- 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.

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Uluslararası Demiryolu Sempkzyumu | International Railway Symposium

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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 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, cylinder 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 black smoke 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 Bryzik [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 Bryzik used thermally insulating materials such as silicon nitride for insulating different surfaces of the combustion chamber. An improvement of 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. Woschni 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. Havstad et al. [9] developed a semi-adiabatic diesel engine and reported an improvement ranging from 5 to 9% in ISFC, about 30% 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 superb heat properties, they are corrosion and erosion resistant and have high fracture resistance. 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 hollow 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 (FGM) 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-homogenous material such as FGMs, wall thickness is divided to many sub-cylinders, whose mechanical properties are constant in each layer. Shakeri 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 Si3N4, PSZ, Cr2O3 for thermal barrier coating and FGM are presented in different engine load and speed conditions.

3- MATHEMATICAL FORMULATION

The heat transfer rates from the burned gas to the walls depend on the instantaneous differences between gas and wall temperatures. For the present study, the following usual assumptions are made concerning wall temperature computation, which were successfully used in [12]:

1- All cylinder surfaces are at a uniform temperature,

2- Heat transfer by conduction through the walls is one-dimensional.

The one-dimensional treatment is justified, since temperature varies much more rapidly in directions perpendicular to the surface. The assumption of one-dimensional heat transfer over the engine cycle is reasonable for engines

In order to calculate the heat transfer rate through a certain location of the combustion chamber wall during a complete engine cycle, the unsteady heat conduction equation must be solved with the appropriate boundary conditions for a hollow cylinder with inner radius of r_i and outer radius of r_o . As mentioned before by using multi-layer composite method, the wall thickness has divided to number of elements which material properties stay constant over each layer. Assuming that heat flow through the surface is one-dimensional, we derive heat transfer equation for a single layer. Since material properties remain constant over a specific layer, constants can readily drop from derivation.

$$\frac{1}{r}\frac{\partial}{\partial r}(Kr\frac{\partial T1}{\partial r}) = \rho C\frac{\partial T}{\partial t} \qquad (1)$$

$$\frac{1}{r}\left[K\frac{\partial T}{\partial r} + Kr\frac{\partial^2 T}{\partial r^2}\right] = \rho C\frac{\partial T}{\partial t} \qquad (2)$$

Where k is the thermal conductivity, r is cylinder radius, ρ and C are the density and the specific heat respectively. In addition, T denotes to the temperature. In order to calculate the heat transfer rate through a certain location of the combustion chamber wall during a complete engine cycle, equation 2 must be solved with the appropriate boundary condition. It is subjected to the boundary condition of the inside wall surface to be exposed to the gas temperature and heat transfer coefficient which vary periodically in time [12]. The temperature on the outer cylinder radius is assumed same as the coolant temperature, which were used in previous works such as [13]. To solve equation 2 the combination of finite element - finite difference method has used, with the aim of backward scheme in time domain. The shape functions for finite element modeling are defined as below.

$$N_j(r) = \frac{r_k - r}{r_k - r_j} = \frac{r_k - r}{l} \qquad N_k(r) = \frac{r - r_j}{r_k - r_j} = \frac{r - r_j}{l} \qquad (3)$$

In the above equation, $N_j(r)$ and $N_k(r)$ are called shape function, l is length of element also r_j and r_k denote to the beginning and end of each element respectively.

$$T = Na^e \qquad \frac{dT}{dr} = \frac{dN}{dr}a^e \qquad \dot{T} = N\dot{a} \qquad (4)$$

Using Galerkin method in each element, we can derive the elements of stiffness matrix.

$$\int_{xj}^{xk} N^T \left\{ \frac{K}{r}\left(\frac{\partial T}{\partial r} + r\frac{\partial^2 T}{\partial r^2} \right) - \rho C \frac{\partial T}{\partial t} \right\} 2\pi r dr = 0 \qquad (5)$$

$$\int_{xj}^{xk} K N^T \frac{\partial T}{\partial r} dr = \left[K \int_{xj}^{xk} N^T \frac{\partial N}{\partial r} dr \right] a^e \qquad (6)$$

$$\int_{xj}^{xk} K N^T r \frac{\partial^2 T}{\partial r^2} dr = K N^T r \frac{\partial T}{\partial r}\Big|_{xj}^{xk} - K \left[\int_{xj}^{xk} \left(N^T + r\frac{\partial N^T}{\partial r} \right) \frac{\partial N}{\partial r} dr \right] a^e \qquad (7)$$

$$\int_{rj}^{rk} \rho C N^T r \frac{\partial T}{\partial t} dr = \left[\rho C \int_{rj}^{rk} N^T r N dr \right] \dot{a}^e \qquad (8)$$

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

$$\underbrace{\left[K \int_{xj}^{xk} r \frac{\partial N^T}{\partial r} \frac{\partial N}{\partial r} dr \right]}_{[K]} a^e + \underbrace{\left[\rho C \int_{xj}^{xk} N^T r N dr \right]}_{[C]} \dot{a}^e = \underbrace{K N^T r \frac{\partial N}{\partial r}\Big|_{xj}^{xk}}_{[f]} \qquad (9)$$

Which

$$[C] = \rho C \int_{xj}^{xk} \begin{bmatrix} \frac{rk-r}{l} \\ \frac{r-rj}{l} \end{bmatrix} r \begin{bmatrix} \frac{rk-r}{l} & \frac{r-rj}{l} \end{bmatrix} dr = \rho C \int_{xj}^{xk} \begin{bmatrix} \frac{r(rk-r)^2}{l^2} & \frac{r(rk-r)(r-rj)}{l^2} \\ \frac{r(r-rj)(rk-r)}{l^2} & \frac{r(r-rj)^2}{l^2} \end{bmatrix} dr = \frac{\rho C l}{12} \begin{bmatrix} 3rj+rk & rj+rk \\ rj+rk & rj+3rk \end{bmatrix} \qquad (10)$$

$$[K] = K \int_{xj}^{xk} r \frac{\partial N^T}{\partial r} \frac{\partial N}{\partial r} dr = K \int_{xj}^{xk} r \begin{bmatrix} \frac{-1}{l} \\ \frac{1}{l} \end{bmatrix} \begin{bmatrix} \frac{-1}{l} & \frac{1}{l} \end{bmatrix} dr = K \int_{xj}^{xk} \begin{bmatrix} \frac{r}{l^2} & \frac{-r}{l^2} \\ \frac{-r}{l^2} & \frac{r}{l^2} \end{bmatrix} dr = \frac{K}{2l} \begin{bmatrix} rj+rk & -rj-rk \\ -rj-rk & rj+rk \end{bmatrix} \qquad (11)$$

$$[f] = K N^T r \frac{\partial T}{\partial r}\Big|_{xj}^{xk} \qquad (12)$$

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:

$$P = Pc + (Pm - Pc) \times \left(\frac{r - ri}{ro - ri}\right)^n \qquad (13)$$

where "P" is material property, "n" is a non-negative volume fraction exponent and subscripts "c" and "m" stand for ceramic and metal, respectively, in the volume fraction of [illegible]

4-EXAMPLE

Engine description

The numerical investigation is been conducted on a single cylinder, Lister LV1, direct injection (DI) diesel engine. It has a cylinder bore of 85.73 mm, a piston stroke of 82.55 mm, a connecting rod length of 148.59 mm, a compression ratio of 18:1, and inlet and exhaust valve diameters of 34.5 and 31.5 mm, respectively. The inlet valve opens 15 _CA before TDC and closes 41 _CA after BDC, while the exhaust valve opens 41 _CA before BDC and closes 15 _CA after TDC. This is a naturally aspirated, water-cooled, four-stroke engine, with a bowl-in-piston combustion chamber. The normal speed range is 1000–3000 rpm. A Bryce–Berger injector with a three-hole nozzle (each hole having a diameter of 0.25 mm) is located in the middle of the combustion chamber head, having an opening pressure of 190 bar [12].

Material properties

There are different cases for construction the cylinder liner. The Material arrangement that used in this article listed in table 1. For cylinder model with thermal barrier coating, the coating contains 0.2 mm topcoat of Cr2O3 and 0.4 mm bond coat of PSZ. The bond coat provides a surface texture to promote adhesion of the top coat and reduce the coefficient of thermal expansion (between the top coat and the metallic substrate. In the FGM cylinder model, the ceramic used in the inner radius is Mg-PSZ and the metal used for outer radius is super alloy NiCrAlY. Four different volume fractions have considered for FGM cylinder. Figure 1 shows the variation of thermal conductivity for each volume fraction.

Table 1, Thermal properties of engine wall insulator liner materials[14]

Material	Partially Stabilized Zirconia	Zirconia	Plasma sprayed Cr_2O_3	NiCrAlY	Silicon nitride	Cast iron (flake graphite)
Bulk density, g/cm^3	5.7	6.0	5.0	5.5	3.2	7.0
Thermal conductivity, W/m.K	3.05	2.9-3.8	2.6	10	20.9	33
Specific heat, KJ/Kg.K	0.450	0.46-0.50	0.59	0.450	0.67	0.5

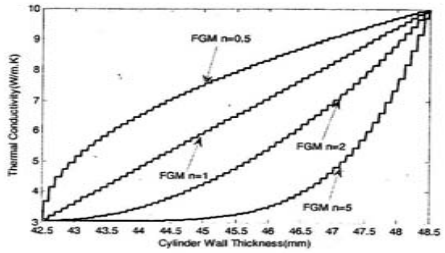

Figure 1, Thermal conductivity variation in cylinder thickness for different volume fraction of FGM cylinder

5-NUMERICAL RESULTS AND DISSCUSSIONS

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.

Figure 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 rule.

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.

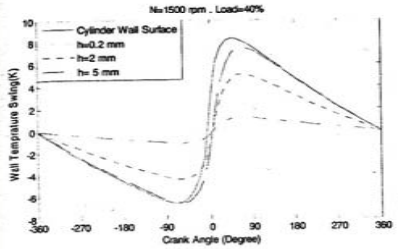

Figure 2, Wall temperature swing against crank angle for cast iron cylinder

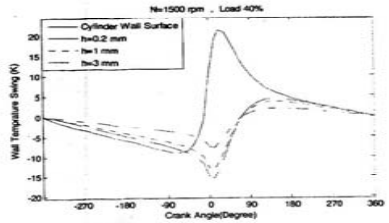

Figure 3, Wall temperature swing against crank angle for ceramic(PSZ) cylinder

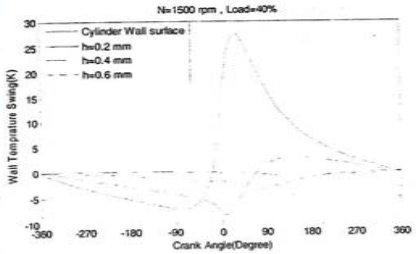

Figure 4, Wall temperature swing against crank angle for FGM(n=2) cylinder

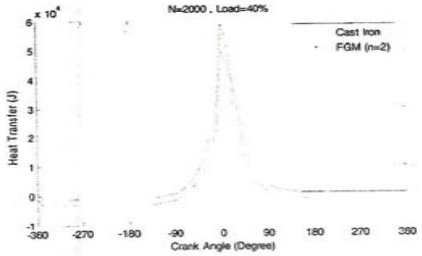

Figure 5, Heat transfer against crank angle in a cast iron and FGM(n=2) cylinder

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 starting. 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 50-68% at 2500 rpm whereas at the same condition, Cr2O3 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.

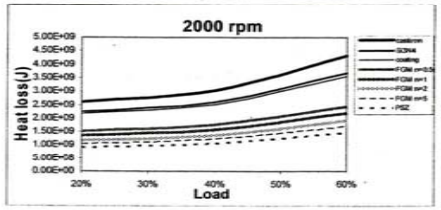

Figure 6,Total heat loss at 1500 rpm and different loads at 10 minutes after cold starting

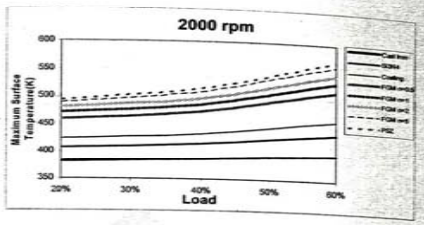

Figure 7, Maximum wall surface temperature at 1500 rpm and different loads

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.

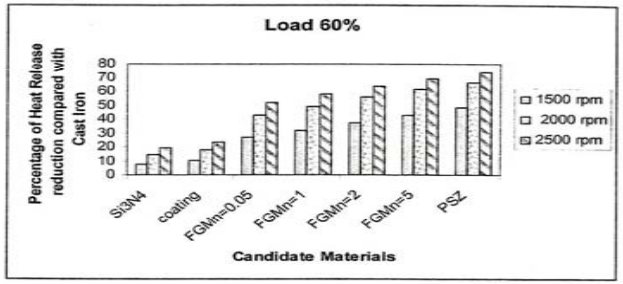

Figure 8, Percentage of heat loss reduction compared with cast iron

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

Candidate Materials	1500 rpm			2000 rpm			2500 rpm		
	20% full load	40% full load	60% full load	20% full load	40% full load	60% full load	20% full load	40% full load	60% full load
Si3N4	7.05	7.12	7.57	13.91	13.98	14.66	19.13	19.25	19.49
coating	9.56	9.56	10.02	17.16	17.18	17.87	22.83	22.90	23.13
FGMn=0.05	25.19	25.44	26.68	41.50	41.66	43.00	50.83	51.05	51.45
FGMn=1	30.15	30.44	31.84	47.74	47.91	49.28	57.12	57.33	57.73
FGMn=2	35.53	35.86	37.40	53.97	54.14	55.51	63.12	63.34	63.72
FGMn=5	40.87	41.24	42.87	59.61	59.79	61.13	68.32	68.53	68.89
PSZ	46.23	46.61	48.28	64.93	65.08	66.31	73.07	73.23	73.53

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 DI diesel engine by using combination of finite element-finite difference method at different load and speed conditions. The results have also compared with various materials of cylinder liner. The conclusions can be outlined as follows:

1- By using FGM cylinder, temperature fluctuation 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 occurred in the interface of ceramic and metal in the ceramic-coated engines.
3- FGM cylinder can decrease heat loss to coolant 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 lighted 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

This research project is supported by the RAI Research Center (Iranian Railway Research Center), which is acknowledged.

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Ankara-İstanbul Hızlı Tren İnşaatı

ÇETİNKAYA Coşkun
Mithatpaşa Cd.Kıvanç Apt.No:56/4 Kızılay/ANKARA

ÖZET

Ulaştırma insanlık tarihi kadar eskiye dayanır. Bu anlamıyla ulaşımın yarattığı etkiler ekonomik kalkınma ve gelişme açısından oldığu kadar toplumsal hayatta da etkilerini göstermektedir. Yolların ve araçların gelişmesi mal ve hizmet dolaşımını artırıp maliyet düşmesini sağlamakla beraber, özellikle demiryolu ulaşımı açısından bir kültür ve uygarlık projesi olarak ta tanımlanabilir. Mesafelerin yakınlaşması, hızı bir metafor olarak toplumsal yaşama sokmuş ve ulaşım sistemleri için güvenli-emniyetli-ucuz tanımlamalarının yanı sıra çabuk-hızlı tanımlamaları da yer almıştır. Dünyanın bir ucundan bir ucuna çabuk gitmek bir ekonomik ihtiyaç olarak tanımlanmaya başlamış ama aynı zamanda ulaşım modları birbirini entegre etmekten ziyade birbiriyle yarışır noktaya gelmiştir. Öyle ki 1900'lü yılların başında 60-70km/saat olan araç hızları 2000'li yıllarda 400 km/saate ulaşmıştır.

Bu anlamda artık günümüzde ulaştırma sistemlerinin hızlandırılması öncelikli hedeflerden biri haline gelmiştir.

Uçakla rekabet edebilecek bir raylı sistem düşü bizi TGV, Shinkansen vb. ileri teknoloji ürünü trenlere getirmiştir.

Ülkemiz açısından bu gelişim trendi olabildiğince yakından izlenilmeye çalışılmıştır. Hatta zaman içerisinde temel altyapı problemlerini bile önceleyecek şekilde...

70'li yılların ilk yarısından itibaren işlemeye başlayan süreç ülkemizi hızlı trenle tanıştırmayı başaramamışsa da ortaya ibret alınacak traji-komik bir öykü çıkarmıştır.

Aslında hızlı trene ilişkin sürecin incelenmesi ülkemiz ulaşımındaki demiryolu payının niçin hızla daraldığını da anlamamıza yardımcı olacaktır.

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