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A-Review Paper for Application of Taguchi Method for the Optimization process of Piston

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ABSTRACT

In the present study, three different coating materials, coated on the top surface of diesel engine piston (AlSi) with different thermal properties are taken: yttria-partially stabilized zirconia (Y-PSZ), Mullite ((Al6Si2O13) and Silicon Dioxide (SiO2).Thermal analysis is carried out for a high temperature Conditionsusing ANSYS 15. Optimization of temperature and stresses induced within the coatings are carried on Minitab Software using Taguchi method to determine the optimum parameters for diesel engine piston. The current study attempts to present an intensive literature survey on use of Taguchi method in different fields of engineering with a specific emphasis on the impact of different operational parameters on multiple performance measures, which can lead to achieve the optimal parametric combinations that can improve the process to get optimized output. These reviews demonstrated that this optimisation method was efficient and can greatly reduce the operational cost and the design process.

II.INTRODUCTION

This chapter mainly presents an overview pertaining to tribological aspects for improving the performance of IC engine. At the end of this chapter, scope for the study is also provided. Internal combustion engine (IC) as shown schematically in Fig.1.is the most important mechanical invention done by human beings, which has played great role in the industrialization of the globe after world war-II. But, now due to fast depletion of conventional fuel resources and increasing environmental issues, there is worldwide relentless pressure on the researchers to develop ever more fuel efficient and compact IC engines having reduced environmental issues. In the last couple of decades, there have been many studies on the frictional evaluations at the various interfaces in IC engines in order to identify the crucial interfaces of the engine components for minimizing the interfacial frictional losses associated with it.

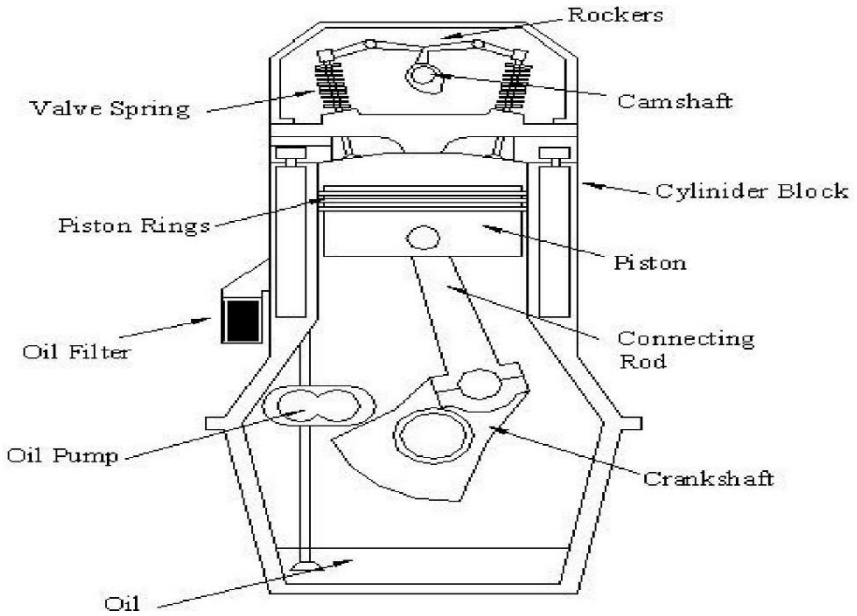

Fig. 1 Vital components of a typical IC engine

Taguchi addresses quality into two main areas offline and online quality. Both of these areas are very cost sensitive. Offline quality control deals with the improvement in quality of the product and process development stages. Online quality control deals with the monitoring of current manufacturing process to verify the quality levels produced. Taguchi method bared designs are different from the classical experiments designs by Taguchi method minimizes the variance of characteristics of interests. But the major limitation it has is it is only effective in solving single response problems.

It is worth mentioning here that major portion of fuel energy (i.e. chemical energy) goes as waste in the form of heat. Even, significant portion of chemical energy liberated during the combustion of precious fuel is consumed in the frictional resistance present at the various interfaces of the moving engine components.

Reductions of fuel consumption and emission in an internal combustion engine are largely a function of improved lubrication. Therefore, advanced concepts are now being explored to reduce the friction at various interfaces in an IC engine.

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III.SCOPE OF STUDY

It is widely understood that surface profiling and surface topography of mating solids have remarkable influence on tribological behaviours in both dry and lubricated sliding conditions. Though the influences of the micro and nano scale topography are more complex but, at the same time it offers interesting possibilities for friction reduction. The most promising results related to friction reduction may come out with some novel surface profiles in presence and absence of surface texturing. Therefore, in light of stringent federal legislations pertaining to better fuel economy and reduced emissions, there are needs to revisit lubrication and tribological contact design aspects in IC engine for friction reduction. Improving performance of piston assembly from tribological aspects (reducing friction) will have immense influence on fuel saving and controlling the emissions.

The Taguchi method optimizes a process or product design in three mainstages.

- Concept design or Systemdesign
- Parameterdesign
- Tolerancedesign

The concept design is called as the first step of a design strategy. This stage gathers the technical knowledge and experiences to help the designer to select the most suitable design for a given product. Thencomestheparameterdesign.Herethebestsettingof thecontrolfactorsisdetermined.Thisisthe most important step as it does not affect the manufacturing cost of each single unit of product. After these two steps are done the third step which is called the tolerance design is initiated. This process deals with the relation between quality and cost. Here the designers only consider upgrading material standards and components.

IV.RESEARCH MOTIVATION

The vehicle manufactures use an engine driven oil pump to lubricate the critical sliding or the rotating-type moving components of an internal combustion (IC) engine. The critical components and sub-assemblies include the piston and rings assembly, the crankshaft, the camshaft and valves drive mechanism, etc. During the operation of an IC engine the interacting rough surfaces of the moving components are in relative motion. Due to the forces of adhesion the static and kinetic friction cause energy dissipation and loss of power during the components motion. In the process the moving surfaces should be lubricated sufficiently, continuously and effectively to reduce friction and adhesive wear. A liquid lubricant is introduced between the interacting engine surfaces to reduce the friction, loss of power and wear. It caters for the adhesive wear of the moving components but introduces viscous friction, shear heating and energy losses. In an IC engine an effective lubrication is a difficult and relatively complex problem. The complexity arises due to the high temperatures generated during the combustion process and the wide range of temperature gradients encountered during the engine operation under the variable loads and speeds. studied the multi response parameter of CNC turning by taguchi method-based surface analysis. They have found out the SNR for all done experiments along with the objective functions. After optimizing the performance parameters, they found out that it has increased the efficiency of the CNC turning and the machining cost was reduced significantly. The intensity and the magnitude of the combustion gas force vary as an effective engine cooling system and the other heat removal mechanisms remove the heat continuously. The time-dependent heat generation, dissipation and removal mechanisms produce the fluctuating thermal loads. The fluctuating loads generated during a particular engine operation differ in the pattern and magnitude from those at the other operating conditions. The time-dependent variations in an engine performance cycle make an effective lubrication of the piston skirts, rings and the liner extremely difficult at some of the engine operating conditions. studied the use of taguchi method on optimising the combustion performance of a diesel engine with diesel biodiesel blend and port introducing hydrogen gas. They have given importance to BTE, BSFC, oxides of nitrogen and smoke in their study. They found out that the best results are achieved from combination of 30% of hydrogen 40% of EGR ratio which improves the combustion performance and saves 67% of time taken to perform experiments. taguchi method to investigate factors affecting emission of a diesel engine running with tobacco seed methyl ester. A peculiar engine operating condition is the low-speed initial engine start up under the low-load conditions when the lubrication fails to prevent wear of the piston and the rings. The start up wear must be minimized and prevented to enhance the life of an IC engine.

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V. TWO-STROKE PISTON

Fig.2 shows two stroke piston that be made by casting process. These pistons are mainly used in gasoline and diesel engines for passenger cars under heavy load conditions. They have cast-in steel strips but are not slotted. As a result, they form a uniform body with extreme strength.

The head of the piston can beflat, bulged or otherwise shaped. Pistons can be forged or cast. The shape of thepiston is normally rounded but can be different.

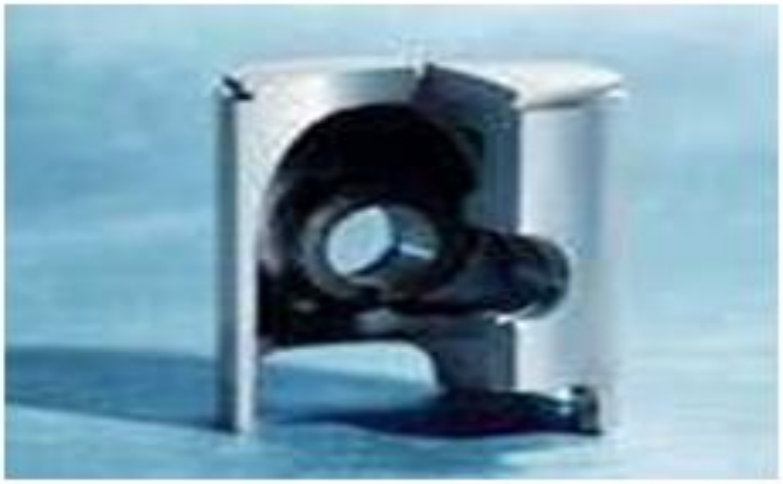

Fig.2. Two stroke Piston.

VI. CAST SOLID SKIRT PISTON

Cast solid skirt pistons have a long service life.Furthermore this piston moreuseable that can be used in gasoline and diesel engines. Besides that, their range ofapplications extends from model engines to large power units as shown in Figure 3.Pistontop, ringbelt and skirt form arobustunit.

Fig.3Cast Solid Skirt Piston

VII. FORGED SOLID SKIRT PISTON

For this piston as shown in Figure there are made by forged process that gives the piston more strength. This type of piston can mainly be found in high performance series production and racing engines. Besides that, due to the manufacturing process they are stronger and therefore allow reduced wall cross-sections and piston weight. Also, due to relative manufacturing procedures, forged pistons tend to be more expensive than other process.

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VIII. HYDROTHERMIK PISTON

For this type of piston as shown in Figure 4 that gives very quiet running pistons are used primarily in passenger cars. On the other hand, the pistons have cast- in steel strips and are slotted at the transition from ring belt to skirt section

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Fig.4 Hydrothermik piston

IX. Ring carrier pistons with cooling channel

This type of pistons is for diesel engines as shown in Figure 5.There have a ring carrier made from special cast iron that is connected metallically and rigidly with the piston material in order to make it more wear resistant, in particular in the first groove. Furthermore, the pin boss bushes made from a special material, the load-bearing capacity of the pin boss is increased

Fig.5 Ring carrier pistons with cooling channel

X. Pistons with cooled ringc arriers

For these pistons, ring carriers and cooling channels are combined into one system in a special production process as can say that is combination of ring carrier pistons with cooling channel and ring carrier pistons with cooling channel and crown reinforcement as shown in Figure 7. Besides that, this provides the pistons with significantly improved heat removal properties, especially in the first ring groove.

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Fig.6 Forged solid skirt piston

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