Reverse Engineering Based Modelling Manufacturing and Analysis

S.S.Pawar
B.E.-Mechanical
Gramin ITI Kandhar
SRTMU Nanded

Suresh Kumar Chakka
ME- Mechanical (CAD/CAM)
Department of Mechanical Engineering
SRTMU Nanded.

ABSTRACT
Many times in industry parent parts of the machine are damaged and required to manufacture without its drawing because the original manufacturer may have gone out of business but the part is vital for their business, for simple parts it is easier to trace the geometry and manufacture the part but for complicated it will take much time to replicate the geometry and manufacture the part. ***Many times failure of parts takes place during the working conditions and it is quite difficult to trace the reason behind failure as we do not having CAD file for finite element analysis or actual parts for experimental analysis.*** A dramatic paradigm shift has occurred in the design engineering and purchasing community regarding the design of new components. In the past, design engineers, manufacturers and component testers worked with a wall between them. These groups rarely talked during component design and sourcing and when they did, it was for finger pointing when an error was uncovered. This lack of communication led to observation that 80% of component problems could be solved for 20% of final cost if various groups communicated and solved problems in the early phases of design. There is need of new paradigm to takeout the "wall" between the designer, manufacturers and testers so they can work together to generate the best product first time. This new paradigm which turns the process into an iterative system in which the design can be As product varieties increase and life cycles shorten, the need to reduce product development time becomes more critical to maintain competitiveness in the market. The reduction of the product development time, therefore, requires revolutionary improvements rather than gradual changes in technology

Keywords
Modelling. Reverse engineering, analysis, Meshing

1. INTRODUCTION
Manufacturing industry is frequently facing above mentioned problems. Many efforts were carried out for solving the said problem by application of Reverse engineering. RE can be defined as: 'Systematic evaluation of a product with the purpose of replication. This involves design of a new part, copy of an existing part, *recovery of a damaged* or *broken* part, improvement of model precision and inspection of a numerical model. Advantages of the technique include immediate feedback, data reduction, and direct generation of geometry and higher precision of the final product.

Geometrical and topological data of the component is analyzed and changed to improve manufacturability and function as it progresses. This manufacturability and function evaluation is performed via computer simulation or rapid prototyping. Computer simulation builds the component in virtual factory with design tradeoffs evaluated on the computer screen as they are proposed. Reverse engineering is uncovered by following step as described in following figure 1.1

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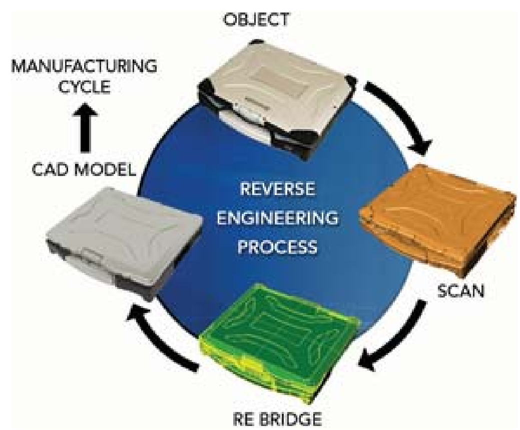

Figure 1 – Steps in Reverse engineering process

- 3 D object scanning
- Geometry cleanup
- CAD model generation
- Manufacturing of Component by RP or CNC or other suitable method.

3D scanning is the fast and accurate process of using a 3D scanner to capture and convert physical objects into digital 3D data. 3D scanners come in many forms, but the purpose of every one of them is to capture the shape, and sometimes color, of real-world physical objects or environments. This captured data is typically stored as a list of xyz-coordinates in a point cloud file. 3D scanners can be categorized as contact (CMM arms) or non-contact (white light, 3D laser scanners, or stereo-vision based)

To increase efficiency of digitization, an improved sampling planning approach is generally adopted; it is based on surface curvature and tangent line slope of a measured point. In surface reconstruction, a new adaptive extracting approach based on curvature of surface reconstructs the non-uniform rational B-spline (NURBS) surface for the scattered data. Once clear geometry and topology of the object is cleaned, CAD model is developed and can be used for further manufacturing process. The manufacturing process chosen is dependent on time and resources constraints and also on the end user requirement.

Rapid prototyping uses automated technologies to provide substantial improvements in the speed and cost of prototype creation. Rapid prototyping does not represent a break with the tradition of cyclical design by incremental improvement or successive approximation; rather, it speeds the design cycle and increases the use of prototypes to an extent that new ideas, new results, and new techniques become possible. It's also worth noting that in a commercial setting, rapid prototyping can often provide a significant and demonstrable return on investment.

In many ways, rapid prototyping is the natural result of two earlier, converging technologies. For the past several decades, Computer Assisted Design (CAD) software has provided designers with computer-based tools for drafting, mechanical drawing, architectural blueprints, and so on, offering advantages similar to those available to 2D designers using desktop publishing tools. Over the same period of time, machine shops have used Numerical Control (NC) computers with milling machines, allowing the automation of their operation, and thus the creation of parts at lower expense and greater precision. Rapid prototyping in a sense marries these two technologies by allowing designers to create plans for real world objects in the virtual world of the computer, and then in a single step to create a physical object directly from those plans.

However, there is an important difference between CAD-driven NC milling and rapid prototyping. Traditional shop techniques, whether manual or numerically controlled, are a subtractive process. They start with a block, sheet, or tube of raw material and then, by drilling, cutting, lathing, and grinding, material is removed, yielding the desired object or product. Rapid prototyping, on the other hand, is an additive process: the desired object is built from bottom to top in very thin layers.

Whereas subtractive techniques require hard-earned craft skills for the complicated and unique setups that vary with each job, additive techniques require no special knowledge on the part of the prototype fabricator. In fact, some rapid prototyping systems are called "3D Printers" because it is as easy to send a model to such a prototyping system as it is to send a document to a networked printer. Even complicated mechanisms with moving parts, multiple enclosed parts, or trapped volumes, bearing assemblies, and so on can be "printed" directly, without the need for further assembly.

Rapid prototyping is important to artists because it allows them to directly translate ideas into physical objects. It contributes to the trend in the digital arts of moving away from purely virtual creations and reconnecting with the physical world by using "high-tech" tools.

If we analyze the work carried out in this field we find that in most of the cases the work is restricted up to the retrieval of the geometry of damaged component, developing of CAD model and manufacturing of component by suitable and quick method, but in this work along with above mentioned work we have attempted to analyze the component by Finite element analysis and tried to find out the reason for failure of the component.

From the literature analyzed it can be concluded that many researchers worked on the reverse engineering process for many end applications major of the contribution is in the field of CAD model building by various approaches and then manufacturing that object by means of Rapid prototyping. Still there is lacuna in this research work is observed and that is no one is worked on prediction of failure of component by reverse engineering technology. Here we have attempted not only to retrieve the model of damaged component but tried to predict the failure of the component by using reverse engineering technology. This study aims to uncover following objectives

- To 3 D scan and reconstruct the geometry of damaged component
- To develop CAD model and clean up the geometry of the component.
- To manufacture the component by Rapid Prototyping
- To develop the CNC programme by using CAD model
- To manufacture component by CNC machining
- To make the analysis of failure of component by Finite Element Analysis.

Thus we are going to uncover large area in the proposed work by not only retrieving and cleaning the geometry but manufacturing component by two methods and also prediction of failure of component by analysis.

2. 3D SCANNING AND GEOMETRY RETRIEVAL

A 3D scanning device that uses a laser to reflect off the part and triangulate with a camera lens, allowing the scanner to determine and create XYZ coordinates. The scanner then uses these points to form a 3D digital model of the part. 3D scanners come in many forms, but the purpose of every one of them is to capture the shape, and sometimes color, of real-world physical objects or environments. This captured data is typically stored as a list of xyz-coordinates in a point cloud file. 3D scanners can be categorized as contact (CMM arms) or non-contact (white light, 3D laser scanners, or stereo-vision based). Some can even capture internal features. 3D scanning is the fast and accurate process of using a 3D scanner to capture and convert physical objects into digital 3D data. The accuracy is most important aspect in 3 D scanning it is the closeness of a measurement to the actual feature. The opposite of accuracy is uncertainty, which is an inverse perspective of the same value we have to keep the value of uncertainty as small as possible. The first process is of aligning two objects in a common coordinate system. Commonly refers to aligning scan data to reference objects in inspection applications. Wrapping a patch-work is required by quilt of freeform NURBS surfaces around scan data, quickly and automatically generating surfaces.

The most simple mathematical curve or surface that can describe a shape. For good results a "Class A" IGES surface is needed for a super smooth surface typically used in aerospace or automotive applications. When several of the same parts are scanned and the resulting data is averaged and used to create one representative 3D model then median part verification is used to minimize the effect of manufacturing defects on the resultant model by combining two or more scan data sets into one larger data set. NURBS - Non Uniform Rational Basis, or Bezier Spline. It is a mathematical model commonly used for generating and representing curves and surfaces that cannot be decimated in a uniform manner. It can also be a surface created by two or more b-Splines. First developed mid-century but didn't arrive on the desktop until 1989. Mesh data consisting of point cloud data with mathematical point spacing based on surface data. An organized STL of a cube would consist of 8 points (1 for each corner). Parametric Model - A data set that retains the history of how it was designed, so that modifications update all downstream features. Exchange of such models is supported by IGES. Solid Works is a software program that is popular for creating and modifying parametric models. We have used the technique of White Light Scanning (Interferometry) Optical non-contact method for measuring physical parts. White light scanners obtain measurements of an object by determining changes in the fringe and distortion of a pattern of white light projected on an object.

Fig 2 – 3D scanning of component

3. RAPID PROTOTYPING

Most commercially available rapid prototyping machines use one of six techniques.

- StereoLithography (SLA)
- Laminated Object Manufacturing (LOM)
- Selective Laser Sintering (SLS)
- Fused Deposition Modeling (FDM)
- Solid Ground Curing (SGC)
- 3-D Ink Jet Printing

We have developed the model by this SLS process which is developed by Carl Deckard for his master's thesis at the University of Texas, selective laser sintering was patented in 1989. The technique, shown in Fig. 2.4, uses a laser beam to selectively fuse powdered materials, such as nylon, elastomer, and metal, into a solid object. Parts are built upon a platform which sits just below the surface in a bin of the heat-fusable powder. A laser traces the pattern of the first layer, sintering it together. The platform is lowered by the height of the next layer and powder is reapplied. This process continues until the part is complete. Excess powder in each layer helps to support the part during the build. SLS machines are produced by DTM of Austin, TX.

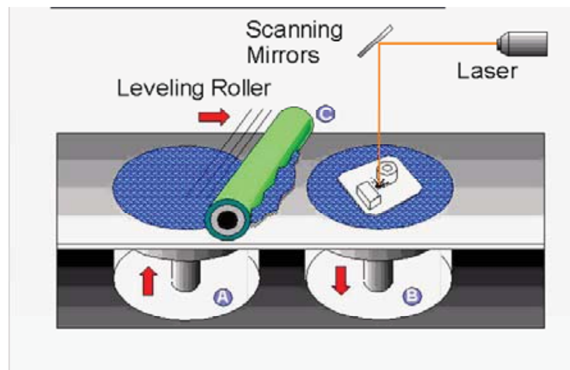

Fig. 3 Working of SLS system

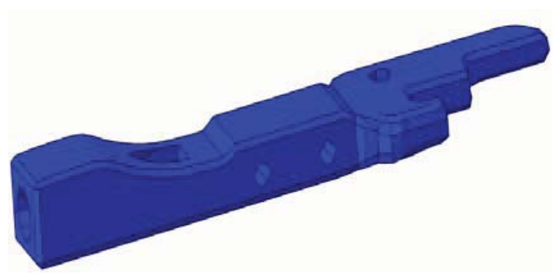

Fig 4 RP Model

4. MANUFACTURING COMPONENT BY CAM

In some cases the input program is insufficient and must be modified. While modifications ultimately need to be reflected back to the designers or process planners, machinists can be given the authorization to interactively test alternatives on the machine.

This way of working has been found especially useful when optimizing technological parameters during the setup of a new NC program. STEP-NC allows both for a rather high-level description of manufacturing features and for a detailed description of tool paths and cutting conditions, if needed. This way, once the parameters have been optimized at the machine, they can be stored in all detail in the very same data model which was handed down from the process planning department. This mechanism allows to give feedback to the planning department in a consistent manner. At the same time, it allows the planning department to prescribe exact tool paths in cases where the CAD/CAM system's output has been found to be more efficient than Controller Inc's internal feature resolution and path generation. This has greatly helped Supplier Inc to improve its overall information management and to avoid double work when re-using programs. The programme developed ,some of the programming lines developed are as given below.

```
%
N0010 G40 G17 G90 G70
N0020 G91 G28 Z0.0
:0030 T00 M06
N0040 G0 G90 X1.5073 Y.4515 S0 M03
N0050 G43 Z.3937 H00
N0060 Z.1064
N0070 G1 Z-.0117 F9.8 M08
N0080 X1.5159 Y.3654
N0090 G2 X1.528 Y.1164 I-2.4446 J-.2438
N0100 G1 X1.5276 Y-.0402
N0110 G2 X1.5044 Y-.3708 I-2.4567 J.0064
N0120 G1 X1.4929 Y-.4537
N0130 Z.1064
N0140 G0 Z.3937
N0150 X1.459 Y.4545
N0160 Z.1064
N0170 G1 Z-.0117
N0180 X1.4673 Y.3758
N0190 G2 X1.4808 Y.1165 I-2.396 J-.2542
N0200 G1 X1.4804 Y-.0401
N0210 G2 X1.456 Y-.3758 I-2.4095 J.0063
N0220 G1 X1.4447 Y-.4545
N0230 Z.1064
N0240 G0 Z.3937
N0250 X1.4113 Y.4545
N0260 Z.1064
N0270 G1 Z-.0117
N0280 X1.4198 Y.3758
N0290 G2 X1.4335 Y.1165 I-2.3485 J-.2542
N0300 G1 X1.4331 Y-.0399
N0310 G2 X1.4082 Y-.3758 I-2.3622 J.0061
N0320 G1 X1.3967 Y-.4545
N0330 Z.1064
N0340 G0 Z.3937
N0350 X1.3636 Y.4545
N0360 Z.1064
```

I. ANALYSIS OF COMPONENT

ANSYS multiphysics finite element program with the powerful pre and post processing capabilities of the ANSYS program. The procedure for an static analysis is similar to any other analysis that is available in the ANSYS program. The three main steps are:

- Build the model
- Apply loads and obtain the solution
- Review the results

For the analysis CAD model which is scanned previously is taken. Model and meshing of the component is as given in figure

- Jacobean
- War page
- size of mesh

Uniformity Above quality parameters can only be achieved by using special software like hypermesh.

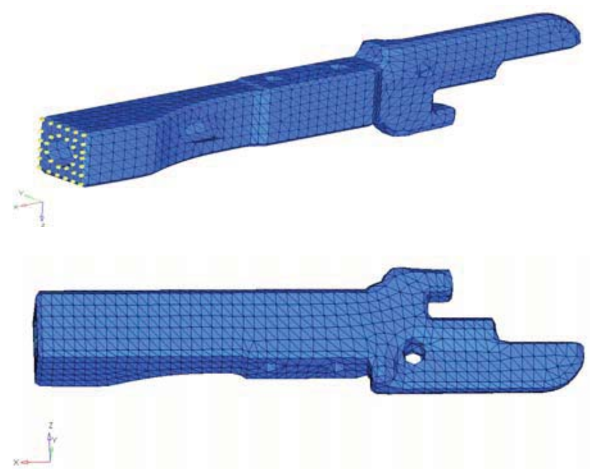

Fig 5 Meshing of component with interntional norms

Analysis is made for different modes of failure for different stress and strain as given below.The von messions stress are analysed by giving conditions in the preporcessor and porcessor which closly resembles to the actual practical conditions in which the component is subjected to the various forces.

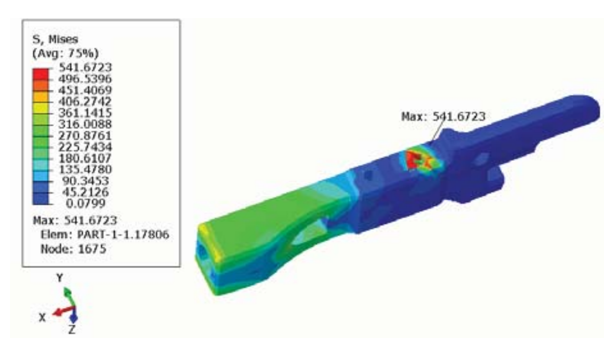

Fig 6. Results of Von Messons stress.

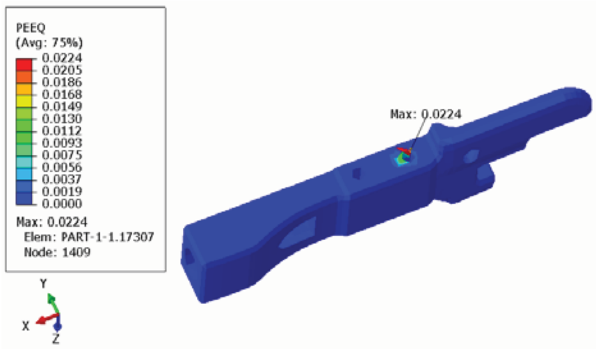

Fig 7. Results of Plastic equivalent strain

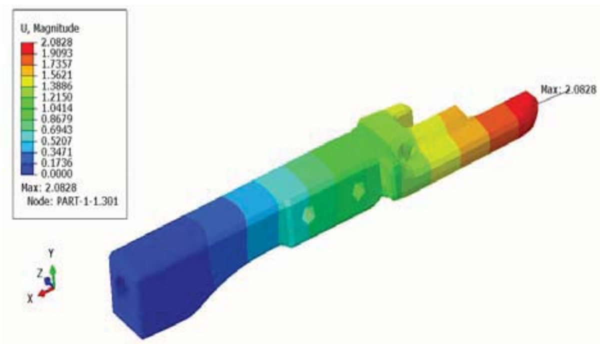

Fig 8. Results of Overall strain

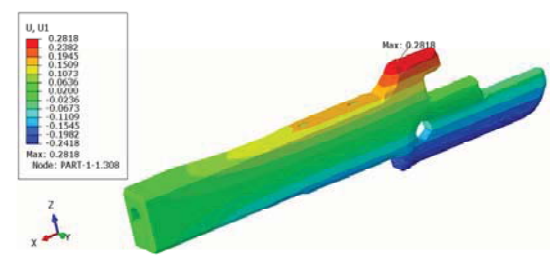

Fig 9. Results of displacement in X direction.

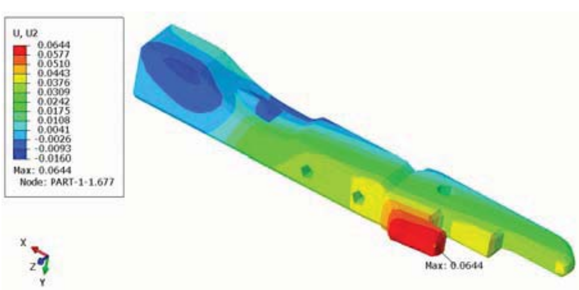

Fig 10 Displacement along Y- direction

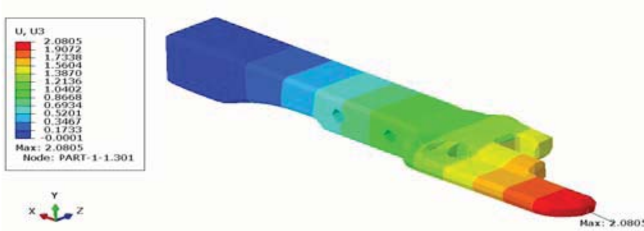

Fig 10 Displacement along Z- direction

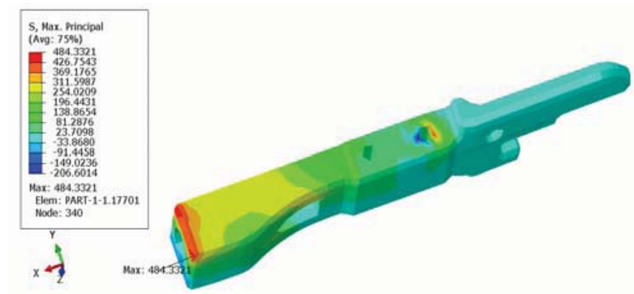

Fig 11 .Results of Maximum principal stress

Fig 11 .Results of Minimum principal stress

TAB LE 9	author email address (in Courier), cell in a table	abstract body	abstract heading (also in Bold)

5. CONCLUSIONS

3D scanning is the fast and accurate process of using a 3D scanner to capture and convert physical objects into digital 3D data. 3D scanners come in many forms, but the purpose of every one of them is to capture the shape, and sometimes color, of real-world physical objects or environments.3 D data of damaged component is processed and geometry and topology of the component can be retrieved by cleaning Bezier or B-spline curves. We have successfully adopted this technique.

Rapid prototyping is starting to change the way companies design and build products. Today's commercially available machines are accurate to ~0.08 millimeters in the x-y plane, but less in the z (vertical) direction. Improvements in laser optics and motor control should increase accuracy in all three directions. In addition, Rapid Prototyping companies are developing new polymers that will be less prone to curing and temperature-induced war page. Today's plastic prototypes work well for visualization and fit tests, but they are often too weak for function testing. More rugged materials would yield prototypes that could be subjected to actual service conditions. In addition, metal and composite materials will greatly expand the range of products that can be made by rapid manufacturing. By using the CAD model we have successfully developed RP object.

Since numerical control technology was developed in early 1950s, it has undergone significant advancement to an extent that high speed machining with ultra-high precision is realized. However, modern CNC still needs further improvement especially to cope with the information-based modern manufacturing system, such as E-manufacturing. In particular, the current .G-code. is a low level language, which delivers only limited information to CNC excluding the valuable information, such as part geometry and process plan

Even though .G-code. is a well-accepted standard world-wide it is in fact a bottleneck for today's CNC production chain. Despite the high performance of both modern CAD/CAM systems and CNC controllers the inadequate interface inhibits the expected increase in productivity and surface quality. Programming with .G-code. results huge programmes which are difficult to handle; last-minute changes or correction of machining problems on the shop floor are hardly possible and control of programme execution at the machine is severely limited. Even worse, due to many different .dialects. and vendor-specific additions to the programming language, part programmes are not interchangeable between different controls. We have used successfully the data generated form CAD model for developing the CNC programme and then for manufacturing the component directly by using CNC.

Finite Element Analysis (FEA) has become the most popular choice of practicing engineers to solve real life problems in stress, vibration, heat flow and other fields of analysis. ANSYS is general purpose Finite Element Analysis software, which enables us to perform stress and strain analysis for the given component. Thus in this project we have successfully completed

- 3 D scan and reconstruction of geometry of damaged component
- Developed CAD model and clean up the geometry of the component.
- Manufactured the component by Rapid Prototyping
- Developed the CNC programme by using CAD model
- Manufactured component by CNC machining
- Made the analysis of failure of component by Finite Element Analysis.

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