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DESIGN & DEVELOPMENT A PISTON HEAD FOR INTERNAL COMBUSTION ENGINE USING COORDINATE MEASURING MACHINE- A REVIEW

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Abstract – Reverse engineering was done on a direct injection piston compressing natural gas. Reverse engineering is a way to redesign a product to create a new product which has similar functions and improvement in the ability of the original product. The objectives of this research are to get the piston point cloud to be used in CAD three dimension modeling, to obtain the accuracy between existing designed pistons and reverse engineered designed piston, to calculate the accuracy of the prototype. In this research discuss about pervious research on design and development piston head for internal combustion engine using coordinate measuring machine and also discuss the assumptions and affect, which is taken by researcher. In this paper we have discussed about effecting parameters of design to piston head and force surface measurement.

Index Terms— Reverse Engineering, S. I. engine, CAD, Prototype.

I. INTRODUCTION

Geometrical and dimensional measurements using precision measuring devices are crucial during the manufacturing processes of parts to insure their compliance with the design requirements.[1] In addition; those accurate measurements may also be employed with reference to their benchmark values to monitor the extent and severity of functional deterioration of the parts, especially those working with their surfaces during service. This helps the maintenance engineer take proper decisions regarding his forthcoming maintenance plan and/or repair actions. Thus, the durability and reliability of the parts and the assembly would be favorably affected.

Air-cooled Diesel engine, for instance, is commonly used in heavy-duty transport fleets applications due to their high performance, efficiency, and low fuel consumption. The surface contact problems between cylinders and pistons through their rings are vital to the engine performance within the adverse operating conditions of high pressure, temperature rise, and high relative velocity of the contacting surfaces.[2,3,4] Fine finish and surface treatment together with proper geometrical and dimensional tolerances standards implementation are required in order to ensure good sealing between cylinder wall and piston rings, good load carrying capacity, good lubrication conditions, less friction, suitable wear resistance, low translated vibration levels, high engine efficiency, and longer service life span.

[5,6] The main function of the piston rings assembly is to provide a good dynamic sealing between combustion chamber and crankcase during compression and power strokes. Reasonable sealing minimizes power loss due to charge escape from the combustion chamber within suitable ring expansion gap and limited friction force. For long sealing service life, friction and wear between piston rings and cylinder wall have to be properly controlled.[7,8] They are controlled by lubrication of the interface with dry lubrication of cylinder bore material composition besides an oil film thick enough to separate the asperities of piston rings and cylinder surface.

[3,7] The friction loss varies according to piston velocity between top dead center (TDC) and bottom dead center (BDC), where the oil film thickness depends on the instantaneous relative velocity of the piston ring, which varies from zero at TDC and BDC to a maximum in the middle section. This means that wear conditions will vary along the piston ring traveling distance, from mild to severe.[9] Normally the cylinder bore is not cylindrical along its entire length. Practically, the bore distortion causes loss of conformity between piston rings and cylinder wall, which in turn produces some troubles to oil film distribution. Variation in the oil film thickness exposes piston rings and cylinder to the whole spectrum of lubrication regimes, from mixed and probably elastohydrodynamic to full film hydrodynamic lubrication. [5,7,10] Consequently, different wear mechanisms will develop geometrical departures in transverse sections along the cylinder bore.[9] TDC location on the bore suffers heavily from oil starvation more than that at the BDC and its vicinity. Although the piston at both locations are kinematically characterized by marginal inversion velocity situations where it reaches zero before starting to get inverted, the most severe wear is expected to appear at the TDC due to the oil shortage while at the BDC the oil is

available either from the source or due to gravity. However, the BDC may also experience high wear rate due to the existence of hard grit and wear debris accumulated by the gravity at this location and the neighboring area. The middle location and the nearby zone, where the piston velocity reaches its maximum value, mild wear only is expected because the oil film becomes dynamically thick enough to separate the mating solid surfaces and prevent metal-to-metal contact. [11] Although there are many new advanced inspection equipment such as CMM machines of which their use is so far only monopolized to the manufacturing fields,[12,13] rare published research work yet exists in the use of such advanced CMM metrology utilities in the field of engine health monitoring through geometrical departure measurements and analysis. Characterization of engine cylinder bore geometry and dimensions are a two manifold problem. The first is related to the applied techniques and quality standards adopted during manufacturing inspection process. This concerns the prescribed surface design parameters such as dimensional and geometrical tolerances, and surface roughness. The second is related to processing such data with the purpose of monitoring the changes that happened to the surface geometry and dimensions during engine service life span. This would help in two aspects: the first is related to maintenance decisions, while the second is related to design modifications. Research work has been done on surfaces with Gaussian distribution roughness, but cylinder wall fine finished surface with specified geometrical features and properties participate simultaneously together to controlling the environment that critically affects the engine functional performance and life.[14-17] Although the specified surface parameters represent advanced features, their definition is generally unrelated to any physical or mathematical properties of the surface topography.18 The plotted accumulation of surface asperities heights according to the Gaussian distribution appears as straight-line scales. For transitional surface topography, such a scale appears as two intersecting straight lines. The slopes of the lines are proportional to the standard deviations of the two distributions, while the point of intersection represents the depth of transition from one finish to another. Difficulties encountered using this technique to apply, has recently solved with developing advanced calculations software.[12] On the other hand, the numerical description of the changes in the operating surface geometry during service life span necessitates detecting and follow up the surface geometrical deviations. However, some changes occur in such a way that a band of surface fine wavelength may disappear. Hence, Fourier Transformation Analysis is needed in this case to determine the surface power spectrum using special software to characterize the changes in the surface straightness and roundness relevant to operation environment changes.[11] Statistical calculation analysis of combined standard uncertainty (type A) is also needed for CMM measurements.[20] The purpose of this work is to demonstrate employing the accurate precise surface geometrical and dimensional measurements to monitor and follow up the extent of severity of wear changes in a worn out cylinder of an Automotive Diesel Engine as related to the resulted geometrical distortions in both transverse directions (out of-roundness, and derived concentricity), and longitudinal directions (out-of-straightness). Thus, design improvements and/or correction actions to the scheduled maintenance plan could be suggested in the light of the analysis of the obtained measurements within the relevant uncertainties. Innovative design modification and inspired ideas may also be pointed at for the sake of extending the engine service life span and minimizing the running operational and maintenance expenses. Reverse engineering is a way to redesign a product to reconstruct a new product which has similar functions and to improve the ability of the original product [1]. Reverse engineering is applied in software engineering, civil engineering, manufacturing engineering, entertainment, automotive, microchip, chemical engineering, electronic engineering and many more. The advantage of reverse engineering is that the new product created has an improvement. The concept is still the same as the existing product but improvements have been made on the concept and the quality in order to make the new product better than the original product. By using this engineering method, costs for improving the product could be reduced [1]. Besides that, the time consumed for the improvement of the product and the production time of the product is reduced better than any other engineering method. This is because a new concept does not have to be generated. Concepts are the same but their characteristics differ due to the improvements made. Reverse engineering is also used to redesign a product with problems. Paying attention while reconstructing the product is very essential to obtain an accuracy of up to 0.0005 inches to 0.005 inches. This kind of accuracy could be obtained by using auxiliary equipment and new technologies for instance the three dimension scanner, coordinate measuring machine, CAD softwares and many more [1].

A. Design Piston Head through CMM

1) Digitization

Digitization is the process of capturing the data of the physical model and converting it into digital form. However, with the introduction of new technologies the term digitizing is now used as the generic Description for the process of acquiring data from undefined surfaces out of which a complete solid model of the part is made. The 3D Solid model of the piston is then created from closed surface model, and solid work simulation software show in the figure 1.

FIGURE 1: FINAL SOLID MODEL OF THE PISTON

2) Material Modeling

The piston performance was evaluated for different classes of Aluminium alloy. The material properties of these

different alloys and all so present in the results of the parametric analyses of the three different material.
Forces and surface measurements

Dynamic friction force Gas pressure due to combustion represents the essential axial force acting on the piston crown area to move it downwards against reciprocating mass inertia. Fn is the instantaneous sum of the normal acting forces on piston pin, Fig. 2. Reciprocating piston motion on angular movable connecting rod generates a variable piston side force Fs. An axial transmitted force Fa of the crankshaft due to clutch engagement force and gear force components affect the cylinder wall. The resultant of piston forces Fs and Fa attacks the wall at an angle with Fs. The angle value varies as a function of the force amplitude to generate a resultant force causing rotation around the cylinder axis. Dynamic friction force Ff has been produced due to relative motion of piston rings with respect to the cylinder wall under the effect of the resultant force in a spiral like motion. This causes the cylinder bore to wear at rates corresponding to the resultant force amplitude and direction to generate eventually a cylinder out-of-roundness (OOR) and out-of-straightness (OOS).

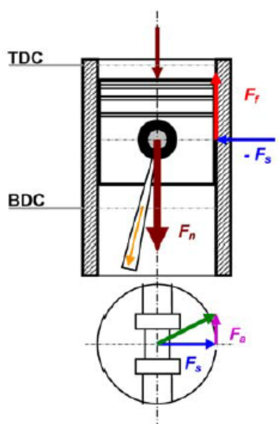

FIGURE 2: FORCE SURFACES OF PISTON ASSEMBLY

II. LITERATURE REVIEW

G. C. Gannod et. al (1999) presented a formal approach for reverse engineering. Authors have been suggested many different approaches for reverse engineering in his literature. The availability of such approaches provides the opportunity to study the effect of their combination. In its previous investigations, authors have developed a formal approach for reverse engineering. When applied as a standalone technique, the complexity of this approach is unmanageable. [1]

C. X. (Jack) Feng (2000) have elaborated a computer-aided reverse engineering (CARE) approach. In this approach, a CMM is used to digitize an existing mechanical object, and then a piece of software called ScanPak is used to generate the IGES files of the point data from CMM digitization. Pro/Engineer then is used to create the solid model of the object, and finally the laminated object manufacturing process (LOM - one of the many rapid prototyping technologies) is used to duplicate the object. The methodology is presented, and a case study has been illustrating the approach. Finally, challenges and future research directions in CARE has been identified. [2] V.H. Chan et.al (2001), finds that two primary aspects of reverse engineering are accomplished by the incorporation of a CCD camera into the CMM system: tool path planning for the touch probe and the identification of separate surfaces on the object. Although use of neural networks for machine vision is quite established, the use segmenting of images with non-constrained boundaries for application in reverse engineering has proved promising. [3]

L Li et al (2002) presented a reverse engineering system for rapid modelling and manufacturing of products with complex surfaces. The system consists of three main components: a 3D optical digitizing system, surface reconstruction software and a rapid prototyping machine. The unique features of the 3D optical digitizing system include the use of white-light source, and cost-effective and quick image acquisition. The modelling software exports models in STL format, which are used as input to an FDM 2000 machine to manufacture products. The examples are included to illustrate the systems and the methods. [4]

S. Ali (2005) explained that laser scanning presents options that previously used methods do not allow. Damaging parts surfaces due to contact is not a problem with laser scanning. His system uses the IVP 2000 Range Scanner to acquire scanned data and generate a 3D freeform model using Rapid Form 2004. The IVP Range Scanner is equipped with a camera system and laser scanner that acquires the data after scanning. [5]

M. Sokovic et. al (2006) elaborated that how for some product development processes Reverse Engineering (RE) allows to generate surface models by three-dimensional (3D) scanning technique, and consequently this methodology permits to manufacture different parts (for cars, for household appliances) and tools (moulds, dies, press tools) in a short development period. Author shows review of the advantages and weaknesses of different scanning systems. [6]

M. M. Hussain et. al (2008) have studied an object to demonstrate ability of error analysis using coordinate measuring machine. The object reversed in this case study is injection mould with two damaged cavities in the part, without any drawing prints. Using CMM and CAD software point cloud files are created. He further concluded that, if scanning data is converted into datum curves/curves (Blend) scanning itself, 50% of manual work can be reduced.

Scanning along and across directions in surface scanning will improve the accuracy of surfaces. Accuracy in surfaces will depend on complexity of shape. The accuracy of surfaces will increase by manipulation of surfaces. [7]
S. Babu et. al (2011), studied about pattern less casting process using CAD\CAM applications, scanning/digitizing, coordinate measuring arm machine, and 5-axis machine. An adjustable diffuser vane blade used in oil and gas

industry was manufactured by reverse engineering and pattern less process starting from a worn out sample. First the blade was digitized by Cimcore-3000i 3D Coordinate Measuring Arm. The obtained point cloud data is imported to Pro/Engineer CAD\CAM software to develop the 3D model and design the moulds. Then direct sand blocks (cope and drag) milling on Poseidon CNC specific purpose 5-axis machine was adopted completely eliminating any use of patterns. The moulds were directly used for metal pouring at the casting stage. [8]

N. Singh (2012) [9] elaborated the concept of Reverse Engineering as the process of duplicating an existing part, subassembly, or product with the aid of drawings, documentation, or a computer model is known as REVERSE ENGINEERING. After a brief introduction, the various stages involved in reverse engineering, and its applications in different fields have been discussed.

III. CONCULSION

The results of this study show that reverse engineering can be used to make any existing part or component in engineering field to making easily regenerating, so in this paper conceder to be making piston head of existing car then will be analysis of now days of available material choose beater one of the material can withstand the heat and wear during the working cycle of engine.

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