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FRE: Functional Reverse Engineering for Mechanical Components

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Abstract

In the present work, aspects of reverse engineering (RE) of mechanical component are carried out without using any machine such as coordinate measuring machine which helps in generating the CAD model. This paper focuses on carrying out reverse engineering without using any such machine and proposes an approach, called Functional Reverse Engineering (FRE), for reverse engineering that enables a RE user to bring out the detailed functional specifications of any mechanical component. Both the techniques are implemented on a commercial model of stapler using commercial design software known as Creo. These techniques allow in the extraction of the main intention behind the design of the part and all the sub functions being performed by that part.

Keywords: Functional reverse engineering, subtract and operate, force flow diagram.

1. Introduction

In mechanical engineering, RE is an integrated domain that helps us to bring out technological and physical principals of any mechanical part or component by undergoing the analysis procedure of some of its basic aspects such as structure, function and operation. Certain reasons why people have to go for the RE operations are, most of the time: lack of the documentation, to fix some or more of the bugs, to improvise, no manufacturing of the product anymore, commercial espionage, duplication and many more. RE is an activity that comprises of creating the complete 3D virtual models of the existing physical models of the subjects in concern (Durupt et al, 2010). There are two methods to generate the 3D models of any subject which are:

Manual methodology includes the complete disassembly of the subject and then the measurements are taken with a very accurate measurement tool such as vernier caliper or screw gauge. All the dimensions should be recorded on a rough estimated drawing of the individual components of the subject which is followed by the 3D modeling of all the components in any software such as ProE, autoCAD etc.

Mechanical methodology includes the regeneration of a full CAD model of a given mechanical part from a 3D point cloud. The 3D point cloud is usually made available by the 3D scanners or by the results of FEM approaches.

Functional reverse engineering incorporates some protocols while working on reverse engineering of any object that prove very useful to determine the detailed functional description of the whole object along with the functional specification of each and every sub system that is employed in that object. It does not miss the individual standalone components that are present in the object. One of the main objectives of determining the functional specifications of the object is to redesign any feature or any part or component of the object without compromising on the functions to be performed by that redesigned part.

Also some products may be over designed a bit too. Over designing of a product may be understood by considering a product that uses multiple solutions to sub functions which could more efficiently be solved using fewer or singular solutions (Lefever et al, 1996). In such situations, more often than not, there is an opportunity for elimination of components producing the redundancy. Identifying the functional specifications can also help in determining the redundant components in any product.

All the important steps in this paper have been properly explained using an example of Kangaro HS-R10 Stapler.

2. Main Concepts of Manual Reverse Engineering

Manual reverse engineering can be described as the form of RE that does not uses any machine to take the dimensions of the component in concern. A particular sequence of steps then has to be followed to reverse engineer which is as follows.

2.1 Product Dissection

First step is to take apart the subject throughout. All the parts has to be taken apart of that subject without causing any damage to any part without forgetting their arrangement.

Fig. 1: Dissected stapler.

Proper review for the ergonomics and aesthetics should be made. Ripping apart of the subject provides the user with great visual feedback and also develops the curiosity, proficiency and manual dexterity in the user (Shooter, 2008).

2.2 Measurements with Rough Drawing

All the dimensions have to be recorded of all the parts of the disassembled subject on a rough drawing of all the respective parts. These should be good enough to be easily understood by the user. The rough drawing serves a great purpose while creating their 3D model on any CAD software.

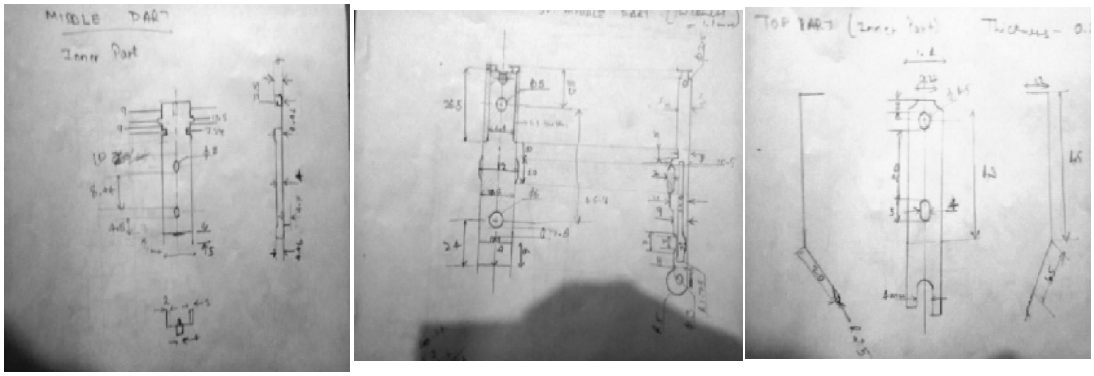

Fig. 2: Dimensioning of different components.

2.3 3D Modeling

After recording all the dimensions, last step is to create the 3D CAD model on any software. Several software are available now a days to allow easy modeling of the subject. Different parts can be modeled separately and finally while creating the complete model. All the different part models can be assembled together as one. In any assembly drawing, it is highly convenient to show the exploded view of the complete subject so that it becomes easy to understand the assembly.

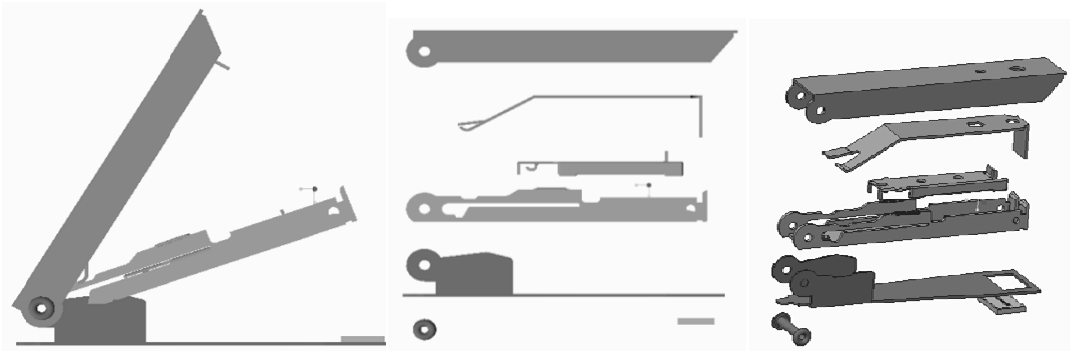

Fig. 3: 3D modeling of the stapler.

3. Main Concepts of Functional Reverse Engineering

Functional Reverse Engineering is the branch of RE that proves very useful in bringing out the detailed functional descriptions of the subject and all of its components. This approach proves highly useful to RE user in determining and defining all the systems and subsystem used in the subject to accomplish a particular task. Using this approach, it also becomes convenient to find out the redundant parts used in the subject (if any). This approach is not the complete approach to find the redundant parts; it is one of its advantages. This approach uses a sequence to accomplish this which is as follows.

3.1 Subtract and Operate

This step incorporates subtracting each component of the subject one by one. Removal of the components may occur in any order. It may be required to remove one or more component in order to remove the desired component. These pre requisite components should be reassembled if possible and then operating the subject in its complete range. Then analyze the effect of removal of that part. This is mostly carried out through visual inspection. Note all the changes in a tabular manner. Sub functions of the missing component can be deduced through this. This is critical while detecting redundancies (Lefever and Wood, 1996).

Table 1: Subtract and operate effects.

<table>
<tr><th colspan="2">Base Assembly</th><th colspan="2">Top Assembly</th><th colspan="2">Spring Assembly</th></tr>
<tr><td>Base plate</td><td>Press-force is not supported</td><td>Top plate</td><td>The spring assembly is loose</td><td>Carriage</td><td>The staples does not move</td></tr>
<tr><td>Base cover:</td><td>Press-force goes to surface</td><td>Top cover</td><td>The hand grip is not comfortable</td><td>Spring</td><td>The staples does not move forward</td></tr>
<tr><td>Jaw support:</td><td>The movement is not solid</td><td>Locator plate</td><td>The spring assembly is loose</td><td rowspan="2">Magazine cartridge</td><td rowspan="2">No place to put the staples</td></tr>
<tr><td>Stake rivet:</td><td>The staple is not formed</td><td>Stake rivet</td><td>Not enough force is created for staples</td></tr>
<tr><td>Base Spring:</td><td>The arm does not move back</td><td colspan="4">Pin: The assemblies are not held together</td></tr>
</table>

3.2 Force Flow Diagram

It focuses on the component combination and represents the transfer of force through a product’s components. Seldom is this phase completed through modeling and analysis. This phase requires sophisticated CAD software which is also capable of doing analysis. The components are represented by using circles and forces are drawn on arrows in a given order without disturbing the general topology (Lefever and Wood, 1996). In general words force flow diagram depicts the flow of force from input to the point where task is accomplished. This approach helps in understanding the type of force being experienced by each member of the subject.

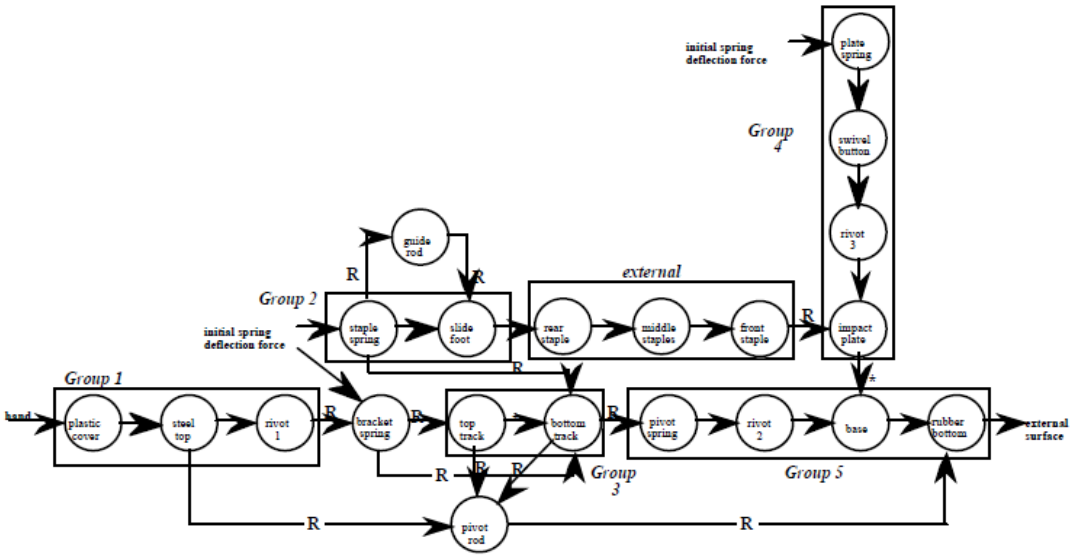

Fig. 4: Force flow diagram of a stapler [douglas, 1996]

4. Conclusions and Discussions

Reverse engineering of the subject without using coordinate measuring machine proves a great tool to provide the user with 3 great treats of an engineer which are visual feedback, curiosity, proficiency and manual dexterity in the use. Product dissection along with the creation of rough drawings proves a powerful technique for grasping engineering and design. The rough drawing serves a great purpose while creating their 3D model on any CAD software.

The main idea of FRE is to establish the connection between engineering design while reverse engineering and the functional and sub functional descriptions about the subject in concern. Although the FRE approach is not the complete approach to find the redundant parts; it proves useful.

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