Reverse Engineering

Introduction

Reverse Engineering or Product Dissection is based upon the older activity known as benchmarking where engineers for example could observe, measure or take apart their own or another organisation’s product for the benefit of discovering how it works, performs or what improvements could be copied or enhanced for their own product.

Reverse Engineering also includes software and hardware engineering in which the former is done to retrieve the source code of a programme due to it being lost, what operations the programme carries out, improve programme performance or to fix inherent bugs. Hardware reverse engineering involves taking apart a device (or processor) to see how it works. For example, if a processor manufacturer wants to see how a competitor's processor works, they can purchase a competitor's processor; disassemble it, and then make their own processor similar to it. However, this process is illegal in many countries. Normally hardware reverse engineering requires a great deal of expertise and is quite expensive.

Question 1
What would be the reasons for a business to reverse engineer a product?

Before the advent of computers and/or associated techniques of a product’s geometric data, products, their sub-assemblies and components would be analysed for their build, materials, lifetime in operation, environmental use and cost. This normally entailed the dismantling of a product to determine the selection and arrangement of component parts and gain insight about how the product is made. The "teardown" of a product is often a part of product benchmarking, but without the intent of copying the design. However, the collection of this type of benchmark information provides a better understanding of the solutions selected by the competition.

Learning about a product, its components, and how it is made is easier when given access to engineering specifications, complete product drawings, manufacturing process plans, and the product's business plans. A design engineer is well acquainted with this documentation for the products produced by his or her own design team.
Question 2
Is a competitor likely to give all the necessary documentation to enable a designer better understanding of the product?

However, competitive performance benchmarking requires that the same information be obtained for competitors' products. In this case, the design engineer only has access to the product itself (assuming it is available on the open market). Product dissection is performed to learn about a product from the physical artefact itself. The product dissection process includes four activities. Listed with each activity are important questions to be answered during that step in the dissection process, these are:

1. Discover the operational requirements of the product. How does the product operate? What conditions are necessary for proper functioning of the product? The product needs to be fully assembled at this stage.
2. Disassembling the product is necessary to complete these next activities Examine how the product performs its functions. What mechanical, electrical, control systems or other devices are used in the product to generate the desired functions? What are the power and force flows through the product? What are the spatial constraints for subassemblies and components? Is clearance required for proper functioning? If a clearance is present, why is it present?
3. Determine the relationships between component parts of the product. What is the product's architecture? What are the major subassemblies? What are the key component interfaces?
4. Determine the manufacturing and assembly processes used to produce the product. Of what material and by what process is each component made? What are the joining methods used on the key components? What kinds of fasteners are used and where are they located on the product?

Question 3
What would be a good idea to do whilst investigating and stripping the product down?

Nowadays, reverse engineering refers to the process that creates a CAD model by acquiring the geometric data of an existing part using a 3 D measuring device. Reverse engineering is more prominent as its uses are not just copying an existing product but also its uses in RP, casting, CNC machining, part inspection and others. Using reverse engineering can obviously reduce lead time.
The reverse engineering process starts with the reconstruction of a physical part into a computerised form. Obtaining a CAD model is usually the ultimate goal of RE. The point of this is that the CAD model can then be translated into a programme for manufacture. The RE process aids in the interpretation of the intended design idea in order to obtain a CAD model, whereas traditional engineering turns engineering schemes and ideas into the real parts or prototypes. The process approaches traditional engineering from the opposite side, and this is the reason why it is called reverse engineering. It is a reversed concept of conventional engineering.

Once a CAD model is built using RE techniques, the advantages of a CAD/CAM system can be fully appreciated. The lack of an existing CAD model may be attributed to various reasons, all of which would then require the use of the RE process. These are typical uses of RE where the CAD model for an existing part is not available:

- A clay model is built by a designer.
- A part has gone through many design revisions without documentation.
- The drawing of a part is lost or no longer available.

In the conventional reverse engineering process shown in Figure 1, the CAD model is created based on the point data sampled from the part surfaces by scanning or probing.

Figure 1 The conventional use of RE procedure
Measuring Devices

As with other technologies, the application of RE techniques is expanding and also therefore the methods employed. More complex parts and the importance of manufacture demands a quicker way of interpreting product’s features and geometric data. In RE, the CAD model of a product is generated from the measured point data of a physical product/prototype. Some methods of data capture are shown below.

Figure 2 Classification of measuring devices

Two types of measuring devices are used in sampling point data from a part surface: contact type and non-contact type. The most popular contact-type measuring device is the CMM (coordinate measuring machine), which has been used in the field extensively. This type of machine is usually NC driven and can obtain point data with an accuracy of several microns. However, it is inherently slow in acquiring point data since it needs to make physical contact with the part surface for every point that is sampled.

Question 4
What would influence the type of measuring device?
Question 5
Due to the shortcomings of CMMs, what type of products would it be used for?

Figure 3 A touch probe

Non-contact-type devices are becoming more popular in industry. These devices can capture complex shaped surfaces and parts with soft materials because there is no physical contact between the product and probe. Among various non-contact-type measuring devices, the laser scanner is one of the most dominant systems. Laser scanning devices can acquire a large amount of point data in a short period of time compared to that of a contact device and thus makes this a good tool on obtaining accurate product data.
Figure 3 Principle of Laser scanning

Table 1 Comparison of the two methods

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<thead>
<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td><strong>Non-contact</strong></td>
<td>Fast measuring speed</td>
<td>Relatively low accuracy</td>
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<td>Applicable to soft materials</td>
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<td>Large number of point data</td>
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<td>Complex shapes</td>
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<td></td>
<td>Casting and moulding objects</td>
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<td><strong>Contact</strong></td>
<td>Can measure transparent shapes</td>
<td>Relatively slow measuring speed</td>
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<td>High accuracy</td>
<td>Primitive shapes</td>
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<td></td>
<td>Deep holes</td>
<td>Relationship of probe to surface</td>
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<td>Interior features</td>
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<td>Machined parts</td>
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