-7	450^0c	435.03
COATED NIMONIC	0.08673	7.7115e-6	450^0c	435.03
NON COATED NIMONIC	0.2904	7.536E-6	450^0c	435.03

Conclusion

The combustion, performance parameters and exhaust emissions were investigated experimentally in two different TBC LHRE diesel engines. The following were main conclusions drawn: i. The specific fuel consumption is reduced by 20.58% and11.60% at full load condition in Titanium and Nimonic alloy coated CI and YSZ coated CI engine respectively. ii. Heat flux increase by 26.13% and 13.23% in Titanium and Nimonic alloy coated CI and Titanium and Nimonic coated CI engine respectively. iii. The 10.50% and 5.26% higher peak cylinder pressure produce in Titanium and Nimonic alloy coated CI and YSZ coated CI engine respectively. The better combustion characterizes found in Titanium and Nimonic alloy coated CI engine. iv. Heat used in brake power of CI engines are better than the base engine. The heat lost in exhaust gas and heat lost in cooling water was found more in CI engine than the base engine. Heat loss as an unaccounted was reduced by 55% in LHRE engine. After all heat balance sheet improved in CI engines. v. CO, HC, smoke density level reduced and NOx level found higher in CI engine. vi. Noise level was found satisfactory in both type of CI engines. vii. Comparatively Titanium and Nimonic alloy coated CI engine found better combustion, performance and exhaust emissions.

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