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Reverse Engineering based Methodology for Modelling Cutting Tools

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Abstract

Reverse Engineering involves the use of techniques for extracting information about manufactured products. Assembled products contain usually hidden parts. Because of this, it is difficult finding RE procedures that involve the use of 3D-scanning techniques. However, 3D scanning technologies can help to capture information about their geometry for generating virtual models (VM), which can offer many possibilities for digital analysis. On the other hand, starting form a VM, it is possible to achieve the physical reproduction of the piece using additive manufacturing technologies. This allows performing functional tests or, simply, obtaining a physical high-scale model. All that permits improving the product through a redesign process.

This work reports on the results of a preliminary study on the application of different 3D-S and AM technologies for generating VM and PHSM of a two edges mill. A comparison based on cost, result, difficulties-capabilities and runtime has been made.

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Keywords: Reverse Engineering; Cutting Tools; 3D Scanning; Modelling; Additive Manufacturing.

1. Introduction

The machining is one of the most currently used manufacturing process, and within the same, conventional machining. The tools used for this type of conventional machining are known as cutting tools, and they have very different geometries and a short life.

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The variety and complexity of manufacturing processes have led to a major impact of the industrial sector on the GDP of developed nations. These processes are conventional machining requiring many cutting tool models which differ in composition, shape, dimension and tolerance, depending on the use and the material machined. The same model may have substantial differences, as the number of edges, the geometric characteristics, etc. Therefore, it is necessary to assess all the processes requirements with different cutting tools through systematic studies.

To conduct this study and to modify geometry without subjecting the functional testing tool, it is necessary to obtain the three-dimensional digital or Virtual Model (VM), because geometrical parameters required to define this model are sometimes impossible or too expensive to get. Reverse Engineering techniques seek to obtain them [1].

Reverse Engineering (RE) involves the use of techniques to retrieve information about manufactured products. Thus consists in analysing the procedure of design and manufacturing process of a product, not only with regard to geometries, but also materials and functionality [1, 2].

Currently, there are several RE techniques widely used and known but many of them still leave the object unusable to analyse or future use. Nevertheless, other alternative to this problem can be a kind of Three-Dimensional Scanning, which allows for obtaining a Digital or Virtual Model (VM). Getting the scan (VM) of an item makes it possible to redesign it, perform virtual testing, check its geometry and features, get conceptual physical models, or even perform functional prototypes for actual tests [3-5].

Different techniques can be used in the application of RE to recreate in detail the cutting tool geometry for further analysis and development. Accordingly, RE techniques allow for getting a VM of the cutting tool. This also enables to improve the product through a redesign process.

The use of RE in the Computer Aided Engineering is relatively new. There are some different applications to combine these two techniques [6-10], such as the physical reproduction of an element in the same or different material for performing functional tests or just obtaining a conceptual physical model. The latter is performed by Additive Manufacturing techniques (AM) [11, 12].

This study has carried out the digitization and subsequent physical reproduction of several cutting tools using 3D-P and Rapid Prototyping, providing a physical model, strictly conceptual, to analyse measured deviations resulting from the tolerance of the machines in the processes used. A comparison will be made between possible methods to perform each process, using different machines and software and taking into account costs, results, difficulties encountered and runtime.

2. Experimental Procedure

Although several methods could be used to carry out the experimental procedure, steps or general ideas for digitization and subsequent manufacture of a prototype can be established, Fig. 1.First of all, a starting model must be selected. Different problems can be observed in some models in their color, brightness, finishing or just their geometries. These techniques have limits and some models are not suitable for this purpose.

This model will be scanned to obtain the Virtual Model, the scanning being an important phase as the system obtains a point cloud the precision of which will define the quality of the model. On completion of the scanning, the cloud is processed and the three-dimensional surfaces are obtained. The VM is then created in the required format.

As soon as this VM is achieved, it is possible to modify some of its features and redesign the object if necessary. When the processing is completed, the VM can be used in the intended application.

The resulting model, whether modified or not from the starting one, can be reproduced by AM. Afterwards, the VM must be adapted to the appropriate format used by these techniques (STL). Once the format has been transformed, the three-dimensional model can be printed by AM technologies.

Fig. 1. Chart-flow of the Experimental Procedure