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Research Paper Engineering

Reverse Engineering of Car Piston

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ABSTRACT

This paper aims to assess an integrated design outline of adjacent mechanical components from the reverse engineering point of view. The methodology proposed comprises an integrated and systematic outline for design recovery of crankshaft and its bearing and car piston .The relationship between all components is carefully documented during the disassembly phase .The form, functions and material relationships are coupled. The remanufacturing parameters may be different than the original based on the present set of design and manufacturing constraints.

Keywords: Mechanical Parts; Crank Shaft, Bearing, outline, car piston

INTRODUCTION

Reverse engineering aims at reproducing an existing object by analyzing its dimensions, features, form and properties. The collected data and information must be transferred into pertinent product knowledge at both the detail and embodiment levels. An integrated and systematic framework for design recovery of mechanical parts is proposed. R.J.Urbanic, W.H.Eimaraghy1 proposed an integrated and systematic framework for design recovery of rfundamentals of machine elements.V.Cabone,M.Carocci,E.Savio,G.Sansoni and L.De chiffri3 proposed on computer-aided Design on forecasted technical system evolution. Jeremy, J.Michalek, Oben Ceryn4 proposed manufacturing objectives in product line design with optimal profitability J.Higham M.E. Abdelsalam, Han p. Bao5 proposed Resequencing of design process with Activity stochastic time &cost approach. S.Somani, V.Karma6 proposed the reverse engineering process that can be integrated with the recent rapid prototyping for product development. Loana Boiler, Martin, Holly Rushmeier7 proposed a constrained parameterization approach that allow to represent 3D scanned model as parametric surfaces defined over polyhedral domains.

The Present work is aimed at the technology of reverse engineering which is being empirically evaluated and different factors should be compared with different parameters. Reverse engineering clearly identifies the difference between existing technologies that should be used as a base line comparison and the letest technology that is to assessed. Therefore, it is imperative that the crankshaft and its bearing be remanufactured so that maintenance will never be needed in the lifetime of the automobile and machine.

Reverse engineering, within the part design and manufacturing domain, typically arises when: A) No drawing or design modal exist or for a product that must be replaced and the original manufacture no longer exists or produces that product B) Drawing has been created, but the components have been modified during design, hence, the existing documentation is no longer relevant. C) Comparing a fabricated part to its CAD description or to standard items for inspection and quality assurance purposes. Reverse engineering is useful as a benchmarking tool for design recovery, product redesign or for a new product design. Presently, reverse engineering practices focus on the process of creating a three Dimensional (3D) geometric model from a physical object. This in essence is not reverse engineering. Reverse geometric modeling, which is fundamental building block of a complete reverse engineering process. The controlling aspects of reverse engineering process consist of the available product documentation, available information with regard to the mating components and the knowledge of the operating environment.

The generic reverse engineering activities are as follows 1) Design the part 2) Collect functional features 3) Remanufacture the component ‘detailed’ functional model. Gather product information about the relationship between all components that must be carefully documented during the disassemble phase.

APPLICATIONS

1. Feature Based Reverse Engineering of Mechanical Parts
2. Reverse Engineering Vertebrate Brain.
3. Reverse Engineering on human hip joint.
4. Third party instant messenger.
5. Software Reverse Engineering.
6. Hardware Reverse engineering.
7. Reverse Engineering for Biometric Application

Feature Based Reverse Engineering of Mechanical Parts

Mechanical engineering design has been drastically changed due to improvements in CAD/CAM/CAE tools. Considering the dynamic aspects of the markets, the product development process is strongly influenced by these available new technologies. “Time to market” is another factor that governs the reduction in development time to achieve the profitability of the company. The new and revised goals in today’s competitive environment such as drastic reduction of product development time and increase of customized features of product require innovation strategies and support tools. The concept of Concurrent Engineering (CE) is the need of hour for the basic survival of any company. Looking to such essentialities, the emerging Reverse Engineering (RE) techniques are effective tools which help in the implementation of concept such as CE. From very old days, Reverse Engineering (RE) has been used for the purpose of replicating the existing design. RE is basically the process by which a physical object is converted in a virtual CAD model. Traditionally, it has been carried out taking the measurements from product itself with certain probes and transforming these into mathematical surfaces by means of some CAD software. While such techniques are relatively old, RE uses digitizers without contact and modern techniques .The object is to review such emerging methodologies devoted to applications of RE, considering their impact in the mechanical design process .The software dedicated to modal reconstruction are also available. The economics of reverse engineering is also studies for cost reduction. The reverse engineering is a very effective technique; particularly for small and medium scale industries and the benefits are reductions in the cost, time and labor among several others.

In today's competitive era industries are facing stiff competition due to many factors, the product diversity, right time to launch the product in the market, manufacturing process diversity, manufacturing economy, product complexity, product quality, CAD/CAE/CAM improvements, etc. In order to stat in global market, it is very necessary and important to reduce product manufacturing time starting from product development and manufacturing, to handing over to final end-user, using the available resources. These requirements necessitate the industries to adopt feasibly best methodology for developing the product.

In RE, the digitizer generates an enormous amount of point data (clouds). Representing the geometry in terms of surface points or collections of parametric surface patch is adequate /sufficient to describe positional information, but cannot be used for the higher-level structure of the part. Further processing the data to get the final CAD model is difficult and need skill too. The other difficulties are also encountered while processing point data such as it becomes hard to make changes, create problems in modeling parts with surface discontinuities, there are accuracy limitations, it become hard to optimize NC code generations, create problems in importing models into feature-based CAD systems etc.

THE REVERSE ENGINEERING METHODOLOGY

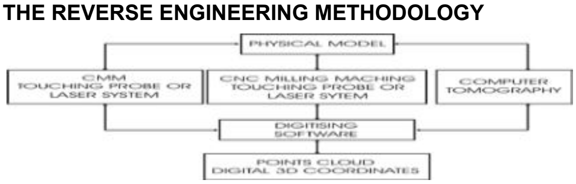

Figure 1: 3-D Digitizing Techniques

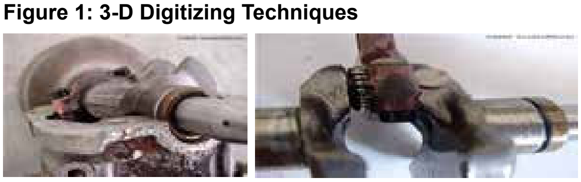

Figure 2: Functioning of Crank Shaft and bearing.
(Courtesy of Howstuffworks.com)

The basis of reverse engineering methodology is to develop a conceptual model from a physical model. The physical model may be any type of part or its prototype. For obtaining the data from the physical model there are various 3D-scaning digitizing technique which are further aided by specialized software for modal reconstruction.

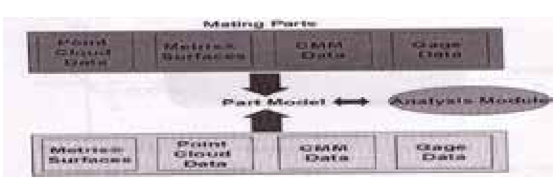

Figure 3: data gathering and analysis flow.

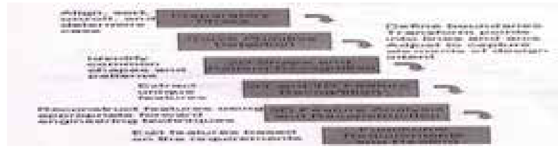

Figure 4: proposed reverse engineering methodology

PISTON
Design and analysis
For any meaningful analysis of a piston, it is imperative that an appropriate piston pin and connecting rod assembly is incorporated into the study since the dynamic performance of the piston is a function of the contact pressure between the pin and the bearing system, and the flexing and oval distortion of the pin which are all important criteria for assessment of whether the forces occurring can be transferred from the piston to the pin safely. Due to the complex geometries and the interactions involved, the finite element analysis approach is an attractive and easy means to understand such interactions. Consequently, in this study, an appropriate assembly was designed to suit the reversed engineered piston. This assembly is as shown in the Figure 5 below. The model was meshed with Solid186 elements using standard mechanical shape checking in ANSYS workbench using 44603 nodes and 23234 elements. A preliminary mesh convergence analysis showed that this level of mesh refinement was adequate to perform both the linear static and thermal-structural analysis of the model.

[13, 16] Boundary conditions for thermal analysis
It is important to calculate the piston temperature distribution in order to control the thermal stresses and deformations within acceptable levels. The temperature distribution enables us to optimize the thermal aspects of the piston design at lower cost, before the first prototype is constructed. As much as 60% of the total engine mechanical power lost is generated by piston ring assembly . The piston skirt surface slides on the cylinder bore. A lubricant film fills the clearance between the surfaces. The small values of the clearance increase the frictional losses and the high values increase the secondary motion of the piston. Most of the Internal Combustion (IC) engine pistons are made of aluminum alloy which has a thermal expansion coefficient, 80% higher than the cylinder bore material made of cast iron. This leads to some differences between running and the design clearances. Therefore, analysis of the piston thermal behavior is extremely crucial in designing more efficient engine.

The thermal analysis of piston is important from different perspectives. First, the highest temperature of any point in piston must not exceed more than 66% of the melting point temperature of the alloy . This limit temperature for the current engine piston alloy is about 640 K. Temperature distribution leads to thermal deformations and thermal stresses.It is generally assumed for piston temperature to remain constant throughout a working cycle and not dependent on the operating states. This assumption is justified for zones within the piston. Thin surface layers on the piston head are also subjected to cyclic temperature exposure within the working cycle, resulting in thermally induced stresses that constitute a high cycle load on the material. The piston thermal deformation has an important role in piston skirt design which has a potential to reduce friction and piston slap. In this design, both of the thermal and mechanical stresses must be considered indicating the importance of piston thermal analysis. The heat transfer coefficients for the different parts of the piston were calculated using the procedure outlined . Assuming a steady state thermal case, Figure 3 below shows the heat transfer coefficients for the piston at different positions.

Figure 6 shows the structural boundary conditions that were used to simulate the piston behavior accurately. Apart from the fixed support at the bottom end of the connecting rod, a frictionless support was declared on the circumference of the piston to simulate the movement within the cylinder. Further, the connection between the piston and piston pin and the piston pin and connecting rod were changed from the default "bonded" to "no separation" to permit relative translational and rotary motions respectively.

Figure 5: Final Solid Model of the Piston from RE
Figure 6 : stress von Mises (WCS) Red color means critically stressed region Blue color means low stress region

Figure 7: Temperature Profile and Equivalent Stress Distribution of the Piston Red color means critically stressed region Blue color means low stress region

The 3D scanning digitizing techniques are used to capture geometries and give the generated points cloud matrix, i.e.3D-coordinates, from the surface geometry of a physical part. There are different digitizing techniques from which the digital points cloud can be captured. These techniques may be classified as mechanical techniques and the optical techniques .In mechanical technique usually physical contact sensors are used where as in the optical technique the part is not contacted. In both the techniques a coordinate measuring machine or a CNC milling machine can be used. The optical technique generally uses laser beam probes associated to optical sensors for non –contact coordinate measuring another possibility is to use computer topography (CT) that also allows to capture the inside part geometrical details.

The data generated with the help of 3D-scanning, i.e. the digital points cloud data in x, y, z coordinates, is taken into any RE modal reconstruction software. This software gives a conceptual model supported by a triangulated (pyramid etc.) surface geometry or by a CAD surface data. After getting the conceptual model, the subsequent procedures are similar for the conventional as well as non – conventional technique.

In case of mechanical component, a deductive and creative approach is combined with data gathering techniques to migrate from a physical "what" to the imaginary "why'' and a conjectured final modal .The existing mechanical component, related documentation, and the functions the product performs are component feature. The device functional requirements, the link between the form and function, the product model and documentation are the desired outputs. The development process is to generate the desired output from the input are the from technical resources, the design and analysis tools, the information systems and the technical know how knowledge.

CONCLUSION:
Reverse engineering is to asses an integrated design outline of adjacent mechanical components. Reverse engineering aims at reproduction of and car piston, crankshaft and its bearing by analyzing its dimension, features and properties. The crankshaft is located in one of the most difficult – to access portions of the engine. Therefore, it is imperative that the crankshaft and its bearing be remanufactured so that maintenance will never be needed in the lifetime of the automobile.

Bearings are usually mounted with the rotating ring a press fit, whether it is the inner or outer ring. The stationary ring is then mounted with a push fit. This permits the stationary ring to creep in its mounting slightly, bringing new portions of the ring into the load –bearing zone to equalize wear. The permissible misalignment in cylindrical and tapered roller bearing is limited to 0.001 rad. For spherical ball bearing, the misalignment should not exceed 0.0087 rad. But for deep-groove ball bearing, the allowable range of misalignment is 0.0035 to 0.0047 rad.

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