PRODUCT DEVELOPMENT AND MOULD PRODUCTION TIME DECREASE BY USE OF REVERSE ENGINEERING METHODS

Samo Gazvoda[1], Luka Botolin[1], Blaž Nardin[1], Boleslav Kmet[2]

[1]TECOS, Slovenian Tool and Die Centre, Mariborska 2, SI-3000 Celje, Slovenia; tecos@tecos.si
[2]Forstek d.d., Planinska 15, SI-1431 Dol pri Hrastniku, Slovenia; boleslav.kmet@forstek.si

Abstract

Due to the fact that product development phase is very time consuming it is a big benefit if one manages to shorten it substantially. By use of reverse engineering it is possible to use existing products or solutions thus shortening the time of development and/or mould production. The paper presents the steps needed for the reverse engineering applications in real tool and mould production. One of the data output formats of this process is poligonized (STL) 3D object data based on point cloud data exported from digitizer software. This paper concentrates on how use of STL data can help save time and money in tool and mould production. The disadvantages of use of poligonized data are also presented.

Keywords: *STL, reverse engineering, direct milling, optical 3D digitizing*

1. Introduction

In a constant battle with time an engineer must always follow trends of how to shorten a specific procedure even more. In our case we are talking about branch of tool and mould making. This paper is therefor mostly devoted to choosing the right approach in tool and mould production, focusing on 3D models for NC programming and consequently CNC machining.

As reverse engineering is already a well known and established technology [1][2], the question is how to optimize it even more. No general answer or conclusion can be made. Each project is a story of its own so it has to be studied separately.

Here is a list of some fields of use of digitizing and reverse engineering:

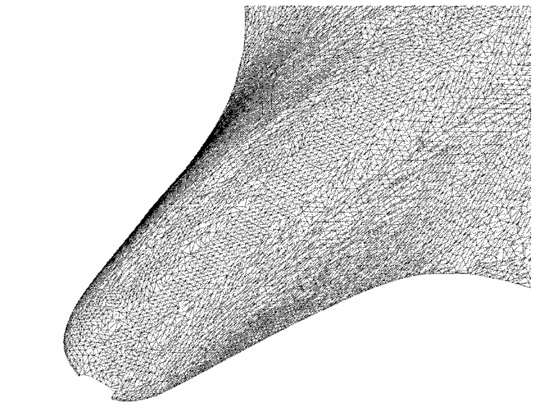
- rapid prototyping (STL, DMLS, direct milling etc.),
- CAD comparisson,
- reverse engineering (surface reconstruction),
- digital mock-up,
- product visualisation,
- etc.

In the field of tool and mould production there are several applications where a product already exists and a mould for its production has to be made. If such product consists of complex geometry which maybe includes even some artistic relief surfaces, it is very hard or almost impossible to reproduce it by any classical method. One possibility is to use copy-milling. But due to copy milling machines mostly being quite old this is a very time consuming procedure. Here 3D digitizing and reverse engineering come into place.

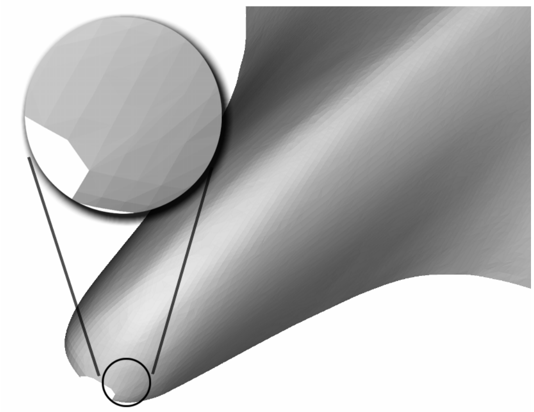
2. CAD versus STL data

2.1 Description of STL data

STL is a file format which is a standard input format for majority of rapid prototyping applications. It is a 3D poligonized object data, consisting of small triangles which create a triangular mesh based on 3D object shape (Fig. 1).



a) triangular mesh



b) triangular mesh (flat-shaded)

Fig. 1: Example of STL data

It must be kept in mind that STL is a discrete model. Modifications on STL data are possible but very limited. This is due to a vast amount of data needed to fully qualify an 3D object.

Since 3D modelling is based on geometrical transformations and mathematical algorithms a transformation of surface into discrete point representation has to be made after its creation if modelling is done directly on STL. This is one of the main problems of STL modelling – it consumes a lot of computer resources.

2.2 Description of CAD (surface or feature based) data

A CAD model is entirely defined with mathematical equations, series, geometrical transformations etc. In short it can be called a mathematical 3D model as well. Each surface or feature (Fig. 2) is represented with a few parameter values and a mathematical relation between them.

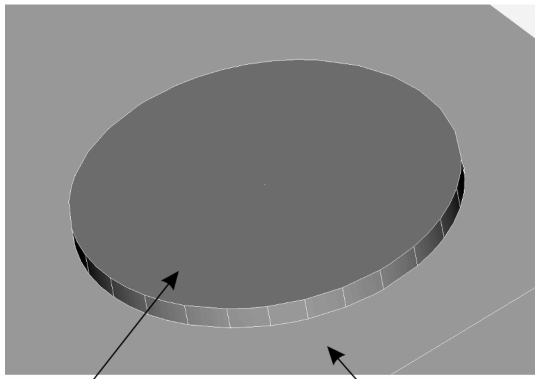


Fig. 2: Arrows show feature and base surface

This leads to relatively easy modifications of such models. They are also compact and small in size.

2.3 STL to CAD model comparison

As we briefly described both types of models one question comes up – which one is better and more importantly when? For answering this question a closer look at advantages and disadvantages of both types must be taken. But we must keep in mind that this is taken from *reverse engineering point of view*!

STL model

Advantages:

– quick generation by digitalization and data post-processing;
– accurately describes physical model shape;

Disadvantages:

– surface imperfections and defects are copied onto the model (removal of such defects is often not a simple procedure);
– large file sizes;
– modifications of the model are difficult or even impossible;
– bad boundary condition controls;
– hard to describe complex physical models due to digitizer limitations;

Mathematical (CAD) model

Advantages:

- compact files small in size;
- easy modifications;
- easy boundary condition controls (depends on software package used);

Disadvantages:

- creation is time consuming, especially if there is no point cloud or STL data of physical part available;
- it is hard to make good quality surfaces which accurately describe physical model;

2.4 Choosing the right approach

After evaluating previous two paragraphs it is clear that no general assumption can be made. Current state of STL modelling prevents it from being widely used on today's hardware platforms. So it could be said that the complete mathematical surface reconstruction (or reverse engineering) is the right approach. But there are cases where use of STL data is essential for a successful outcome of a project.

Tipically these include decorative products with relief design patterns like vases, artistic glass bottles, medallions, toys etc. Such surfaces are very difficult to re-create mathematically. Of course reverse engineering software with modules for automatic surface reconstruction allready exist and some of them are very good. But it still takes time to do it. With good STL data the reverse engineering step can be omitted thus saving us a lot of time. Figure 3 illustrates this on a fictional example but it has to be observed with care though.

Objects with complex geometry, especially such which represent difficulties for digitizers (deep or narrow cavities, sharp shiny borders etc.), are difficult for digitizing. It is almost impossible to capture all areas of such objects solely by digitizing. In such case a lot of data postprocessing after digitizing has to be done and usually it is impossible to generate a closed STL model. Consequently reverse engineering proves to be better in such cases. This is simply because it is easy to extend mathematical surfaces. By doing this it is possible to fill problem areas and consequently create a closed model.

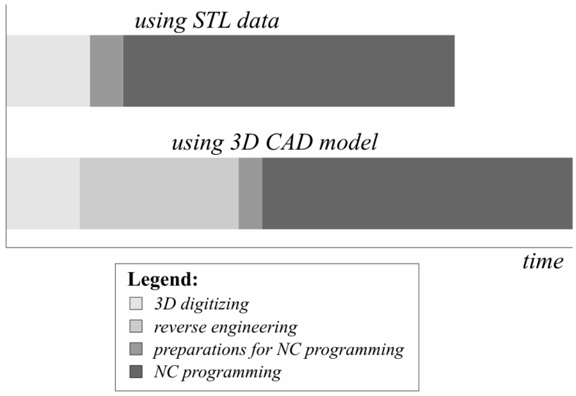


Fig. 3: A fictional example of how using STL data can help us save time; this is an example for objects with non-complex shapes, which can be captured completely with digitizer, i.e. no holes and areas with missing data exist.

It must also be taken into account that NC programming takes a bit longer when applying it on STL models. This is due to the fact that creation of limiting curves for machining is more difficult than in mathematical models.

3. Industrial example

In a real industrial example [3] a glazier's tool production company came to us with a project where they needed a computer model of a glass bowl with a complex relief artistic pattern (Fig. 4).

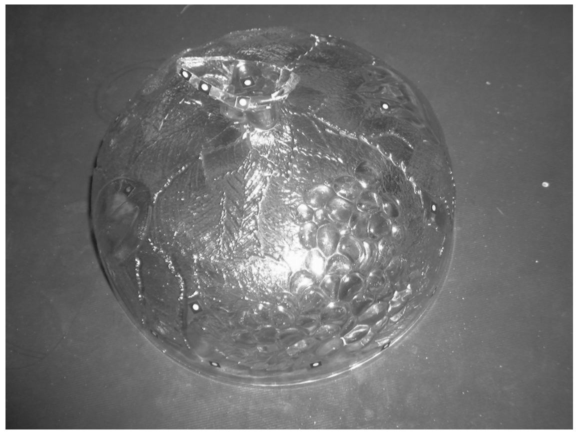


Fig. 4: Object for which a mould had to be manufactured

Input data was a sample product which design had to be copied for production of a mould. Classical approach would be to cast a sample into artificial mass araldite. Aquired cast then serves as a sample for milling the shape on copy-milling machine.

In this case 10 tools needed to be produced in a short time. Because of the sample object's size (diameter of the bowl 227 mm) classical approach could not be used. The decision was made – digitalization had to be used. Because of short deadline reverse engineering process was not appropriate so direct milling on STL data was chosen.

The object was digitized in four hours and another four or five hours were needed to postprocess the data to get a really good STL representation of the object. Resolution of points received from digitizing was approximately one point every 0,1 mm which proved to be more than enough. The resulting model is shown on Figure 5.

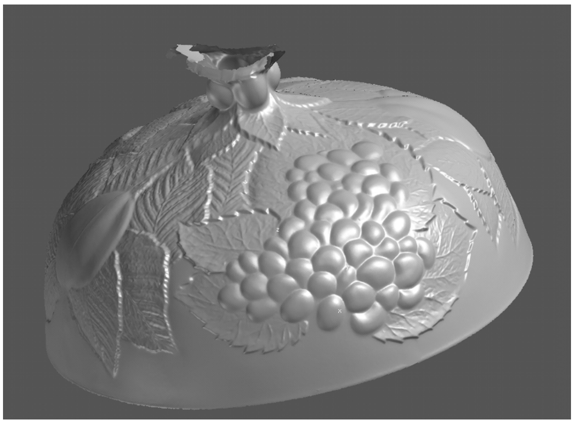


Fig. 5: STL model of concerned sample object

The model was used for NC programming. Some minor modifications had to be made on machine controler and at last the customers were very satisfied with final die impression after milling and polishing.

Direct milling on STL data proved to be a very good solutions in this case. Final mould surface after polishing is shown on Fig. 6.

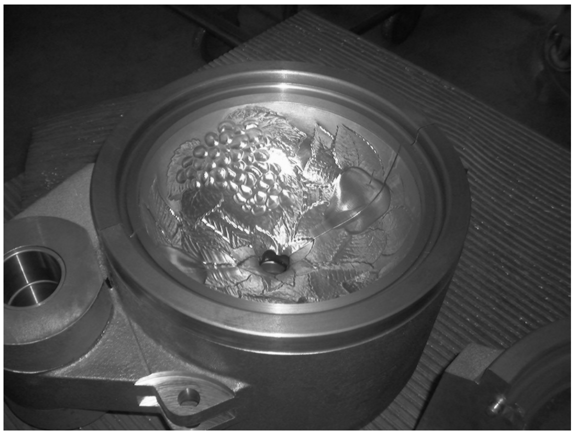


Fig. 6: Mould after polishing

4. Conclusion

In the paper a relatively new approach to fast mould production was shown. In chapter 2 all the benefits as well as as the down sides of use of both mathematical and STL model for milling were presented. If put all together it is clear that classical approach (digitizing and reverse engineering on digitized data) is still favourable in most cases.

But as the practical example has shown there are some cases where direct milling on STL data (reverse engineering step can be omitted) proves to save us time and money as well. And with further development of hardware [1] STL modelling will be more and more powerful thus leading to even more practical applications of using STL data to achieve desired results.

It is the author's oppinion that in future mostly due to time reduction, STL data will be more and more accepted and widely used for practical applications.

5. References

[1] Herbertson, T.: *Reverse engineering,* Proc. of the 4th Int. Conf. on Industrial Tools – ICIT 2003, Bled, p. 419-422

[2] Bernard, A., Fischer, A.: *New Trends in Rapid Product Development*, CIRP Annals 2002: Manufaturing Technology, vol. 51/2/2002, San Sebastian, Aug. 2002, p. 635-652

[3] Kmet, B.: *Reengineering at glazier's tool production*, TCS Newspaper, Celje, June 2003, p. 6-7