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Reverse engineering : a brief review

Suresh Batni, M.L. Jain* Ashesh Tiwari**

Deptt. of Mech. Engg., A.I.T.R., Indore

**S.G.S.I.T.S.Indore,*

***I.E.T. D.A.V.V. Indore*

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 turbine blade .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, Turbine blade.

I. INTRODUCTION

Reverse engineering aims at reproducing an existing object by analyzing its dimensions, features, form and properties.

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 latest technology that is to be 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 as pects 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.

A. Applications

- Feature based reverse engineering of mechanical parts,
- Reverse engineering vertebrate brain.
- Reverse engineering on human hip joint.
- Third party instant messenger.
- Software reverse engineering.
- Hardware reverse engineering.
- Reverse engineering for biometric application.

II. THE REVERSE ENGINEERING METHODOLOGY

A. Literature survey

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. Urbanic, *W.H.Eimaraghy* proposed an integrated and systematic framework for design recovery of fundamentals of machine elements :

[1] Cabone proposed on computer-aided Design on forecasted technical system evolution.

[2] *J. Michalek, Oben Ceryn* proposed manufacturing objectives in product line design with optimal profitability.

[3] Higham *M.E. Abdelsalam, Han p. Bao* proposed Resequencing of design process with Activity stochastic time andcost approach.

[4] Somani, proposed the reverse engineering process that can be integrated with the recent rapid prototyping for product development.

[5] Loana *Boiler, Martin, Holly Rushmeier* proposed a constrained parameterization approach that allow to represent 3D scanned model as parametric surfaces defined over polyhedral domains.

B. 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.

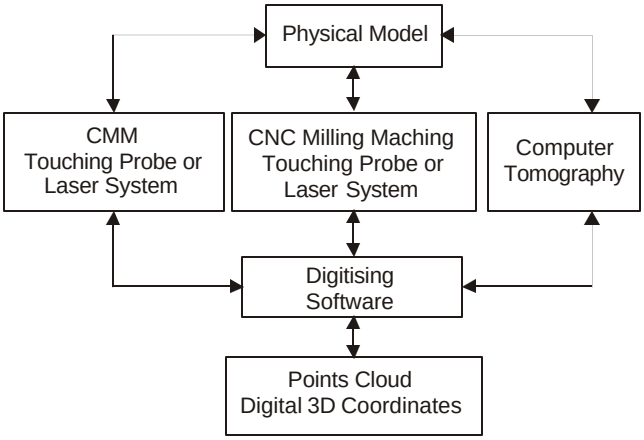

Fig. 1. 3D Digitizing techniques.

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, inFig. 1 RE uses digitizers without contact and modern techniques. In fig. 2 and 3 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 is 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.

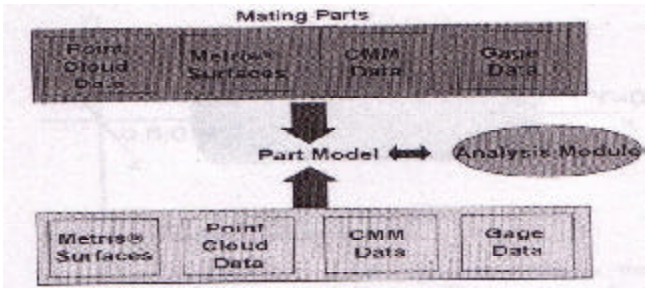

Fig. 2. Data gathering and analysis flow.

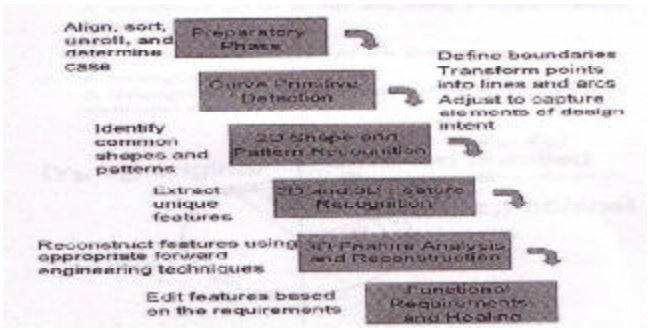

Fig. 3. Proposed reverse engineering methodology.

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.

The crankshaft is a one piece casting or forging of heat-treated alloy steel having considerable strength. The crankshaft be remanufactured so that, It should possess the following qualities :

(*a*) It must be strong enough to take the downward thrusts of the pistons during the power strokes without excessive distortion.

(*b*) Must be well balanced to eliminate undue vibration resulting from the weight of offset cranks.

In Fig. 4 the crankshafts are provided with counter weights opposites to the cranks for keeping them in balance. These contain drilled passages through which oil flows from the main bearing to the lubrication purposes.

Fig. 4. Functioning of Crank Shaft and bearing. (Courtesy of Howstuffworks.com)

A flywheel is attached to rear end of the crankshaft in order to keep it in the regular motion, as the flow of power from the engine cylinders is not smooth. The crankshaft is held with the engine block through split type plain bearing. The bearing back is usually of steel to which is attached the lining. The lining is a combination of several metals such as copper, lead, tin mercury, antimony, cadmium etc. The factors that need to be considered for reverse engineering are functional, form and fabrication features, Interface, and assembly features,

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 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.

The prototype of a turbine blade (50x15x25 mm^3) was digitized using the optical digitizer. The figure 5, 6, 7 and 8, are step to shading of the turbine blade CAD MODEL is shown.

Fig. 5. Point clouds acquired in correspondence with two views of the turbine blade and aligned in a common reference system.

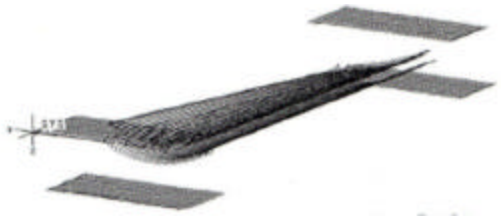

Fig. 6. Reconstruction of scan curves ordered in *y*-direction.

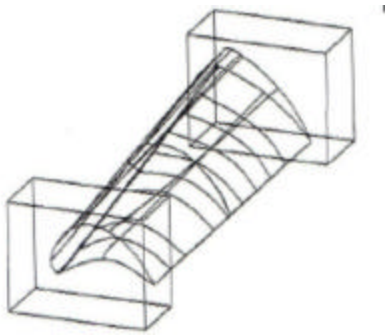

Fig. 7. Partial reconstruction of the functional surfaces.

Fig. 8. Final shading turbine blade CAD model.

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 from the technical resources, the design and analysis tools, the information systems and the technical know how knowledge.

A functional feature assists with meeting the product related to; automobile crankshafts are made of high grade steel by drop forging method. All the crankpin and journals are accurately machined and ground to shape and size fig 2 shows a crankshaft for a four strokes diesel engines .It is the main shaft in the engines to which all the other working parts are directly or indirectly related. It is known as backbone of the engine due to its importance. Through the connecting rod, it converts reciprocating motion of the piston into rotary motion.

Reduction in cost is applied in reverse engineering process a main criterion for specifying dimensional tolerance; hence, knowledge of the employed manufacturing process is required for Reverse Engineering Product. The tolerances optimize product performance, allow assemble of parts in the desired way, and ensure component interchangeability, whereas looser tolerances maximize production yields and lower production costs.

The bearing dimensions in the designer direct control are the width and the clearance ratio. Obviously, increasing the width will also increase the film thickness for a given Set of operating condition. These increases would allow an increase radial clearance, which is beneficial for remanufacturing and disassembly reasons. Also, to maintain a full Lubricant film, the minimum thickness must be ten times the surface roughness in the bearing .The bearing surface is ground and lapped, the achievable surface roughness. In some of design the value of either width or clearance to use, we will need to make an assumption and collect information from design data book. In a design the bearing number is affected by (1) Absolute lubricant viscosity (2) Angular shaft speeds (3) Radial loads (4) Radial clearance (5) Journal dimensions. The bearing number is related with (1) dimensionless minimum-filminess, (2) Attitude Angle (3) Dimensionless coefficient of friction variable**.** The greatest challenge is to redesign a bearing that operates at high speed and high temperature and is suddenly brought to idle.

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III. RESULTS AND DISSCUSSIONS

Reverse engineering is to asses an integrated design outline of adjacent mechanical components. Reverse engineering aims at reproduction of and turbine blade, 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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