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PRODUCT DEVELOPMENT FROM 3D SCANNER TO CNC MACHINE IN REVERSE ENGINEERING

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ABSTRACT

The purpose of this article is to introduce reverse engineering procedure (REP). It can achieved by developing an industrial mechanical product that had no design schemes throughout the 3D–Scanners. The aim of getting a geometric CAD model from 3D scanner is to present physical model. Generally, this used in specific applications, like commercial plan and manufacturing tasks. Having a digital data as stereolithography (STL) format. Converting the point cloud be can developed as a work in programming by producing triangles between focuses, a procedure known as triangulation. Then it could be easy to manufacture parts unknown documentation and transferred the information to CNC-machines. In this work, modification was proposed and used in RE program, which is from CAD-CAM software's that used to redesign and modify on point of cloud in 3D modeling. This paper presents reverse engineering (RE) of the flange of water pump. Used mechanical and damaged parts have been selected which had as holes, slots, groove that are considered complex parts in RE to reach a match between original and tradition parts after manufacturing.

Keywords: 3D model, Stereo lithography, CAD-CAM, product development, reverse engineering (RE).

INTRODUCTION

Reverse engineering (RE) is a technique of enhancing learning and outline data from anything man-made and repeating it or re-creating anything in view of the extricated data. "The basic concept of producing a part based on an original or physical model without the use of an engineering drawing" [1]. The application environment of RE is built with coordinate measurement machine (CMM) and CAD/CAM software [2].

A big economical advantage is that products made by rapid prototyping express a low risk failure and the manufacturing process takes less time and lower costs than the conventional techniques [3].

Computer-aided design (CAD) is the use of computer technology for the design of objects, real or virtual. The design of geometric models for object shapes, in particular, often called computer-aided geometric design (CAGD). However, CAD often involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD often must convey also symbolic information such as materials, processes, dimensions, and tolerances, according to application-specific conventions. CAD may use to design curves and figures in two-dimensional ("2D") space; or curves, surfaces, or solids in three-dimensional ("3D") objects [4].

Computer-aided manufacturing (CAM) is the use of computer-based software tools that assist engineers and machinists in manufacturing or prototyping product components. Its primary purpose is to create a faster production process and components with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material (thus minimizing waste), while simultaneously reducing energy consumption. CAM is a programming tool that makes it possible to manufacture physical models using computer-aided design (CAD) programs.

CAM creates real life versions of components designed within a software package. In 1971, CAM was first used for car body design and tooling. Integration of CAD and CAM environment requires an effective CAD data exchange.

Usually it had been necessary to force the CAD operator to export the data in one of the common data formats, such as IGES or STL, that are supported by a wide variety of software. The output from the CAM software is usually a simple text file of G-code, sometimes many thousands of commands long, that is then transferred to a machine tool using a direct numerical control (DNC) program [5] [6]. Which will improve the quality of the results and address issues that might occur during the scanning procedure [7].

The points of RE are making a section in light of unique model without the utilization of an official illustration. The objectives of this work is to develop an original product that makes the tradition more accurate compared to real part design.

METHODOLOGY

The proposed RE methodology is shown in (Fig.1). This method is the most commonly used. It consists of getting the virtual model 3D-CAD of an existing object with the help of software that contains the starting scan [8]. After large point, clouds (3D scan data/ STL) to be imported GEOMAGIC software. Taking in high-resolution 3D scans or any mesh data, at preparation the segmentation and meshes-doctor automatically to analyze and repair the polygon mesh and clear-out defects and create watertight mesh models. Then They Are getting 3D-CAD model by Solid works to convert the point cloud in a solid 3D CAD model [9].

The obtained CAD model can used be to get the automatic NC code for the manufacturing of product as further work with CAD/CAM integration [10]. The sketches in protrusion or revolve operations to rebuild the

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features of the initial object are used [11]. Finally, export to NX-software to generate G-GODE for CNC milling as shown in (Figure-1and Figure-2).

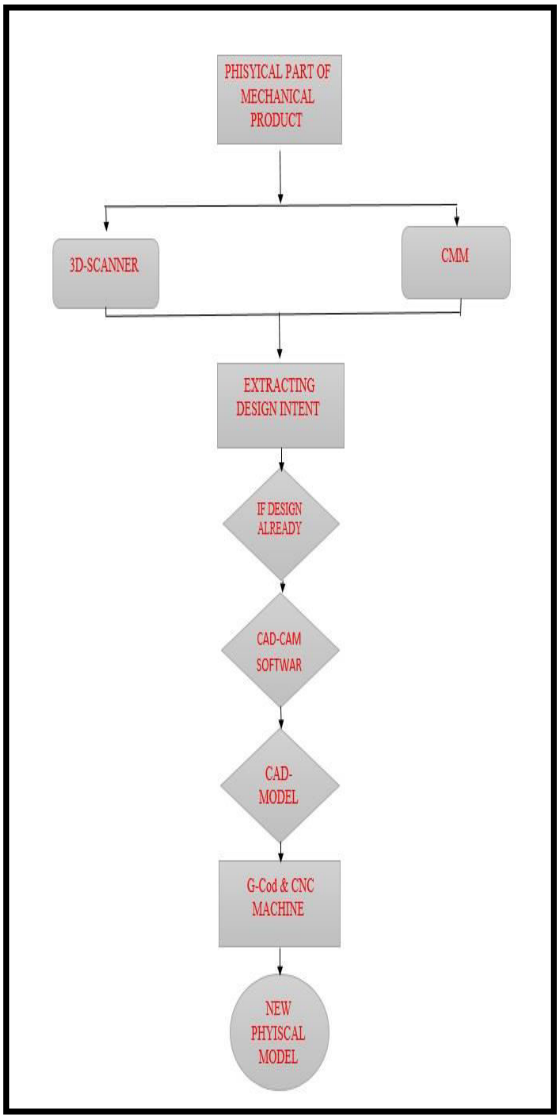

Figure-1. Schematic diagram of proposed RE methodology.

Steps of RE implementation

Principally, the RE steps can be considered as a development chain that is composed of three main operations as follows [12]:

a) Digitization of the object: The three-dimensional shape of the product is acquired by any appropriate measurement method.

b) Processing of measured data: The three-dimensional data acquired is processed in order to fulfill the requirements of the following operation.

c) Creation of a CAD model: A complete CAD model of the product must be built in order to represent all relevant data of the product.

(Figure-2) shows the Main steps in RE implementation. The full process of RE had better than computer aided.

Case study

The scanning system consists of an optical scanner EINSCAN-S, Turntable, and reverse engineering GEOMAGIC DEISGN X software. Prismatic flange of water pump is an object to scan.

Before a scan is attempted, for producing some high quality scan of an object that is glossy, see-through, unclear, or very dark. Therefore, the flange was painted with non-radiant painting as shown in (Figure-3 and Figure-4).

After finishing from painting, the second step was calibration of scanner that ensures the position of the turntable and projector to record accurately so the 3D-scanner can produce the best possible scans.

The scanner had been calibrated in normal lighting. In addition, to avoid direct overhead light, though. The light source must be behind the scanner so it is not shining right into the camera. Therefore, to catch the most of details of the part, examining in low light is best to get the best outcomes. The screen ought to be as dark as possible when the filter is on, as seen in Figure-5. (Figure-6) presents the scanning format that was to acquire digital data into STL.

The teeth of flange did not appear correctly and irregularities in holes and surfaces. So, to examine the basic dimensions by MESHMIXER software as shown in (Figure-7).

The measurement accuracy in the trial inspections is crucial in deciding the outcomes or not. All the differences of dimensions in flange were adjusted, and the uncertainty points in the study were estimated.

Table-1, demonstrates the deviations between the scan data and standard to adjustment precision of the measuring tool. However, to produce a high-quality scan of an object, the data obtained after the scanner is aligned in order obtain the cloud of point that will be processed through reverse engineering.

The application of software (GEOMAGIC DEISGN X) will segment the mesh into different colored feature regions as shown in (Figure-8). It has a feature that helps to repair the mesh and draws the surfaces of the flange.

The X-Y-Z interactive alignment method was used to select a mesh and divided the model view vertically into two views. The left view is the source and the right view is the reference as shown in (Figure-9). This region is used to create drawings that define the various features of the initial object (Figure-10). Then sketches drafted and extruded as shown in (Figures 11, 12, 13, 14 and 15), it is the body of the flange. Making the threads of flange created the angle of thread as shown in (Figure-16), spiral curve. Finally, the surfaces of the body of the flange are filleted as shown in Figure-17. Therefore, the model is export to Solid works for more features and modeling histories. In GEOMAGIC DEISGN X and after modifying meshes, the accuracy of the analyzer in

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allowable range was green color as shown in (Figures 18 and 19). The 3D virtual CAD model of the flange is then obtained as shown in (Figure-20).

Manufacturing of part

CAD-model used after designing in CAM system to generate G-code by special software like Siemens NX, but it will print in three dimensions so to examine the scale of the part then work on CNC-machine as found in Figures 21, 22, 23 and 24.

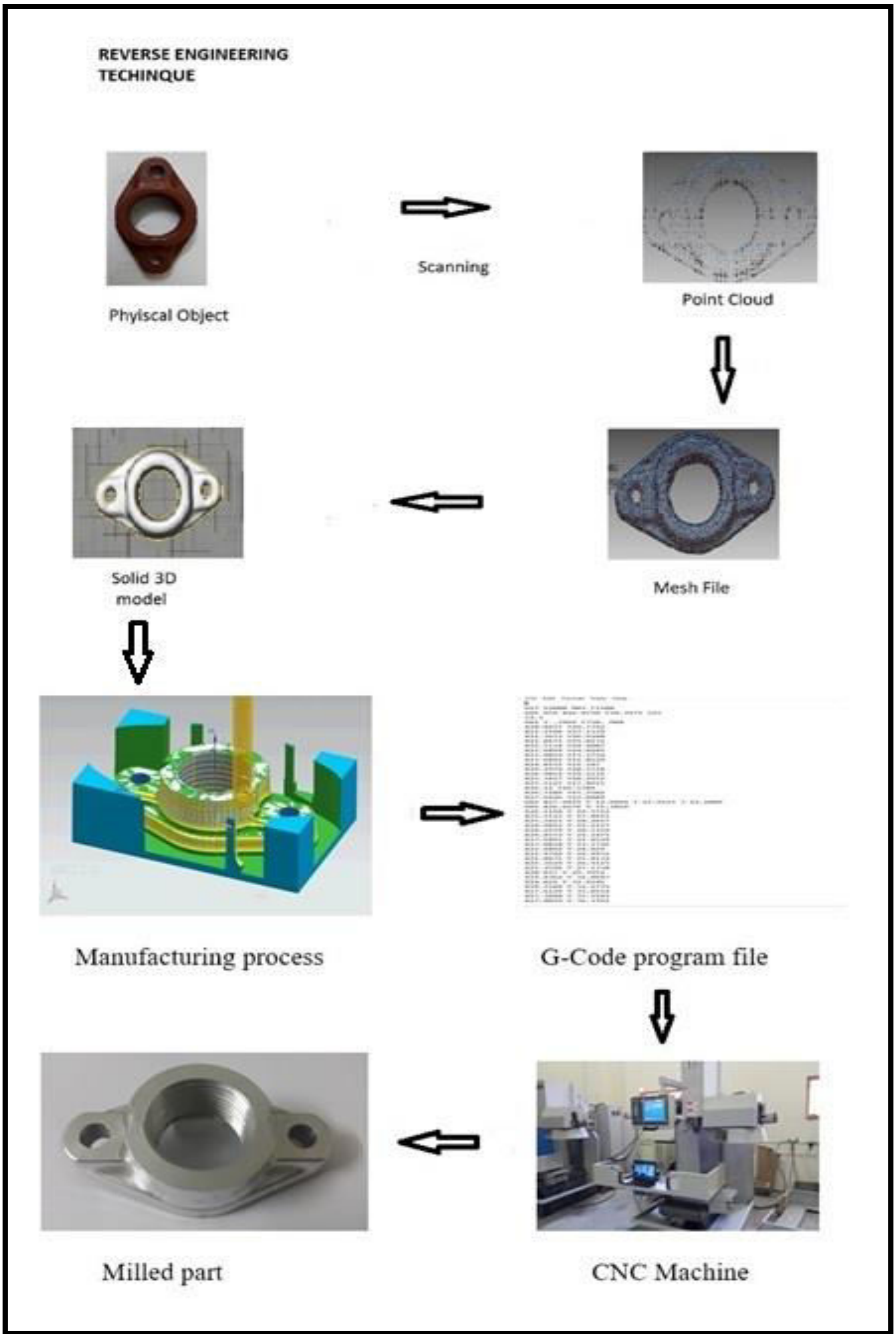

Figure-2. Main steps in RE implementation.

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Figure-3. The original flange: Front view (on left) and Back view (On right).

Figure-4. F.V of pump flange with red painting (on left) and Back view (on right).

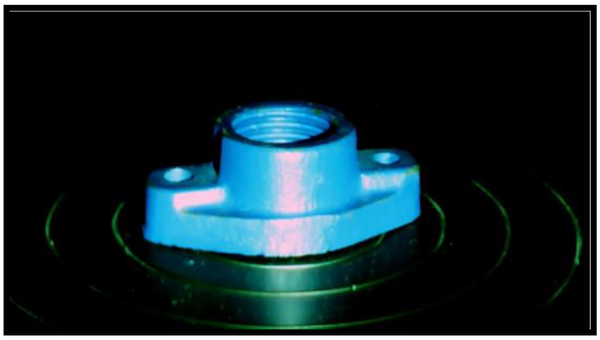

Figure-5. A good preview screen view of a 3D scan.

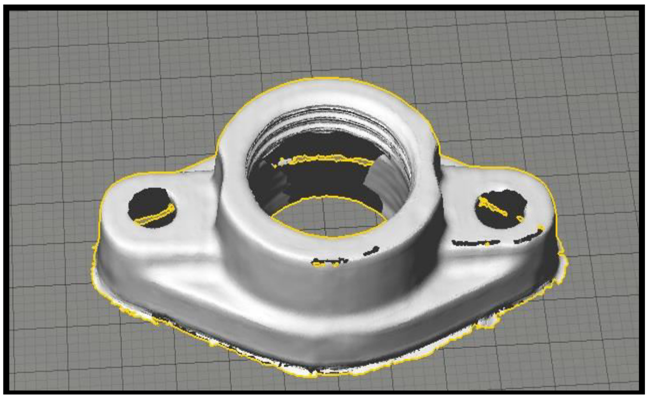

Figure-6. Bad teeth and surfaces.

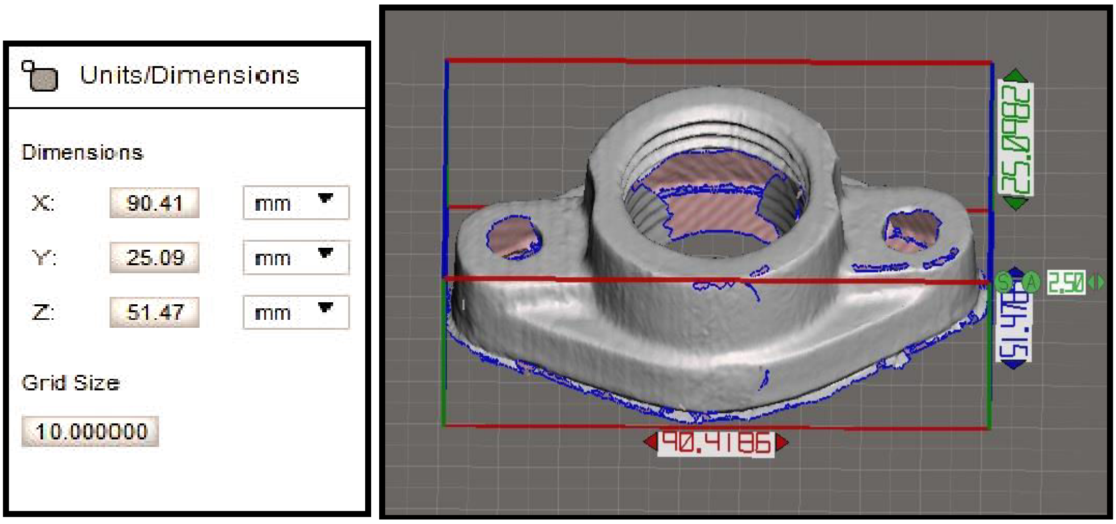

Figure-7. Dimensions of flange (Before modifying).

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Table-1. Differences of dimensions in flange.

No.	**Standard dimensions of flange by Cmm** (Mm)	**Dimensions of scanner by Meshmixer** (Mm)	**Deviations between the scan data and standard** (Mm)
X	87	90.41	3.41
Y	20. 5	25.09	4.59
Z	49.90	51.47	1.57

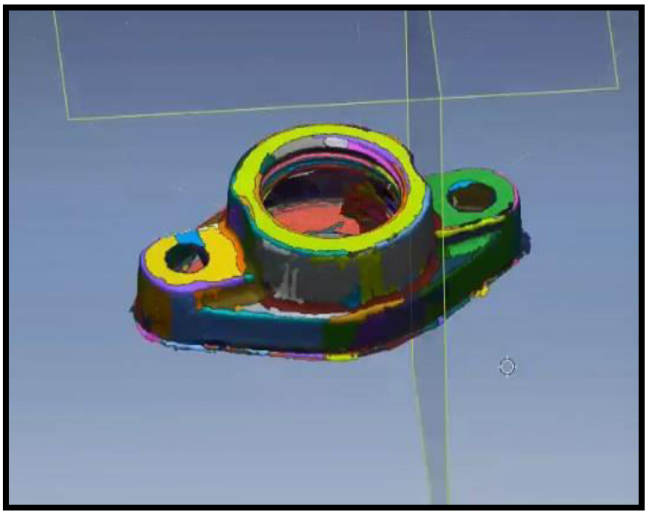

Figure-8. The regions.

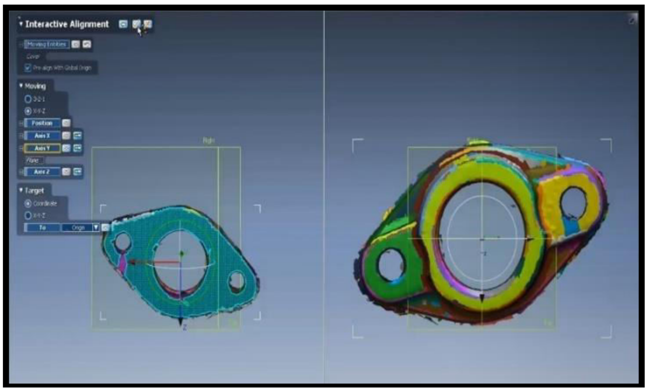

Figure-9. Choose y-axis and reversed the direction of the selection.

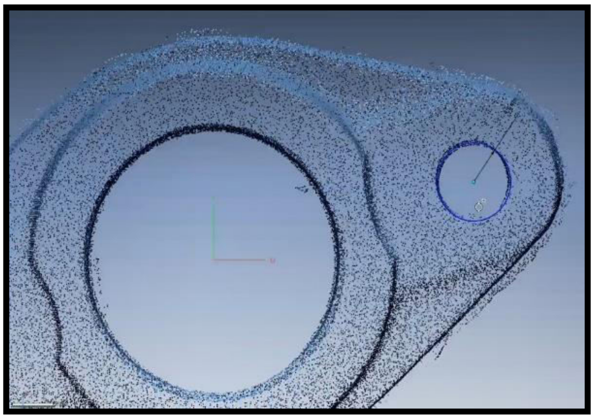

Figure-10. Sketches to reconstruct the initial object.

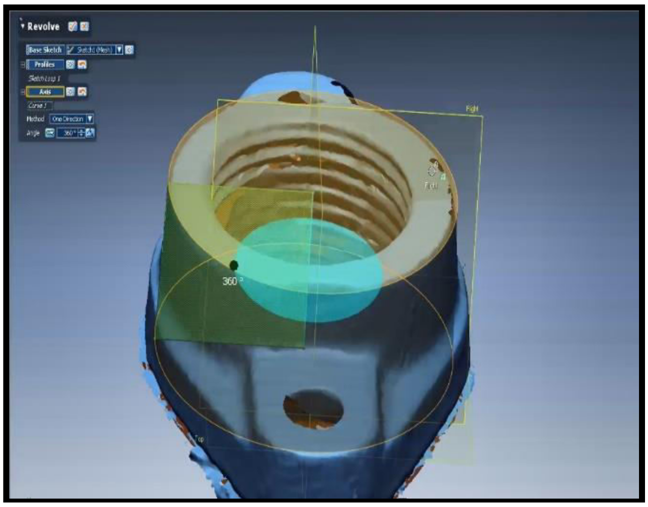

Figure-11. Revolving about axis 360.

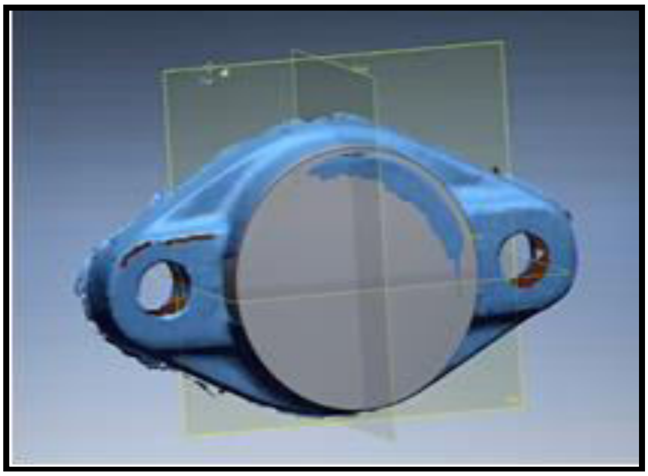

Figure-12. Revolve central circle.

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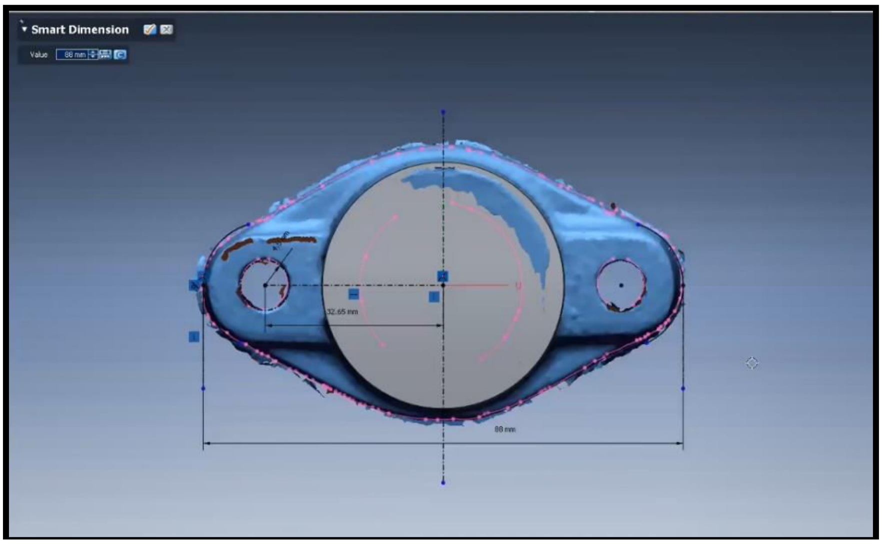

Figure-13. Width of flange by take 87 mm long.

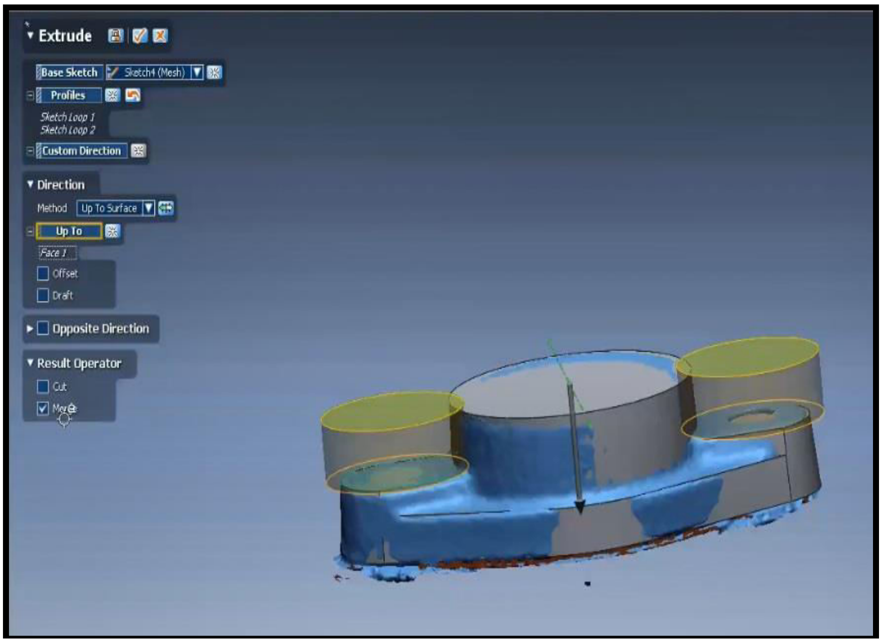

Figure-14. Two circles in both sides.

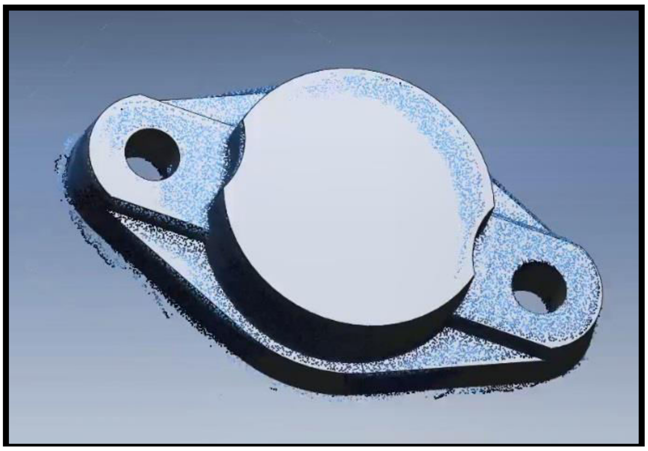
Figure-15. The body of the flange.

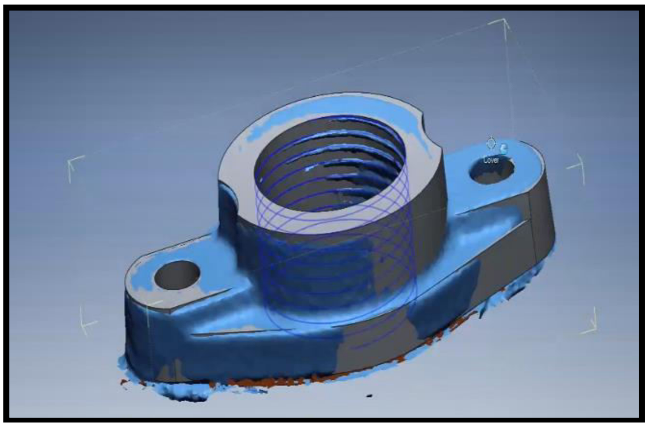
Figure-16. The spiral along the hole.

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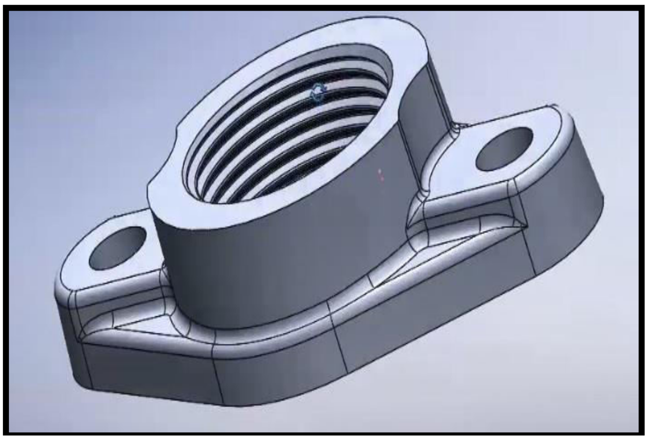

Figure-17. Fillet the rims of flange.

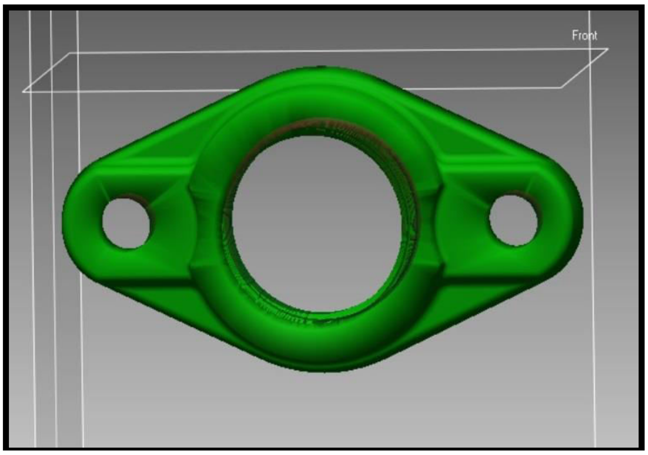

Figure-18. Allowable meshes.

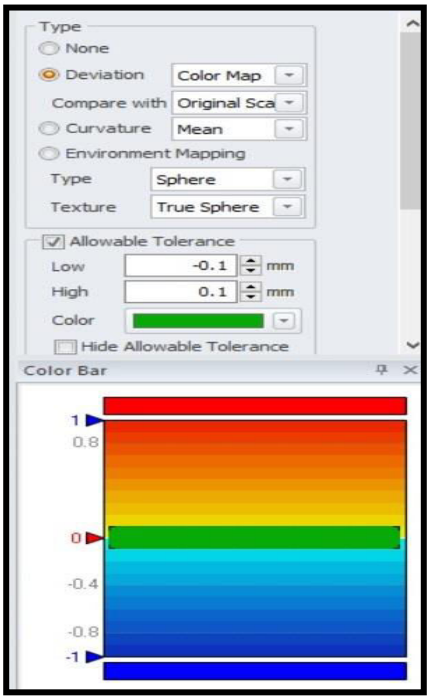

Figure-19. Deviation in color map.

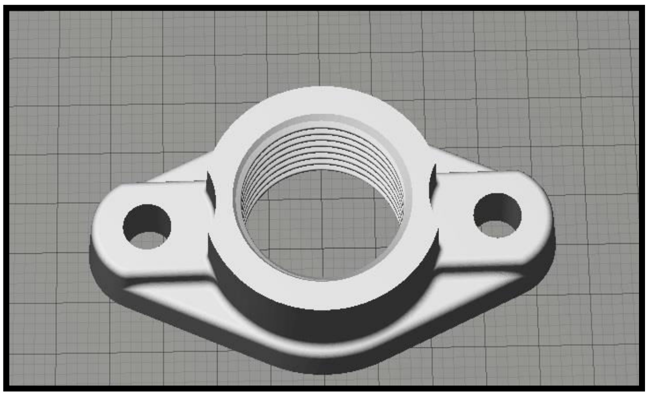

Figure-20. STL model format.

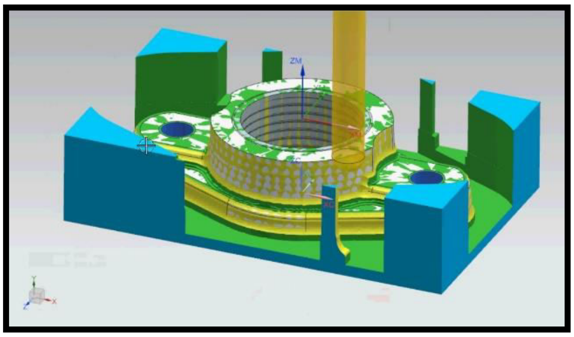

Figure-21. Manufacturing process in Siemens NX.

Figure-22. Milling in CNC.

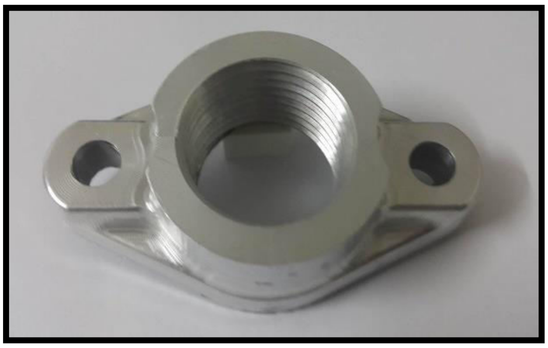

Figure-23. The final flange.

Figure-24. Flange in 3D-printing (rapid prototyping).

RESULT AND DISCUSSIONS

Before modifying and rebuilding to get CAD-modal, the deviations in dimensions of flange for the reason that the chamfers of 3D-image as shown in (Figure-7). These chamfers took about (1mm) in length and height of two sides for flange, but in depth (2.5 mm). The differences of dimensions in flange are presented in (Table-1). So, the dimensions of the original flange took to adjust and apply on mesh in GEOMAGIC DESIGN X software as shown in (Figures 25 and 26).

The generated CAD-CAM model of the flange of the water pump was recognized between of original & traditional (flange) for the given deviations in dimensions. The results of the basic differences are present in (Table-2). See (Figures 25, 26, 27 and 28). The calculated uncertainty in the present study was less (0.2 mm) and more than (0.4 mm) in all deviations these due to fillet the rims.

When comparing the results of the RE methodology with industrial tolerances for the flange, it is clear that cutting and milling sample is used in production CNC machine. In general, the cost of manufacturing increased when the surface finish improved just as different manufacturing processes produce parts at various tolerances.

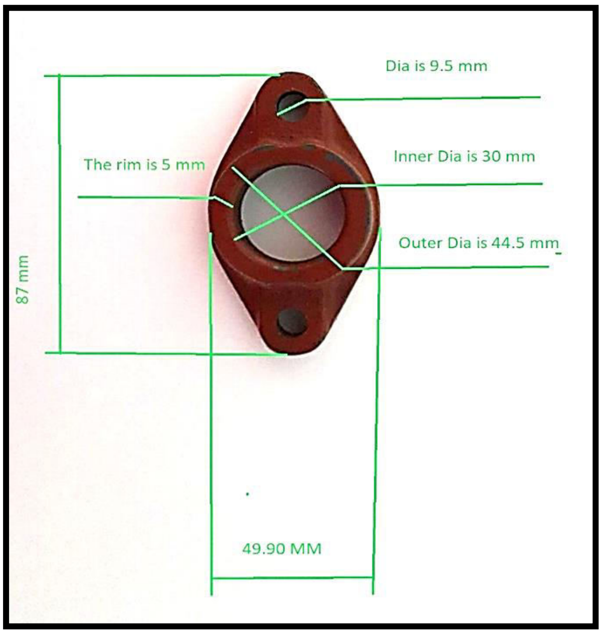

Figure-25. Reference dimensions for front original flange.

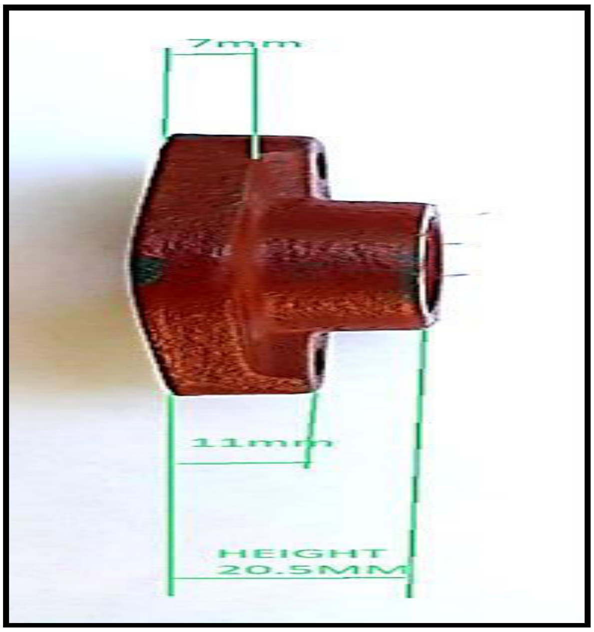

Figure-26. Reference dimensions for side original flange.

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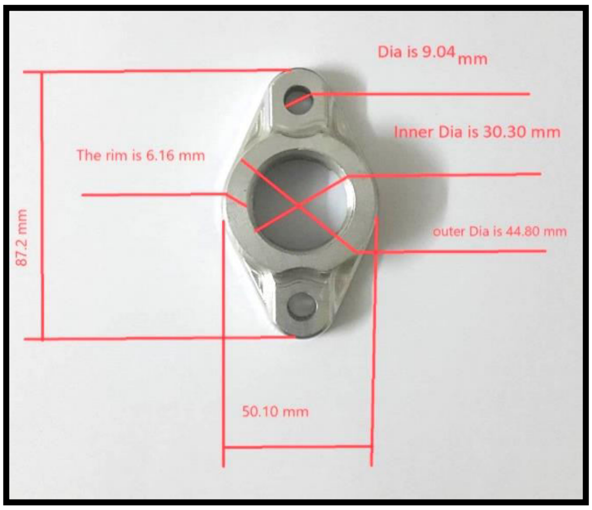

Figure-27. Reference dimensions for front traditional flange.

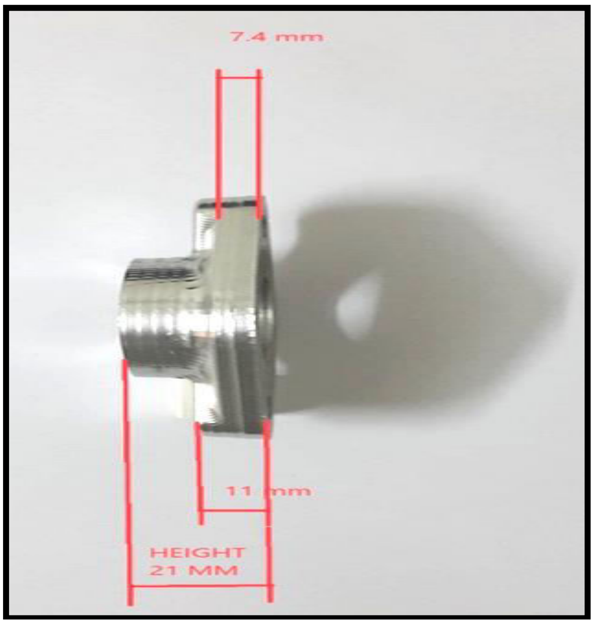

Figure-28. Reference dimensions for side traditional flange

Table-2. Differences of original & traditional (Flange).

Items	**Original dimensions of flange** (mm)	**Traditional dimensions of flange** (mm)	**Deviations between original &traditional** (mm)
Length of flange	87	87.2	0.2
Width of flange	49.90	50.10	0.2
Height of flange	20.5	21	0.5
Central circle	30	30.30	0.3
Small circle	9.5	9.04	0.46

CONCLUSION AND FUTURE SCOPE

Reverse engineering is a technology that is in a perpetual development and can practiced in various areas. One of them in mechanical engineering.

The paper presents the main steps of getting a CAD model to working to be physically realized in order to get a spare part for the used in service flange, or in the manufacturing of spare parts, as soon as documentation or the manufacture no longer occurs. It cuts the time and effort to plan a product. It presents that a valuable level should be appoint, to capture excellent model details. In addition, it presets charge longer processing times and will take turn for better STL had the biggest on size.

Finally, to develop better and improved manufacturing in future by studying of mechanical characteristics in an FEA simulation such as ANSYSIS software.

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