Analysis the Effect of Fatigue Performance of Phosphate Surface Coating on the Cylinder Liner Materials by Using ANOVA and F-Test

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Abstract - ***Cylinder liner plays a vital role in the reciprocating internal combustion engine. Wear of cylinder liner will result in the failure of an engine. Improper carburizing technology leads to decarburization of surface decreases intensely the fatigue strength of surface so that wear initiated from the internal surface of the internal combustion engine,a last fatigue wear occurred. Every effort has to be made to improve fatigue properties of cylinder liner and when it is upgrade the sliding characteristics and wear resistance of metal surface. Coating can often be used effectively without sacrificing any of the major property requirements of the substrate material. In this work analysis the phosphating surface coating on the cylinder liner of different materials is studied by using design of experiments. In the present work improvement in fatigue life is obtained by manganese phosphating process with optimizing parameters the ANOVA and F-test are used to analyze the results.***

Key words - **Fatigue Wear, Optimized Process Parameter, Manganese Phosphating, Cylinder Liner, Taguchi Method.**

I. INTRODUCTION

In the automotive and machine industry there is a great deal of interest in improving environment friendliness, reliability, durability and efficiency. The reduction of wear and friction is a key element in decreasing the energy losses particularly in engines and drive trains, surface treatments and coatings contribute to a better lubrication with oils and can participate significantly in achieving these goals. Among protective coatings, the class of carbon based materials shows interesting properties, combining low friction with a good wear resistance. For these reasons they are increasingly being used as protective films for moving parts. The use of such non-metallic surface with new additives leads to analysis into the interaction between these protective over layers and the base material.

II. PROJECT BACKGROUND

In internal combustion engine, a fundamental consequence of increasing the specific power is increased temperature and stresses in all parts of engine that transmit the force from the combustion gases, as an engine piston runs hotter, the interface between piston and cylinder liner can become susceptible to wear. Therefore an inexpensive and efficient way to analyze the effect of changes in cylinder liner on fatigue life of cylinder liner is needed. Surface treatment also plays a major role in the performance of the cylinder liner. It is analyzed that fatigue fracture takes place because of crack initiate at the surface of cylinder liner. The wear of cylinder liner can reduce its mileage, it consumes more fuels to perform and also damage the engine block itself.

Considering importance of cylinder liner wear, a cylinder liner must be designed to last the lifetime of an engine. Now the wear resistance of cylinder liner has been improved by using hard thin surface coatings, these are diamond like carbon coating which has been shown to be beneficial and pins with this kind of coating have been reasonably widespread use in many catagories of automobile engineering.

III. PROBLEM DEFINITION

Phosphating is most widely used metal surface treatment process. Due to its ability to afford excellent corrosion, wear resistance, adhesion and lubricate properties, it plays a significant role in automobile application such as cylinder liner. Hence an attempt will be made in the present study to replace a DLC coating by phosphating coating. Therefore a development of innovative idea to substitute DLC coated cylinder liner and to improve fatigue performance of cylinder liner material. Thus problem can be defined as "analysis of effect of phosphate surface coating on the fatigue performance of the cylinder liner material".

IV. EXPERIMENTAL STUDY

In view of great application of low alloy steel to make the cylinder liner, we selected EN 24 as material experiments.

V. MECHANICAL TESTING

For determining the mechanical properties, tensile tests tests conducted within the elastic limit of the steel.

TABLE NO 1
MECHANICAL PROPERTIES OF MATERIALS

Steel Grade	Yield Load	Ultimate Load	Yield Strength	Ultimate Tensile Strength	% Of Elongation	Hardness
EN 24	10720N	13800N	537MPa	692MPa	24.72	41HRC

VI. SPECTROSCOPIC TEST

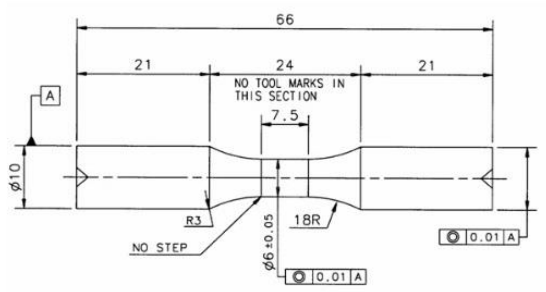
The chemical composition of each grade of steel was evaluated the spectroscopic analysis the result of which are given in table.

TABLE 2
CHEMICAL COMPOSITION OF MATERIALS

Steel grade	Percentage of chemical composition of elements							
	C	Mn	Si	S	P	Cr	Ni	Mo
EN 24	0.47	0.59	0.24	0.022	0.034	1.100	1.430	0.250

VII. FATIGUE TEST SPECIMEN

Based on the recommendations provided in standards, dumbbell shaped round test specimen having nominal neck diameter 6mm and 18mm transition fillets were prepared for carrying out fatigue tests. The drawing of the specimen is given in figure



VIII. PHOSPHATING PROCESS

The coating unit comprised of a number of modular, tube-shaped components holds for accommodating the components to be coated, in order to achieve a uniform deposit over the entire surface of the components during the coating process. The component holders are given complex spinning motion by means of gear arrangements.

IX. DESIGN OF EXPERIMENT

The experiments were designed to establish the effect of phosphating parameters on fatigue strength of EN 24 as a cylinder liner material optimum setting of process parameter is a crucial aspect to improve phosphate ability of specimen. A generic signal to noise ratio is used to improve the present variation.

X. RESPONSE VARIABLE

Response variable are the requirements placed on the systems output. In the present study. Increase in fatigue life of cylinder liner of manganese phosphate coated is the main objective. Hence the response variable used is to accomplish this study is to increase fatigue life of cylinder liner in number of cycles.

XI. CHOICE OF TEST PARAMETERS

The three factors temperature, phosphate time, accelerator were considered as the control factors affecting the fatigue life. Design parameters are the controllable factors that are the testing parameter such as temperature phosphating time and accelerator are easier to control. The levels are chosen keeping in mind the low thickness of the coating otherwise wear may occur through the coating.

TABLE 3
DESIGN PARAMETER LEVEL.

Factors	Unit	levels		
		1	2	3
Temperature	Deg C	92	93.5	95
Phosphating time	Minute	5	10	15
accelerator	mL/L	1	1.5	2

XII. SELECTION OF ORTHOGONAL ARRAY

In the present case since each of the main factors are associated with three levels. The DOF of each of the factor is two. It is important to notice that the number of experimental trial in the OAs must greater than the DOF required for studying the effects. Hence L_9 OA. Requiring nine experimental trials is suitably chosen for the present case.

XIII. RESULTS AND DISCUSSIONS

A. *Anova Analysis*

The most important statistic in the analysis of variance table is the p-value (P), which exists for each term in the modal (except for the error term). The p-value for a term tells you whether the effect for that term is significant.

The effect of temperature (P=0.051) and accelerator is significant (P=0.055) indicates that with different value for quality characteristics.

TABLE 4
ANOVA TABLE

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% of contribution
Temperature	2	1611553	1611553	805776	18.57^b	0.051	69.91
Phosphating Time	2	332540	332540	166270	3.83	0.207	10.96
accelerator	2	1505778	150778	752889	17.35	0.055	14.83
Residual error	2	86798	86798	43399			4.3
Total	8	3536668					

B. *Confirmation Experiment*

Based on the result, following level of parameter is selected.

TABLE 5

LEVEL OF SELECTED PARAMETER

Temperature	95 degree Celsius
Phophating time	15 minutes
Accelerator	1ml/L

C. *Predicted Values*

For the factor settings you selected, the S/N ratio is predicted to be 108.70 and the mean (the fatigue life) is predicted to be 272257.

D. *Evaluation Of Experiment*

In the present study four confirmation experiments (r =4) were carried out to evaluate the performance of experiments trials for fatigue life under optimal conditions.

TABLE 6
EVALUATION OF EXPERIMENTS

Experiments	Temperature	Time	Accelerator	Fatigue life
1	95	15	1	272567
2	95	15	1	272632
3	95	15	1	272418
4	95	15	1	272469

E. *Results Of The Confirmation Experiment*

	Predicted result	Experimental result
Level	95-15-1	95-15-1
Fatigue life	229786	272521.5

F. *Comparison With UnCoated Specimen*

	Uncoated life	Coated life	% of increase in life
Fatigue life	229786	272521.5	15.68

XIV. CONCLUSION

1. Taguchi orthogonal array design is suitably applied to maximize the fatigue life of phosphate coated specimen by optimizing three factors temperature, time and accelerator level. The optimum testing condition obtained from the analysis yields about 15.19% increase in llife compared to uncoated specimen.

2. In the performed experimental trials using taguchi orthogonal arrays, it was found that the temperature (69%) had significant effect on the fatigue life and followed by temperature (11%) and time (15%).
3. The presence of alloying elements and their chemical nature can a cause distinct difference on phosphatability. This may be one of the reasons for improvement in fatigue life.
4. As seen from the percent contribution graph the percent contribution due to error is low i.e 5%, then it is assumed that no important factors were omitted from the experiment and the opportunity for further improvement is not very great.
5. Based on ANOVA and F-test analysis the most statistical significant and percent contribution of the process parameter is temperature, whereas phosphating time and accelerator is less effective.
6. The optimized process parameter for maximizing fatigue life from taguchi analysis are approaching temperature 95 degree Celsius. Phosphating time 15 min and accelerator 1ml/Litre with an estimated fatigue life of coated specimen is **272521.5 cycles.**
7. With the setting above process parameter level, predicted results are **229786 cycles**.
8. The optimal range of fatigue life values obtained are **(27168.52<272521.5<273475.91).**
9. The difference between the predicted result and estimated result is satisfactory.
10. It is observed that an increase of 15.68% in fatigue life coated EN24 material compared to uncoated specimen.

XV. REFERENCES

[1] "Fatigue" chapter 14 elements of metallurgy and engineering alloys ASM international.

[2] T.SN Sankara Narayanan,"Surface Treatment By Phosphate Conversion Coating",130-177, Material Science,Vol 9,2009.

[3] J.A.Berrios-Ortiz.G.La Barbera-Sosa,D.G Teer, E.S puchi-Cabera,"fatigue properties of A 316L stainless steel coated with different Zrn Deposits", surface and coating technology,179 (145-157).

[4] Menke.J.T. "Process Control For Phosphate Coating" In Products Finishing January 1994.

[5] Hiroyuki Akebono,Jun Komotori, Hideko Suzuki,"Effect Of Coating Thickness On Fatigue Prooperties O Steel Thermally Sprayed With Ni Based Alloy", International Journal Of Modern Physics, 2010.

[6] Balakrishnan, N, Mayilsamy, K & Nedunchezhian, N 2015, 'An investigation of the performance, combustion and emission characteristics of CI engine fueled with used vegetable oil methyl ester and producer gas', International Journal of Green Energy, vol.12, pp. 506-514. P-ISSN: 1543-5075, E-ISSN: 1543-5083 (Electronic).

Karthikeyan, R, Solaimuthu, C & Balakrishnan, N 2014, 'A study of performance and emissions of diesel engine fuelled with neat diesel and heat hydnocarpus pentandra biodiesel' IOSR Journal of Mechanical and Civil Engineering, vol. 10, issue.2, pp. 53-57, E-ISSN: 2278-1684, P-ISSN: 2320-334X.

[7] Balakrishnan, N & Mayilsamy, K 2014, 'Effect of compression ratio on CI engine performance with biodiesel and producer gas in mixed fuel mode', Journal of Renewable and Sustainable Energy, vol.6, pp. 0231031-02310313. ISSN: 1941-7012.

[8] Balakrishnan, N & Mayilsamy, K 2013, 'A study of cotton coated with intumescents flame retardant: Kinetics and effect of blends of used vegetable oil methyl ester', Journal of Renewable and Sustainable Energy, vol.5, pp. 0531211-0531218. ISSN: 1941-7012.

[9] Balakrishnan, N, Mayilsamy, K & Nedunchezhian, N 2015, 'Experimental investigation of evaporation rate and emission studies of diesel engine fueled with blends of used vegetable oil biodiesel and producer gas' Thermal Science, vol. 19, No. 6, pp. 1967-1975, ISSN: 0354-9836.

[10] Balakrishnan, N, Mayilsamy, K & Nedunchezhian, N 2013, 'Effects of compression ratio on performance and emission of internal combustion engine with used vegetable oil methyl ester', Advanced Materials Research, vol.768, pp. 250-254. P-ISSN: 1022-6680, E-ISSN: 1662-8985.

[11] Balakrishnan, N, Mayilsamy, K & Nadunchezhian, N 2012, 'Effect of fuel injection pressure in CI engine using biodiesel and producer gas in mixed fuel mode' European Journal of Scientific Research, vol. 92, issue. 1, pp. 38-48. ISSN: 1450-216X.