Reverse Engineering in Product Manufacturing

[1]Pranil Vijay Sawalakhe [2]Ranganathaswamy M K,
[1 2]Department of Mechanical Engineering, Faculty of Engineering and Technology, Jain (Deemed-to-be University), Bengaluru, India
Email: vs.pranil@jainuniversity.ac.in

ABSTRACT: ***In the field of manufacturing and design industry, reverse engineering has proved to be beneficial for the growth and development of the mechanical industries. This technique has been generally accepted as an effective product design and development process technique. In standard computerized manufacturing system, the operating order normally begins with the concept of the product and finishes with various types of machine or CNC operations to turn raw material into finished product which is ready to enter in the market. Using some digitization methods, it is always necessary to replicate a CAD model of the actual component where the documents and drawings prepared by the designers are not accessible and are needed for review and modifications to create an enhanced product design. The essential steps involved in reverse engineering method include classification of geometric structures and associated surface depictions, segmentation & the surface fittings of the basic & free-forms model shape & the development of realistic CAD models. This paper discusses about the technique of reverse engineering and its implementation fields related to the advancement of product design. Re-design of the product and reverse engineering work would substantially minimize the costs and time required for manufacturing the physical components in the manufacturing industries.***

KEYWORDS: CAD Modelling, Manufacturing Industries, Reverse Engineering, Scanned Data.

INTRODUCTION

In the past three decades the world has undergone three digital convergences. Through when emerging innovations crack the boundary between tangible and digital ways, emerging items are delivered and new opportunities are developed. The 1970s utilizes signal processing (1D) to facilitate digitized audio, rendering analogue to digital transfer part of a shared vocabulary in the telecom industry. Using digital recognition (2D), the 1980s brought in digitized images and fonts. The ease of flipping between paper and electronic media has transformed the publishing business, and the way content is processed and exchanged [1].

Beginning in the 1990s, the third integration focuses on digitizing the real world with the help of the geometric modelling (3D). The transformation between physical and digital environments with the assistance of forward and reverse engineering technologies will radically change the way goods are developed, produced, and marketed. The largest innovation of the twenty-first century would be in industrial sector by making a digital image as quickly as taking a visual image. Reversed engineering may used for either re-creation the higher-values company pieces to company gain or valueless heritage sections to historic preservation. The designer requires an awareness of the design of the initial component and the ability to reproduce the signature features in order to accomplish the mission. In the fields of industrial production and mechanical engineering, reverse engineering relates to the process of generating data from current components and their assemblies for product design and documentation. Although he translates engineering models and concepts into actual parts in traditional engineering systems, actual parts are converted into engineering theories and ideas in the reverse engineering method [2].

Reverse engineering is very popular in a broad variety of fields like digital engineering, mechanical engineering, entertainment/animation industry, electronics, chemicals, microchips, medicinal goods etc. Focus onto mechanically engineering environment, by implementing reversed engineering technique, an actual component gets recreated utilizing touch or non-contact digitizing or measuring instruments to collect data on the surface or geometrical features of it. By utilizing reverse engineering, product development profits from the intensive usage of the CAD/CAM/CAE platforms.

And therefore provides significant improvements in quality control, consumer materials, re-design performance, production and research. Hence, the reversed engineering gets going alongwith significant businesses advantages into shortening cycle of products development. Reversed manufacturing was used for manufacture other metal components, like valves, O-rings, nuts and bolts, parts of engine and gaskets, and is commonly employed in other industries. The “Society for the Manufacturing Engineer” (SME) notes reversed engineering method “starting alongwith the finished products or procedure & moving backward into the sequential manner for finding latest technologies behind it” [3].

Manufacturers worldwide have used reverse engineering in the production of their goods. A new analytical technique, which includes high-resolution microscopy and three-dimensional (3D) lasers scanning &, has allowed reversed engineering, but more needs to get learned. Various specialist organizations, from their viewpoint, have established the concepts of reverse engineering. Applying information in mechanics, mathematics, and science in data processing and understanding; usage of reverse engineering methods, equipment and software Performing effective trials and tests to collect the required data into the reversed engineering; defining, formulating & addressing reverse engineering issue; recognizing legal & the ethical obligations related for the reversed engineering; reviewing & analysing documentation and promoting the achievement of reverse engineering has been integrated into acceptable mechanical design and manufacturing technical requirements and various practical product restrictions through specific expertise in different disciplines [4].

The component developed by reverse engineering will follow the specifications set out in the relevant program guidelines. Needs efficient reverse engineering operation. While it has its origins in ancient periods of history, modern developments of reverse engineering have rendered this technique one among key methodologies used into many sectors, includes automobiles, consumer electronic, aerospace, medical instruments, toys, sporting equipments, & jewellery. This is often applicable to inquiries into forensic studies and accidents.

1. Origin of Reverse Engineering:

Throughout the Cold War and World War II, reverse engineering was frequently used. This is also used by the military to clone the equipment, tools or knowledge, or sections of that have acquired from regular forces into field or from the intelligence operation, from another country. Into the recent years, improved computing capacity, much machine resources, & higher-speed touch or the non-contacted scanning machines, discrete geometries have become increasingly important into the designs, production, & the quality control of automotive systems. The effect of reverse engineering in the automotive sector has been rising day by day in the last year and it often plays a significant role in fostering technological transformation by merely removing the costly goods and generating increased rivalry. The total life span of new innovations is significantly shorter, though. Reverse engineering provides a high-tech method to handle this exponential pace of reinvention of existing machinery and equipment and speed up the reinvention cycle for potential technological evolution [5].

2. Introduction to Process of Reverse Engineering:

Reverse engineering method involves three key phases that are used to gain information regarding the product's structure, material, design, surface properties, and working conditions etc. The procedural steps are described as the period of scanning, the stage of point processing and solid modelling. Researchers further classified such steps as data collection, pre–processing (merging and noise filtering), triangulation, selection of images, and fitting and segmentation of surfaces. Figure 1 demonstrates how the RE functions. The whole reverse engineering phase can be helped by computers. In the design technique, part scale (small or large), part difficulty (complex or simple), part substance (hard or soft), structure of part (organic or prismatic, external or internal), finishing of part (shiny or dull), numbness must be deemed a few points before reverse engineering is carried out [6].

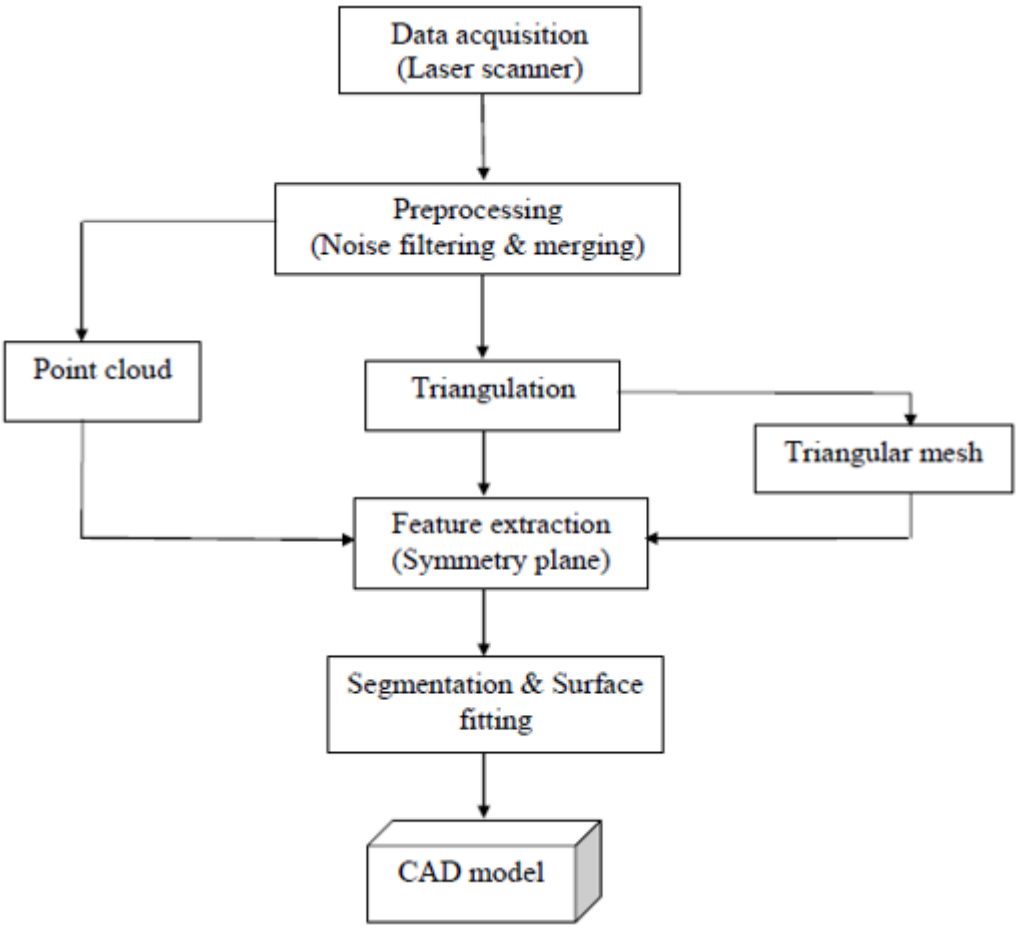

Figure 1: Flow of Reverse Engineering Process

2.1. Scanning/Data Acquisition:

The aim of this process is to collect information about the physical part's geometric dimension by scanning. During this phase, the physical component to be recreated is primed for scanning and then the actual scanning is carried out with an accurate scanner (laser or CMM) to collect all the details regarding the specific features of the item, e.g. curves, gaps, spaces, moves, etc. There are typically two forms of touch form scanners, non-contact and contact. Touch scanners are those that have a communication probe that passes around the actual part's outline. “Coordinate measuring machine” (CMM) is a prominent example of the contact scanner, while non-contact models are the ones that do not have a touch probe, rather they use optics, lasers, and CCD sensors to collect the details [7].

2.2. Pre-processing/Point Processing Phase:

Information collected as a consequence of scanning is analysed in this step in order to minimize the noise and to reduce the amount of data points. Various filter forms are essential for lowering cloud points. This process also provides the option of fusing multiple scan data sets. Multiple tests are often done on the component to ensure sure all of the elements are tested. To achieve so, a component is rotated, and it is important to prepare a decent data such that data sets can be combined efficiently, which ultimately decreases the frequency of point data mistake. A variety of commercial software's for point processing are open.

2.3. Triangulation and Feature Extraction:

It is a process by which point data are formed or divided into triangles. In this step point data triangulation is done by constructing a triangular mesh with the help of the algorithm which is suitable for the process. Extraction of the feature is the next step in this method and is described as the process of identifying a collection of features or image characteristics that will reflect the information that is essential for classification analysis in the most efficient way possible.

2.4. Segmentation and Surface fitting, and Solid Modeling:

This is regarded as the most complicated stage in reverse engineering, because dynamic fitting algorithms are used to produce surfaces that flawlessly reflect the 3D details depicted in the point cloud data sets. In reverse engineering the segmentation is perhaps the most important phase. Segmentation is described as the process of splitting a triangular mesh into sub-meshes to which a suitable single surface can be fitted which seriously affects the quality of the resultant CAD model and then obtains the physical part's 3 dimensional CAD model. In particular, the segmentation method provides an estimation of surface properties in the first & the second orders. The first-ordered segmentations, centred onto ordinary vector, give initial surfaces classification & identified sharp edge along with flattened curved regions. The segmentation of the second order subdivides the surface by key curvatures and offers an appropriate basis for classifying simpler algebric surface. Many of segmentations algorithm comply alongwith surfaces fitting that suits each segmented area with the best primitive surface of suitable kind. A hierarchy of surface forms must be defined in the geometric complexity order. As mentioned above, the feature-based segmentation offers adequate context for the primary & the secondary geometries distinction as seen into Figure 2 or non-parameter & the parametric surface. Algebraic structures, like the planes like triangles, tori, cones, and circles are readily to be built in these areas [8].

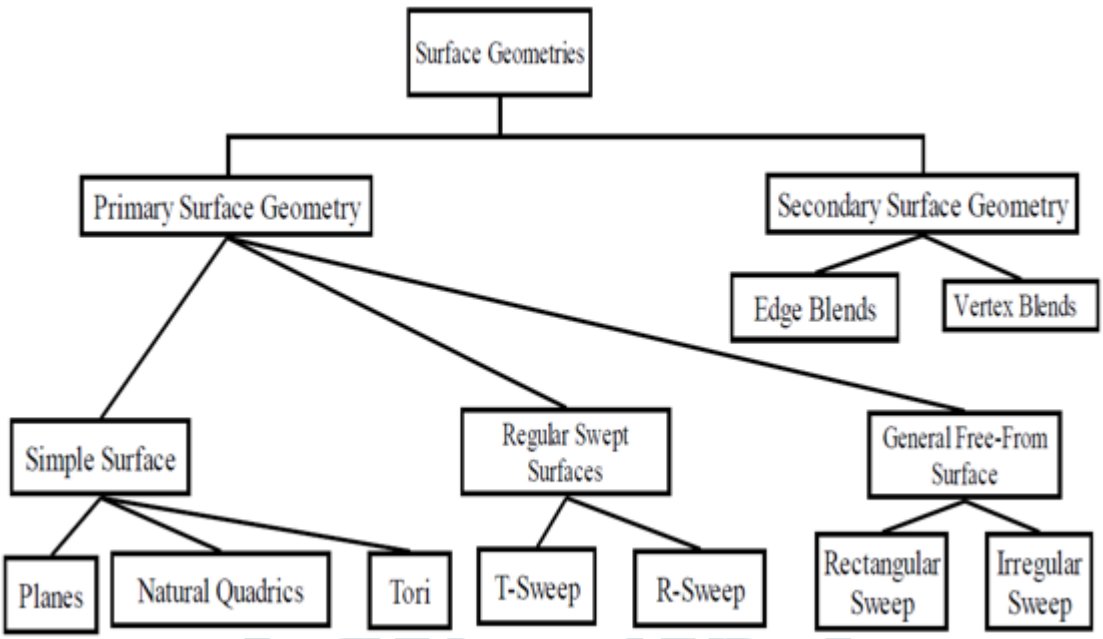

Figure 2: Surface Hierarchy

Possibly, solid modeling is used for shape engineering processes to enable reverse engineering utilizing some modeling tools like CATIA, Pro / E, AutoCAD, etc. Of solid models there exist two essential representation: feature-based and boundary representation. There are several methods where researchers proposed that boundary representation structures be built automatically by the point cloud or the triangular meshes alongwith profiles curves. This produces from connecting the point towards points into splines shape. Few of them concentrated on the identification of manufacturing characteristics for process planning purposes.

Using reverse engineering rebuilt the 3D model, the program would have to export the traditional CAD packages to help the concept development aspects. Convention solid models exchange by the standard, STEP or the IGES, STLs, are inadequately as the exchange of parametric details, sketch constraint & the measurements, includes solid feature, featured trees, aren't same. In certain applications, directed solid models may imported or exported, like "liveTransferTM Rapid form XOR3" module with CAE /CAD/ CAM systems, utilizing common formats like STL, IGES, STEP and VDA [9].

3. Application of the Reversed Engineering:

Reversed innovation is multidisciplinary method that can extended almost exclusively towards the automotive sector. Reverse engineering's prime uses are either to re-create a replica of part of the initial component, or to track back the details to what occurred. It is commonly utilized in the information and software technology sectors, from the creation of software code to the protection of Internet networks. Every year thousands of products are reinvented using reverse engineering to meet demands worth billions

of dollars on the aftermarket. This was profoundly revolutionized with the advent of modern media. The implementations of digitized reverse engineering in the medical device and life science industries have encountered more obstacles relative to the aviation and automobile industries, and have progressed at a more modest level. However, reverse engineering implementations have been met with some short overview as follow:

3.1 Mechanically Industry:

Generally speaking word engineering gets used for defining process of making something useful. Reversed engineering was synonymous alongwith duplication for economic reasons of an initial product. Nevertheless, the concept of reverse engineering has been legally implemented in the manufacturing world for the production of newer product or varieties of the older product. This term reversed comes by concept of the bi-directional information exchanges among both worlds of physical & digital. This main thrust into early of the stages of development of computer-aid designs (CADs), computer-aided manufacturing (CAMs) and computer-aided engineering (CAE) was producing product on computer & present results to the real world.

From its dimensional characteristics CAD meant for able for describe basic component or complicated assembly altogether. This computer representation will be taken over and evaluated by CAE elements, like thermal or structural analysis tools. The CAMs software take the same electronically definitions & generate path for partial manufacture tool cutting. Today the reverse engineering adds complicated geometry mechanical parts like car motor, turbine blade, upper casing, belt, gas package etc. to the surface formation. Boeing and other aerospace firms have used the reverse engineering technique to build automated spare-parts inventories or turn outdated information in the today's CADs environment. Method of reversed engineering having vital for the aerospace manufacturing's future as a CAD resource. For these main factors, the contemporary aerospace industry uses reverse engineering: producing obsolete components that do not have CAD models; resolving obstacles in data exchange; shortening issues that emerge from inconsistencies between the CAD master model and the real tooling or as-built part; verifying consistency and efficiency from computers-aided inspections & technical evaluation. An industry application's of the CADs is introduced to calculate and re-engineer the form of an overall ship hull and parts of the ship, which is an often occurring activity in building and repairing the ship. In order to select the most suitable measuring form, it is important to take into account certain traditional aspects of measuring unit, like its potential obstructions, height, and weak accessibility.

3.2 Software Industries:

Softwares reversed engineering associated alongwith the study of established systems. The IEEE Standards for the Soft wares Maintenance describes reversed engineering "the method for removing operating systems knowledge by the source codes". Commonly, the product for reversed engineering operation gets synthesized, high-levels detail which helps reversed engineer for properly understand system. The reverse engineering phase usually begins from lower rates of knowledge including the source code of the program, likely involving the construction environment of the device as well. While performing the task of reverse engineering, a certain process is followed by the reverse engineer. The reverse engineering process workflow could be disintegrated into the analysis, extraction, and visualization of three subtasks. Into the practice, processes have components which makes ad hoc as well as creativities [9].

3.3. Medical Applications:

The originality for human body's architecture put reversed engineering into unique position into the health sciences & industries of medical devices, specifically when incorporating artificial part in human body. The use of scanned image in reverse engineering alongwith finite-elements modeling lets engineers specifically model personalized parts that better suit particular patients. In health science and medical devices the fundamental criteria for reverse engineering are for the functional nature of human organs, living cells, and the interactions between them. Also scientists and engineers operate in the opposite direction will assist with observable body activities and the processes that will replicate certain bodily functions must be underpinned by the biochemical elements there [10].

The engineers would first define the components required for this component and medical product features in the reverse engineering setting, then digitize the abstract element type correctly and check the production procedure. In many therapeutic areas, reverse engineering is used: hearing aids, dentistry, artificial heart and knees. Advanced computer-aided design systems may develop customized orthodontic products for specific individuals, depending on specifications. The development of reverse engineering applications depends more on technical innovation to render the wireless hearings aid small, much advanced, & much cost-effective. Reversed engineering approaches of orthopaedics, like hip, knee or spine implantation, are very difficult, partially because of the complicated hip, knee, or spines movements. The proper functions for the reversed engineered implant allows them to withstand multi - axial statistical stresses and different types of dynamic loads [11].

DISCUSSION & CONCLUSION

In several industries the basic concepts and basic drawbacks of reverse engineering are identical. The traditional practice of reverse engineering, like modelling, data collection, prototyping, micro-scale detailed analysis, performance assessment and compliance with regulations, is in principle the same for all industries. The success of this project typically comes under the general constraints of contemporary technologies. The basic methodologies practiced in various areas, though, may be significantly different. The design of the components assisted by the CADs/CAEs/CAMs technologies allowed for efficiency of component manufactured alongwith help of the CNC machines, into advance management to the fast products creation & the accelerated production set-upto register customer's time requirement in whole. Reverse engineering (RE) enables the production of surface models through a three-dimensional (3D) scanning technique for certain product development techniques, and this method must then be allowed in a limited development time to reinvent and produce different part (to vehicles, household appliance) & the equipment (press machines, mould, die).

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