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THE STUDY OF TEMPERATURE DISTRIBUTION ON A CYLINDER OF SUZUKI 250GSX ENGINE FUELED WITH GASOLINE BLENDS USING FINITE ELEMENT ANALYSIS

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ABSTRACT: - The alcohol–gasoline blend fuels nowadays are increasingly used instead of gasoline in automobiles. In the present study, the temperature distribution within the cylinder of Suzuki 250Gsx motor was studied, taking in account the use of gasoline, E10-gasoline and E20-gasoline blends as a fuel, separately. The temperature fields are calculated using ANSYS 11 software. The geometric model and dimensions of the cylinder was established using Solid work 2003 program then imported by ANSYS11. After applying the boundary conditions and taking the assumptions in account, the results illustrated that the interchange of gasoline by E10-gasoline and or E20-gasoline blends has a variety of thermal load on the cylinder. Where the temperature distributed decreasingly towards the axial and radial directions. In addition, the engine becomes colder as the ethanol percentage in the fuel been 20%. This may provide supporting information for new designs for using E10-gasoline and or E20-gasoline blends on SI engines so that not to effect the engine operation and lubricating oil performance.

Keywords: E10-gasoline blend, E20-gasoline blend, temperature distribution, SI engine cylinder, ANSYS11.

INTRODUCTION

The temperature distribution within an SI engine is extremely important for proper engine operation to maximize the thermal efficiency of an engine; it has to be operated at specific thermal condition (1) . This condition is controlled by cooling process that tends to remove the heat that is highly critical in keeping an engine and engine lubricant from thermal failure and thermal effects.

However, many researchers studied the temperature field within engine. P. Gustof had studied the temperature distribution in wet cylinder sleeve in initial phase of the work of turbo diesel engine [2]. H. Hai- qiang et.al had calculated the stress and displacement distribution of cylinder liner of YZ4105 diesel engine under the function of heat-coupled structure [3]. W. Zeng and his group had discussed the temperature fields of the piston for burning diesel and Dimethyl Ether in a diesel engine [4]. All The mentioned studies were carried out using finite element analysis (FEA).

While, the present study deals with the temperature distribution generated in a SI engine cylinder SUZKI 250GSX as a result of using E0-gasoline (100%gasoline+0%ethanol), E10-gasoline (90%gasoline+10%Ethanol) and E20-gasoline (80%gasoline+20%Ethanol) blends as fuels, the temperature fields was obtained by finite element analysis using ANSYS11. The specifications of the engine are given in table (1).

MATHEMATICAL RELATION

The temperature distribution with in the cylinder is deduced from the energy conservation law. In which it may give the general heat conduction equation in cylindrical coordinate as [5,6].

$$\frac{1}{r}\frac{\partial}{\partial r}\left(kr\frac{\partial T}{\partial r}\right)+\frac{1}{r^2}\frac{\partial}{\partial \phi}\left(kr\frac{\partial T}{\partial \phi}\right)+\frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right)=\rho C\frac{\partial T}{\partial t} \text{.................(1)}$$

Where r, z and Φ are the coordinates in the radial, axial and angular directions, respectively; T is the wall temperature; k is the thermal conductivity (may be temperature dependent); C is the specific heat of the wall; ρ is the density of the wall and t is the time. For the steady state operation the right side of equation (1) will be equal to zero.

A numerical method that may be used to solve the above equation is crank–Nicolson method which is an implicit and accurate method [7].

The heat flux by conduction is given by [8]:

$$q=-k\nabla T \text{..............(2)}$$

While by convection is given by:

$$q=h\Delta T \text{..............(3)}$$

Where ∇T is temperature gradient in the wall, ΔT is temperature difference between the wall and surrounding fluid and h is heat transfer coefficient which may be obtained using Woschni heat transfer model [3].

THE FINITE ELEMENT MODEL FEM

1. Geometric Model.

A 3-D geometric model of the cylinder was built using solid work 2003 program and then imported by ANSYS11.

The cross section of the model is shown in figure (1). The geometric model represents the actual structure of the cylinder which builds a solid base for satisfactory finite element analysis FEA.

2. Mesh generation

The generation of fine mesh will be helpful to obtain accurate results. The smaller the cell, the higher the accuracy, but longer calculation time needed. Anyway, the cell size may be modified according to the specific conditions. Taking in account to minimize the cell size where ever the shape is complicated or the temperature have high gradient [(4)]. This is useful method to improve the accuracy without increasing the number of cells and nodes.

Figure (2) shows the mesh (the finite element model) generated for the cylinder. Non-structured cells solid 70 which is triangular shape were used to describe the cylinder and the total number of nodes is 165367.

3. The Physical Properties

The Physical Properties is an important parameter that may effects the results. Some of the Properties may be considered to be temperature dependent if its value changes vastly with temperature. Anyway, the material of the cylinder is cast iron with the following physical properties. [(6)]

Density (ρ) = 7833 kg/m^3.

Specific heat= 0.46 kJ/kg. C°.

Thermal conductivity (k) = 50 W/m. C°.

BOUNDARY CONDITION AND FEA

In finite element analysis (FEA) the objects (cylinder in this study) are always subdivided in to limited number of elements to have temperature field analysis. These elements are joint to each other by nodes. Determination of the temperature at each node will provide the temperature distribution. More realistic temperature is obtainable if reasonable boundary conditions of heat transfer were applied.

Temperatures of 185C°, 172C° and 165 C° are specified on the cylinder wall at the region of the fuel combustion for the cases of E0-gasoline, E10-gasoline and E20-gasoline mixtures respectively. These temperatures are specified based on the typical temperature distribution for SI engine during steady state operation [(1)]. The difference in the temperature of the fuels is due to the dissimilarity in the heating value of the fuels, as in [(9)] table (2). These conditions are valid for engines working at 2000 r.p.m [(1)].

While at the outside (the fin side) a convection heat transfer were supposed with heat transfer coefficient of 75 $w/m^2.k$ [6] . The temperature of the ambient was considered to be at 20C°.

The following conditions are assumed:

- Steady state operation.
- The temperature of the surrounding air do not change significantly.
- Constant heat transfer coefficient is considered at the air side.
- The heat generation is neglected.
- Loads are constant.
- Most of physical properties are constant.

RESULTS AND DISCUSSION

The finite element analysis commences by importing the geometric model of the cylinder assembles by ANSYS 11 then the boundary conditions will be loaded for a corresponding fuel. The results from the thermal analysis are demonstrated as temperature contour for the use of the three (E0, E10, E20)-gasoline blends and given in figures (3, 4 and 5).

It's clear from the figures that the temperature distribution for the all fuels have relatively the same behavior, but are different at specific points. The highest temperature for the all cases are locate at the inner wall of the top cylinder assemble. In which it was 185 C°, 172C° and 165 C° for E0-gasoline, E10-gasoline and E10-gasoline respectively. This is due to the chilling effect, where combustion of the fuels occur at the top part of the cylinder then the hot gases will expand to the bottom part as the piston of the engine moves down. As a result the temperature decreases along the cylinder axis from the top to the bottom, where it reaches at the lowest point of the cylinder to 130C°, 125C° and 120 C° for E0, E10 and E20-gasoline blends respectively, this is because of the reason that the cooling fins around the combustion chamber are transferring most the heat to the environment in the sense that it is the shortest path for the heat to travel. While the below part of the cylinder assembly have lower temperature as the heat was conducting away when it flow in the solid. This provides the utility of preserving the engine lubricant from thermal effects.

Figures (6-11) shows the plot of the local temperature across the cylinder including cooling fins. Figures (6, 8 and 10) give the temperature distribution in axial direction within cylinder assemble for the three cases of gasoline blend fuels. The figures illustrate that the temperature distribution is slightly linear. Which means that there is approximately constant heat flux through the cylinder downward. With a bit nonlinearity at the above region for the reason discussed formerly. In addition, it can be observe from the figures (6, 8 and 10) that the temperature gradient is going to be more steeper as increasing the ratio of ethanol in the fuel mixture.

While the figures (7, 9 and 11) give the temperature distribution in radial direction for (E0, E10 and E20) gasoline blends. It’s clear from the figures that there is higher variation in temperature drop in radial direction more than axial direction. This may be because of the geometry of the cylinder and the effect of the fins to dissipate heat to the surrounding air with presence of convection heat transfer. The temperature distribution is affected by two parameters, the first is the distance between the body and the center of the ignition of the fuel while the other is the exposure of the body to cooling by the fins.

CONCLUSION

We can conclude the following:

1. The temperature of the cylinder assembly for the all gasoline blends decrease along the axis from top to bottom.
2. The temperature decreases from combustion chamber wall towards the edge of the fins as well.
3. Besides the higher decrease in the cylinder temperature by increasing the ethanol ratio in the mixture. The increase of temperature drop in the cylinder wall and increasing the rate of heat transfer to more than the required quantity is not desirable for engines. In which can cause to decrease the efficiency of the engine.

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Table (1): specification of the engine.

Type	Suzki 250Gsx motor
Engine volume	250 cm^3
No. of cylinder	4
Ignition system	Spark
Max. speed	18000 rpm
Fuel system	Injection
Lubrication	pump
Max. speed	190 km/hr
No. of stroke	4
Compression ratio	9:1

Table (2): heat of combustion of the fuels [9]

Fuel	Heat of combustion (BUT/gallon)
Gasoline	117000
E10-gasoline	112900
E20-gasoline	109000

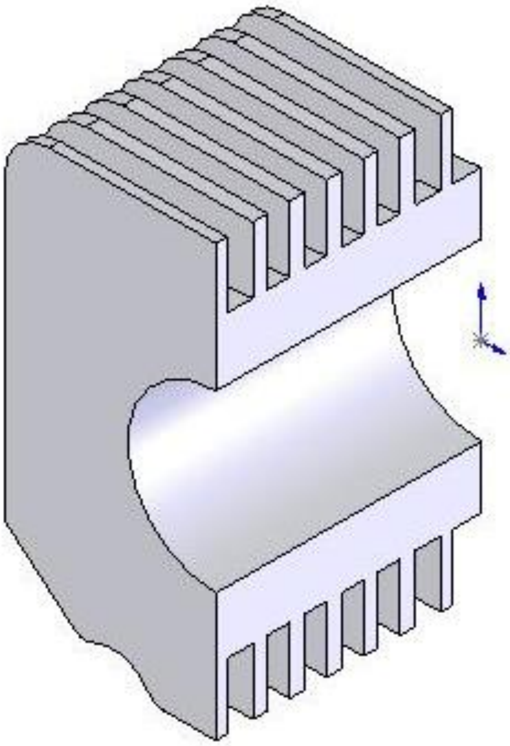

Figure (1): the cross section of the cylinder and fins geometric model.

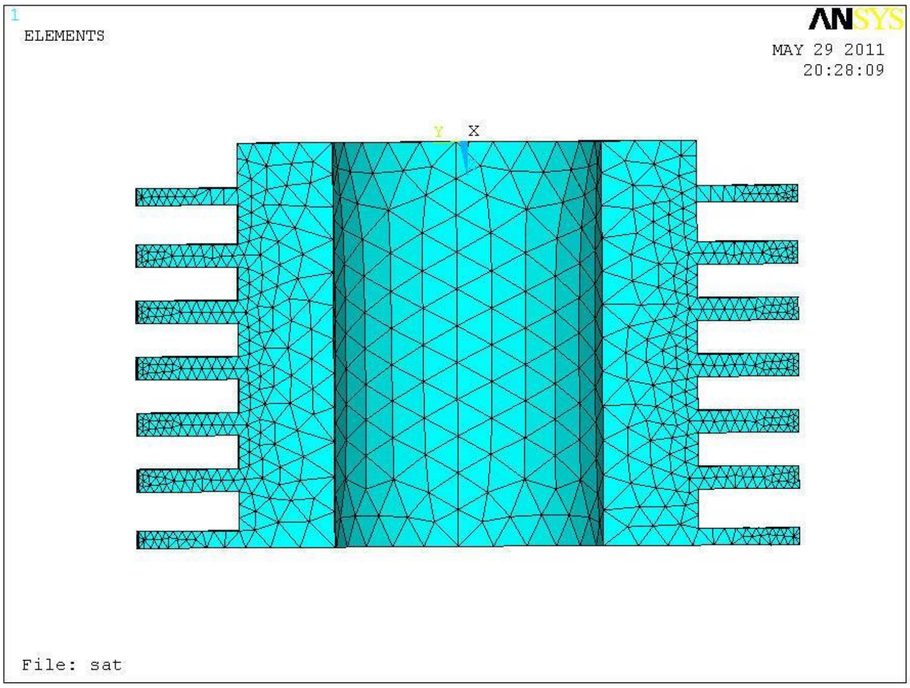

Figure (2): the mesh model generated for the cylinder (cross section).

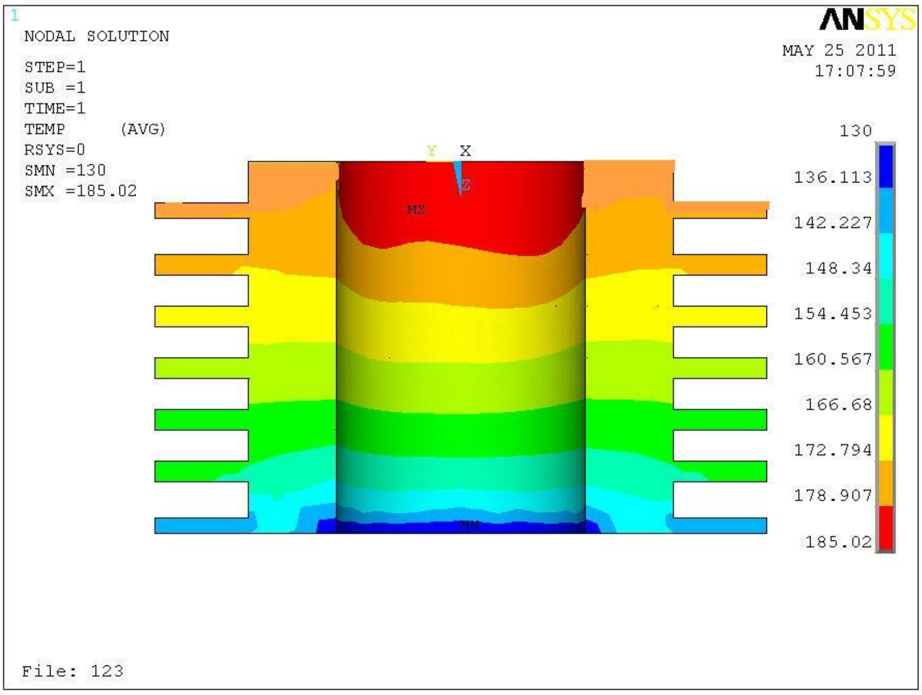

Figure (3): the contour temperature distribution for E0-gasoline fuel.

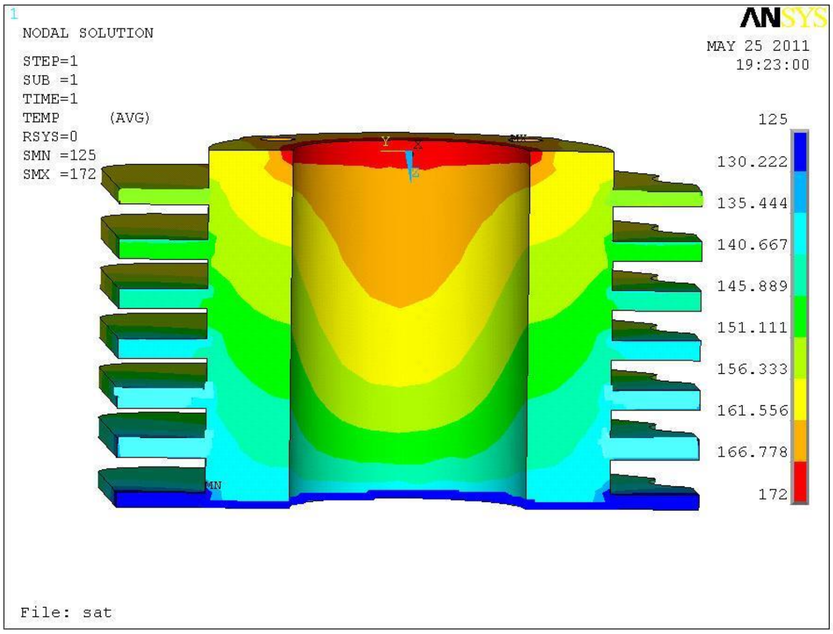

Figure (4): the contour temperature distribution for E10-gasoline blend.

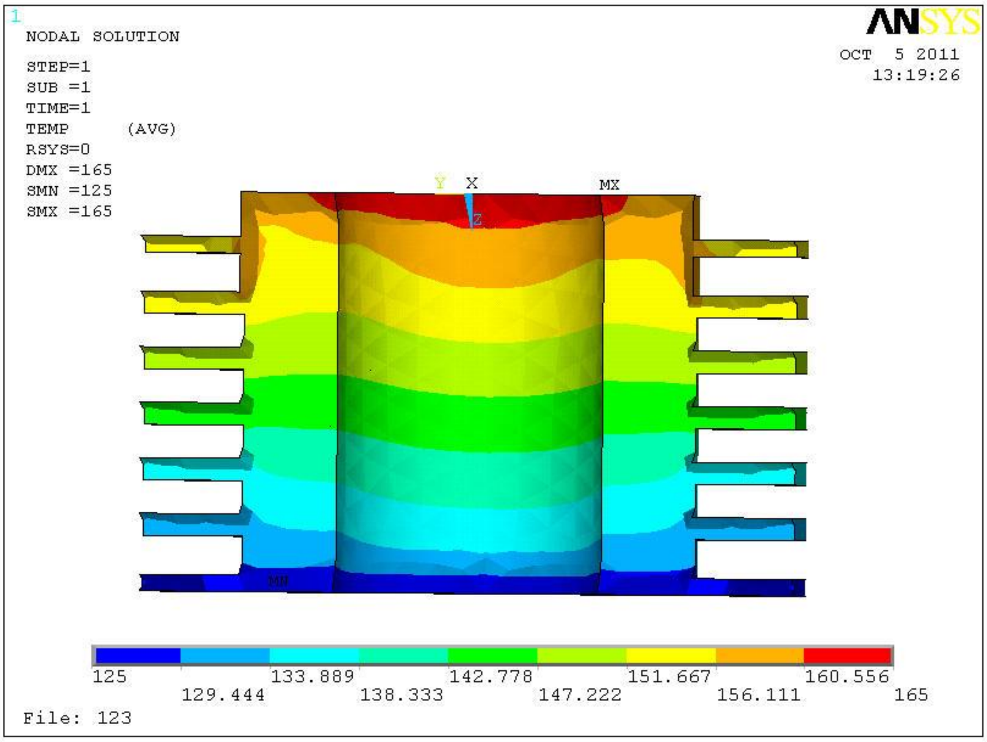

Figure (5): the contour temperature distribution for E20-gasoline blend.

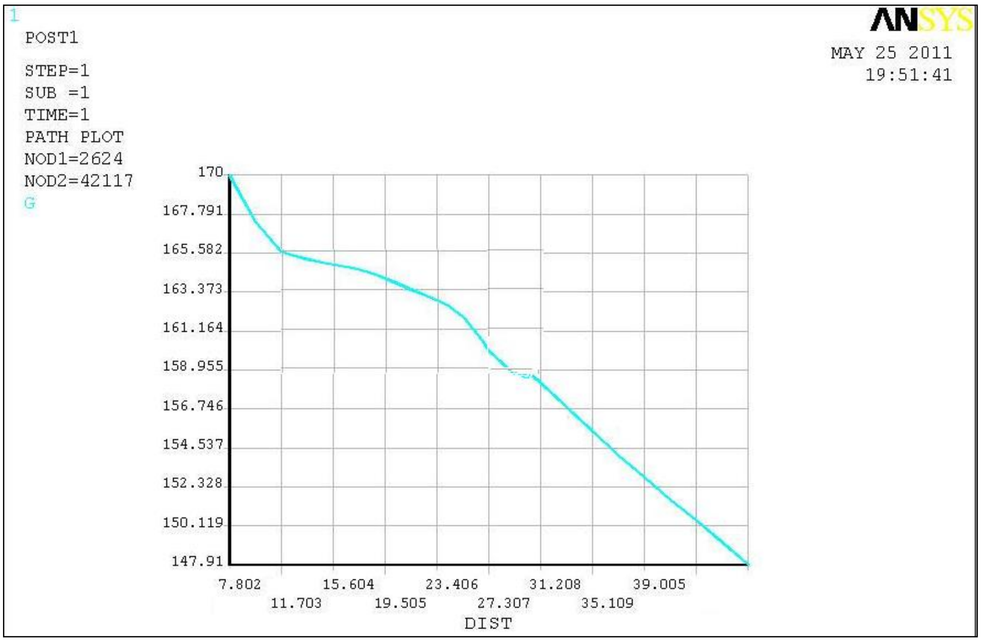

Figure (6): Temperature distribution in axial direction of the cylinder for E0-gasoline fuel.

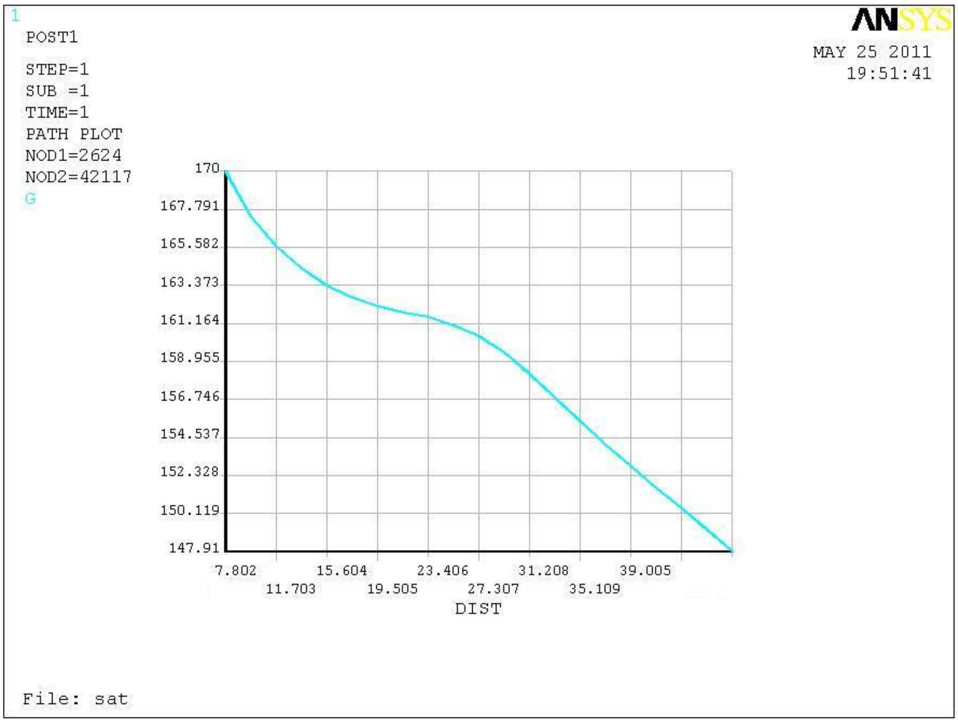

Figure (7): Temperature distribution in radial direction of the cylinder for E0-gasoline fuel.

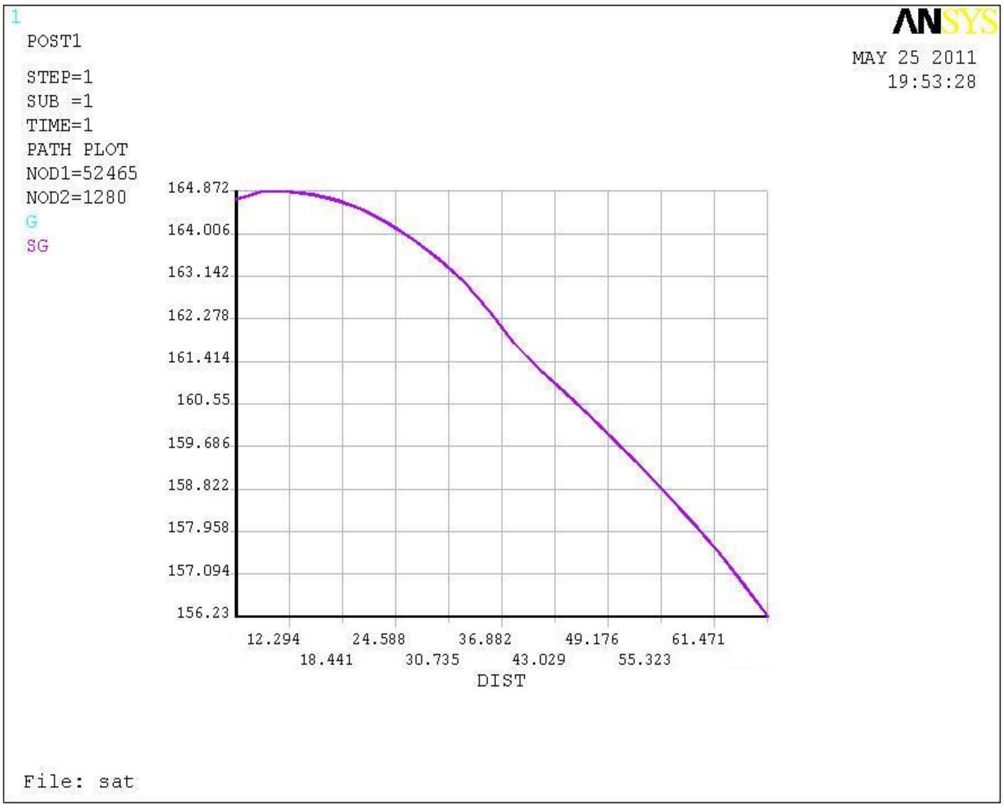

Figure (8): Temperature distribution in axial direction of the cylinder for E10-gasoline blend.

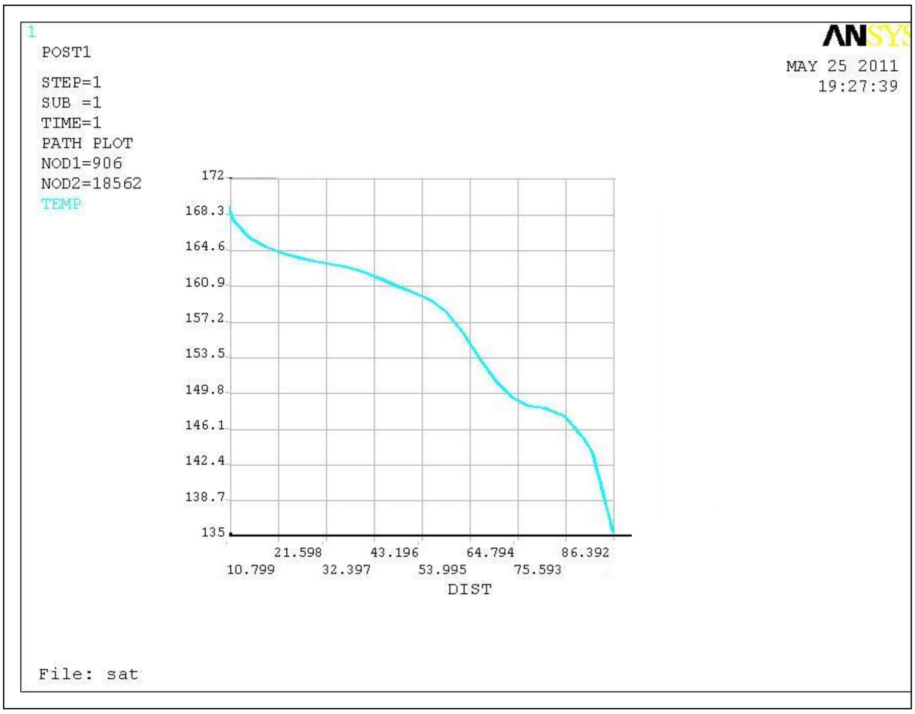

Figure (9): Temperature distribution in radial direction of the cylinder for E10-gasoline blend.

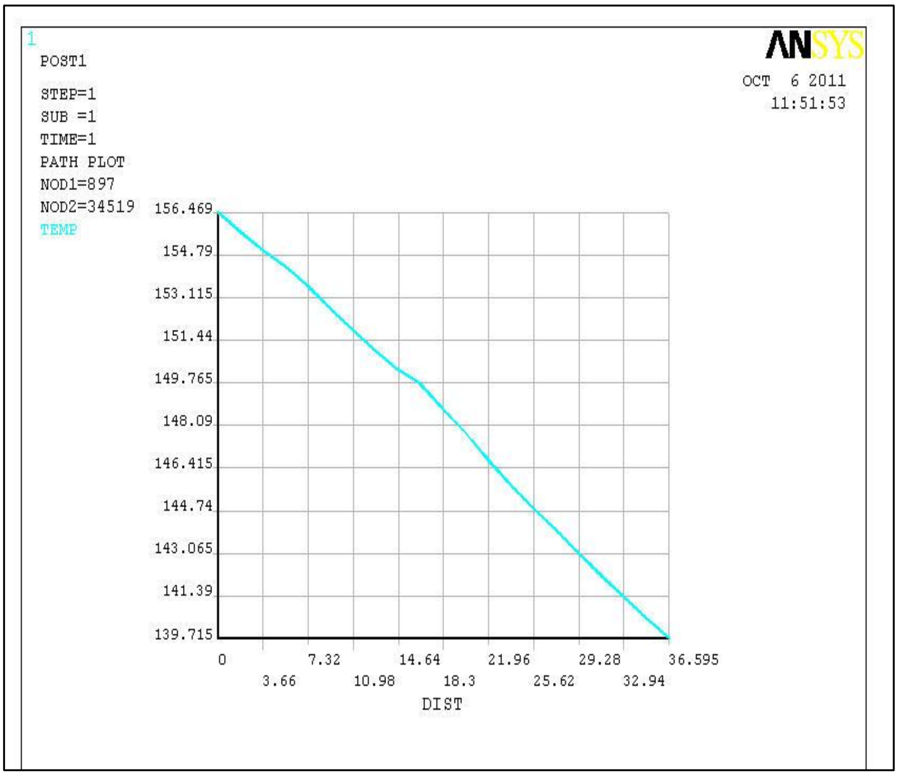

Figure (10): Temperature distribution in axial direction of the cylinder for E20-gasoline blend.

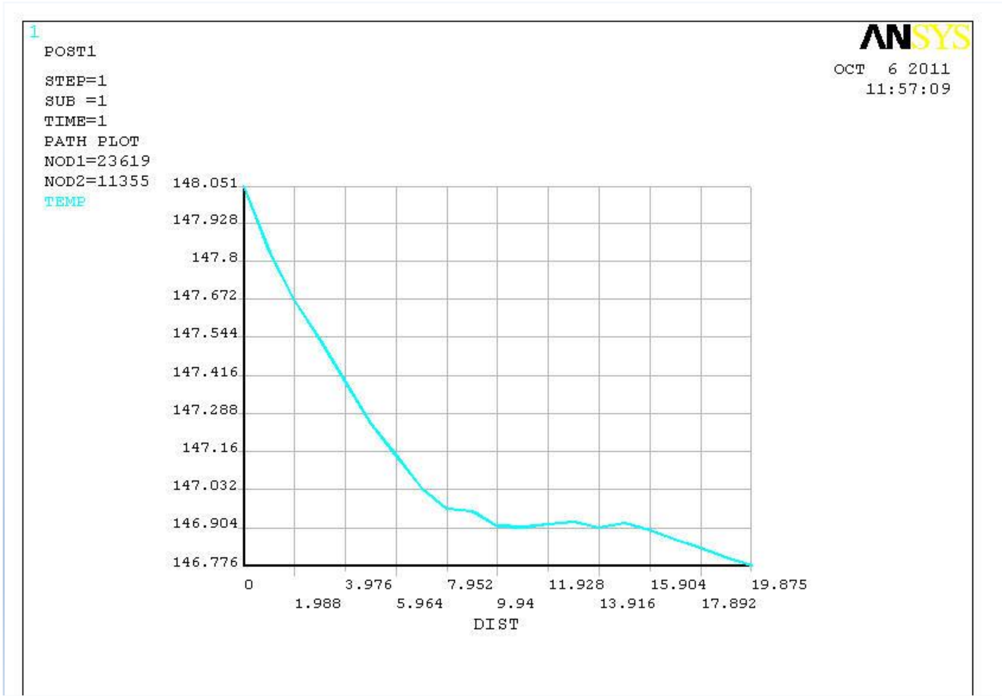

Figure (11): Temperature distribution in radial direction of the cylinder for E20-gasoline blend.

دراسة حول توزيع درجة الحرارة على اسطوانة محرك سوزوكي 250Gsx باستخدام الكازولين الممزوج بالايثانول

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الخلاصة:

يستخدم في الوقت الراهن الكازولين الممزوج بالايثانول كوقود بديل عن الكازولين الصافي. في هذه الورقة البحثية تم دراسة توزيع درجة الحرارة على اسطوانة محرك سوزوكي 250Gsx الناتج من استخدام الكازولين الصافي ومزيج الكازولين والايثانول بنسب 10% و20% كوقود. حيث تم ايجاد توزيع درجة الحرارة باستخدام برنامج ANSYS 11. وقد تم رسم الاسطوانة بأبعادها الحقيقية بواسطة برنامج Solidwork 2003 وثم نقل الى برنامج ANSYS 11. وبعد تسليط الشروط الحدية وأخذ الافتراضات بنظر الاعتبار وجد ان تبديل وقود الكازولين مع خليط الكازولين والايثانول بنسب 10% و 20% يغير الحمل الحراري على اسطوانة المحرك. حيث ان درجة الحرارة توزعت بالتناقص محوريا وقطريا. هذا بالاضافة الى ان المحرك يميل الى البرودة في حال استخدام خليط ايثانول 20%. مما يساهم في توفير معلومات لوضع تصاميم جديدة لمحركات تعمل على وقود خليط الكازولين والايثانول 10% و20% من دون ان يؤثر كفاءة واداء المحرك وزيت التزييت.

الكلمات الدالة: خليط الكازولين والايثانول 10% و 20% , توزيع درجة الحرارة , محرك احتراق داخلي , ANSYS 11