• By making construction on smaller divisions, it will be much easier to focus on that part, and consequently it will take less time to complete.
• If this stepwise method is used, bus schedules need to be oriented according to this new situation. In this way both the number of buses and the distance that buses take will be reduced.

4. CONCLUSION

With respect to current general quality of the suburban rail network of Istanbul, modernization is obligatory. In addition, during construction process, transportation network should be analyzed and modified to serve in a more efficient way. It is necessary to cover the additional passenger load on the network. In this study we proposed some alternatives which are analyzed without reliable data. Obviously, to perform a more precise analysis accurate data is prerequisite. We believe transportation planning should always be one step further from the present conditions with a dynamic, integrated and human oriented approach.

REFERENCES


Increasing Of Energy Efficiency In The Diesel Engine Using Functionally Graded Materials (FGMS)

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1- ABSTRACT

In the internal combustion engines, the high-energy efficiency can be achieved by using materials with low thermal conductivity as the cylinder in combustion chambers. One of the development trends for heat engines is improvement of their energy efficiency. In this paper, the application of cylinder made of Functionally Graded Material (FGM) is developed. FGMs are new kind of materials which thermal resistant and mechanical strength can be considered together for them. The thermal conductivity is studied in the functionally graded cylinders. Functionally using multilayer theory that each sub-cylinder is assumed as an isotropic layer. Functionally graded properties are resulted by suitable arrangement of layers in a multilayer cylinder. Some results have survived for a typical locomotive diesel engine and finally, the heat conduction and temperature distribution are calculated and the results are compared between various engine loads and speed condition for a FGM cylinder and other existing cylinders for a typical diesel engine.

2- INTRODUCTION

A new trend in the field of internal combustion engines is to insulate the heat transfer surfaces as a combustion chamber, cylinder wall, cylinders head, piston and valves by ceramic insulating materials for the improvement of engine performance and elimination of the cooling system. Engelhard Corporation has published results of using ceramic coating for cylinder head and piston crown in an EMD 16V645E3B diesel engine, which is used in GT26CW locomotives. These results show [1]:
- Improve fuel economy by 1.1% (Notch 8) to 6.7% (Notch 5).
- Reduce NOx emissions by 3.15%.
- Reduce CO emissions by 50-90%.
- Reduce carbon monoxide and hydrocarbon emissions.
- Reduce total particulate matter.
There are many researches which present the advantages of the isolated surfaces applications in internal combustion engines [2]. Kamo and Bazyk [3, 4] have achieved a major breakthrough in diesel engine technology. Because of their pioneering efforts in the area of adiabatic engine technology, many governments, industries and academic sources worldwide have begun to work in this area. The coatings of insulation materials used in the low heat rejection (LHR) engine must have a high temperature strength, high expansion coefficient, low friction characteristics, good thermal shock resistance, lightweight and durability [5]. Kamo and Bazyk used thermally insulating materials such as silicon nitride for insulating different surfaces of the combustion chamber. An improvement of 1.7% in the performance was observed [4]. Sekar and Kamo [6] developed an adiabatic engine for passenger cars and reported an improvement in the performance to the maximum extent of 12%. The experimental results of Morel et al. [7] indicate that the higher temperatures of the insulated engine cause reduction in the in-cylinder heat rejection, which is in accordance with the conventional knowledge of convective heat transfer. Woschei et al. [8] state that 5% of the input fuel energy can not be accounted for, which is of the order of the expected improvements. Havstav et al. [9] developed a semi-adiabatic diesel engine and reported an improvement ranging from 5 to 15% in BTE, about 10% reduction in the in-cylinder heat rejection. Prasad et al. [5] used thermally insulating material, namely partially stabilized zirconia (PSZ), on the piston crown face and reported a 19% reduction in heat loss through the piston.

Although nowadays the usage of Thermal Barrier Coatings (TBCs) are so common in diesel engines liner, it is known that the lifetime of thermal barrier coatings (TBCs) is limited by two basic failure mechanisms, thermal expansion mismatch between bond coat and top coat and oxidation of the bond coat. One solution for this problem is application of Functionally Graded Materials as cylinder liner.

Functionally graded materials (FGMs) are new advanced heat resistant materials that are used in modern technologies as advanced structures. In addition to superior heat properties, they are corrosion and erosion resistant and have high fracture toughness. The basic concept is to mix the ceramic and metal such that the material properties continuously vary from one constituent material to the other. In effect, the governing equations for the temperature and stress distributions are coordinate dependent, as the material properties are functions of position. Hosseini et al. [10] carried out the determination of temperature distribution in functionally graded thick ceramic coated cylinder using analytical method. The comparisons between temperature distributions for various mechanical properties were presented in their work.

In this article, the transient heat loss to cooling system, maximum surface temperature and wall temperature swing are analyzed for a Functionally Graded Cylinder (FGC) in a Low Heat Rejection (LHR) DI diesel engine. The cylinder has assumed in plain strain condition and the material properties of functionally graded cylinder have considered as a nonlinear power function. To solve heat transfer equation in a non-homogeneous material such as FGMs, wall thickness is divided to many sub-cylinders, whose mechanical properties are constant in each layer. Skalzer et al. [11] successfully used this method for dynamic analysis of functionally graded thick hollow cylinders.

Finally, the comparison between results for various candidate materials of cylinder liner such as 6024-N, DGC, Cr2303 for thermal barrier coating and FGM are presented in different engine load and speed conditions.
\[
\int_0^T \frac{dN}{d\eta} \left( \frac{\partial T}{\partial \eta} + \frac{\partial T}{\partial \eta} \right) - \rho C \frac{dN}{d\eta} T \left[ \frac{\partial}{\partial \eta} \right]^2 \left. \frac{dN}{d\eta} \right|_{\eta=0} = 0
\] (5)

\[
\int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} = \left[ \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \right]_{\eta=0} \left[ \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \right]_{\eta=0}
\] (6)

\[
\int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} = \left[ \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \right]_{\eta=0} \left[ \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \right]_{\eta=0}
\] (7)

\[
\int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} = \left[ \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \right]_{\eta=0} \left[ \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \right]_{\eta=0}
\] (8)

By substitution equations 6, 7 and 8 into equation 5 and simplifying we have

\[
K \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \left. \right|_{\eta=0} + \rho C \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \left. \right|_{\eta=0} = \frac{K}{\rho C} \frac{dN}{d\eta} \left. \right|_{\eta=0}
\] (9)

Which

\[
[C] = \rho C \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \left. \right|_{\eta=0} + \rho C \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \left. \right|_{\eta=0}
\] (10)

\[
[K] = K \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \left. \right|_{\eta=0} + K \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \left. \right|_{\eta=0}
\] (11)

\[
L(\eta) = K \int_0^T \frac{dN}{d\eta} \frac{\partial T}{\partial \eta} \left. \right|_{\eta=0}
\] (12)

Equation 10 gives temperature distribution in cylinder wall. In FGM cylinder mechanical properties varies in radial direction with a specific volume fraction. Mechanical properties in FGM cylinder are assumed as follows:

\[
P = P_c + \left( \rho m - P_c \right) \left( \frac{\rho r - \rho_0}{\rho} \right)^n
\] (13)

where "P" is material property, "n" is a non-negative volume fraction exponent and subscripts

\[
T, \delta, \rho, \rho_0, \rho m
\]
5. NUMERICAL RESULTS AND DISCUSSIONS

The temperature distribution and heat transfer rate are calculated in three engine speed 1500, 2000 and 2500 rpm for various loads such as 20%, 40% and 60% of full engine load.

Figures 2, 3 and 4 display the transient temperature fluctuation at different points of the wall thickness of cylinder liner for 40% of full load at the speed of 1500 rpm for cast iron liner, PSZ ceramic liner and FGM cylinder respectively. It can be concluded that in FGM cylinder, wall surface temperature swing increased compared with metal and ceramic cylinder, whereas the corresponding temperature swing inside the wall, significantly reduced compared with two mentioned cases.

Figure 4 shows in the case of FGM cylinder, when the depth exceeds about 0.6 mm an obvious transient temperature can hardly be seen. In the other hand, this means the heat conduction over this depth obeys a kind of pseudo steady rate.

Figure 5 depicts the heat transfer absorbed or rejected against crank angle, for the case of 40% of full load at speed of 2000 rpm for cast iron liner and FGM cylinder. The area under these curves representing the associated heats. The heat flows in and out of the body periodically, because of the temperature difference between gas and wall surface become sometimes positive and other times negative due to their phasing. It can clearly be seen that in FGM cylinder the rate of heat transfer reduced compared with a metallic cylinder.

Figure 6 shows the total heat loss to coolant water for different candidate materials at the speed of 1500 rpm and different operation loads within 10 minutes after engine operation under cold start. By using FGM cylinder with different volume fraction, one can obtain 25-40% decrease in heat loss compared with cast iron cylinder at the speed of 1500 rpm, 41-61% at 2000 rpm and 59-68% at 2500 rpm whereas at the same condition, Cr203 coating can reduce heat release up to 9.5% at 1500, 17% at 2000 and 22% at 2500 speed. Data for percentage of heat loss reduction for different materials is listed in table 2.

Figure 7 indicates the maximum wall surface temperature for candidate materials at 1500 rpm and various loads. It is clear that maximum and minimum surface temperature is subjected to ceramic and cast iron cylinder respectively. In the FGM cases, cylinder wall temperature is located between these two cases.
Figure 6, Total heat loss at 1500 rpm and different loads at 10 minutes after cold starting.

Figure 7, Maximum wall surface temperature at 1500 rpm and different loads.

Figure 8 represents the percentage of heat loss reduction for various candidate liner materials compared with cast iron in the case of 60% of full load at different engine speed.

Table 2, Percentage of heat loss reduction compared with cast iron at different engine load and speed condition:

<table>
<thead>
<tr>
<th>Candidate</th>
<th>1500 rpm</th>
<th>2000 rpm</th>
<th>2500 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Si3N4</td>
<td>7.05</td>
<td>7.12</td>
<td>7.57</td>
</tr>
<tr>
<td>coating</td>
<td>9.56</td>
<td>9.56</td>
<td>10.02</td>
</tr>
<tr>
<td>FGMr=0.5</td>
<td>25.19</td>
<td>28.44</td>
<td>20.66</td>
</tr>
<tr>
<td>FGMr=1</td>
<td>30.75</td>
<td>30.44</td>
<td>31.84</td>
</tr>
<tr>
<td>FGMr=2</td>
<td>35.53</td>
<td>35.96</td>
<td>37.40</td>
</tr>
<tr>
<td>FGMr=3</td>
<td>40.67</td>
<td>41.24</td>
<td>42.87</td>
</tr>
<tr>
<td>FGMr=5</td>
<td>46.09</td>
<td>46.58</td>
<td>48.25</td>
</tr>
<tr>
<td>FGMr=7</td>
<td>51.75</td>
<td>52.10</td>
<td>53.75</td>
</tr>
</tbody>
</table>

6-SUMMARY AND CONCLUSIONS

In this paper, the application of ceramic coating is surveyed in a typical locomotive diesel engine and then heat loss to cooling system and cylinder wall temperature swing are analyzed for a FGM cylinder in a typical D1 diesel engine by using combination of finite element-finite difference method at different load and speed conditions. The results have been compared with various materials of cylinder liner. The conclusions can be outlined as follows:

1- By using FGM cylinder, temperature fluctuations of cylinder wall surface will increase compared with metal and ceramic cylinder, but the corresponding temperature swing inside the wall will significantly reduce compared with two mentioned cases.
2- FGM cylinder can decrease some problem which may occur in the entrance of ceramic and metal in the ceramic-coated engines.
3- FGM cylinder can decrease heat loss to cooling water up to 40% compared with cast iron cylinder at 1500 rpm, 61% at 2000 rpm and 68% at 2500 rpm.
4- The extra exhaust gas energy resulting from insulation may be used to aid engine power via compounding.
5- Using FGM cylinder in diesel engines offers the potential of simplified and lightened cooling systems, which cause reduction in cost and noise level due to downsizing of cooling system.
6- High temperatures on the combustion chamber wall surface due to insulation may cause a drop in volumetric efficiency but increased boost pressure from the turbocharger, can be used to overcome this problem.

7-ACKNOWLEDGEMENTS

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ÖZET
Ultağın inşası insanlık tarzı kadar eskive dayanır. Bu anlamda ullaşının yarattığı etkiler ekonomik kazanç ve gelisme açısından olduğuna kadar toplumsal hayatda etkilerini göstermektedir. Yolların ve araçların gelişmesi, mal ve hizmet dağılımını arttıracak yeni belirli inşaat alanları açıdan bir kültür ve uygulak Dönüşümü sağlayacaktır. Özellikle demiryolu ulaşımları açısından bu tür bir geliştirici bir bölgeli inşaatı beşarılması ama aynı zamanda ulaşım modları birbirini ekonomik birlik olarak toplamaları ve tasarlamaları bir araya getirip, geliştirerek en doğru ve sürdürülebilir bir hale getirilmesi.

Bu anlamda arık tônlünde ullaşının sistemlerinin hızlandırılması önemlidir. Bu durumdan bir hali ne gelemiş.

Ulaşak rehabet edilecek bir raylı sistem düşülu bizi TGV, Shinkansen vb. gibi teknolojiyi öne tr_attempt etmektedir.

Ölçümüz açısından bu gelişim trendi onsartığına yatkın duruma gelmiştir. Hatta zaman içerisinde temel alışıtları problemlerini bile öncelikle çekilecektir.

70'tü yılların ilk yıllarında ilkbahar geçen bir ülkenin hizlı treni tarihi için bazı sırlarını da ortaya ıbet alacak doş disagreements bu konuda olarak Yardımıza olmuştur.

Ankara-İstanbul Fast Train Construction

SUMMARY
The history of transportation goes as far as the history of humanity. In this manner, the effects of transportation show themselves in social life as well as economical development. Development of roads and vehicles increases goods and services' circulation and reduces

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