Design of Machines and Structures, Vol. 7, No. 2 (2017), pp. 20–30.
https://doi.org/10.32972/dms.2017.007

APPLICATION POSSIBILITIES OF 3D SCANNING AND PROTOTYPING IN THE MANUFACTURING OF PACKAGING TOOLS – CASE STUDY

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Abstract: In this paper authors describe the results of an industrial based work. The task of the work was to make new packaging tools for different chocolate hollow figures. The packaging machine was manufactured in the former East Germany and new tools are not available now. Two types of packaging tools were made in this project. One type was "poli-shing trough", the other type was lifting/pushing tool. In this paper the whole production of the mentioned tools are introduced from the design to the manufacturing.

Keywords: *prototype milling machine, CAD, 3D scanning, packaging tools*

1. INTRODUCTION, AVAILABLE INFORMATION

Our Institute was asked by one of our industrial partner to make new packaging tools to replace their old ones. Their packaging machines were made in the former East Germany. They cannot order new packaging tools because of the original manufacturer is not existing anymore.



Figure 1. 9 g Hollow Figure gypsum sample

Part of our work was to find the right technology for the manufacturing of packaging tool to be fit the old machines. The client made available some gypsum samples of that type of chocolate hollow figures that should be packaged with new tools. A sample of a 9 g figure can be seen in *Figure 1*.

Packaging tools we made can be divided into two groups. One of them is the polishing trough; the other one is lifting/pushing tool. Polishing troughs are used at the end of the packaging process. Lifting/pushing *(Figure 2)* tools are used at the beginning of the packaging process.

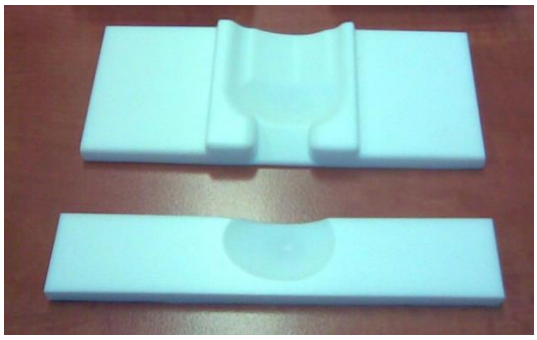


Figure 2. Lifting/pushing tools for 17.5 grams chocolate hollow figures

The task of the lifting/pushing tools is to lift up the product into the packaging machine and push the product into the right position. The finish of the packaging process happens in the polishing troughs. The packaging machine bowls the figure trough the polishing trough *(Figure 3)*, which presses the aluminium foil to the hollow figures. We can use this kind of packaging when the figures are rotationally symmetric.



Figure 3. Polishing trough for a 9 grams hollow figure

We had opportunity to see the old and worn-out packaging tools. It was a good basis to solve the problem.

2. SCANNING THE SAMPLES

We started our work with scanning the gypsum samples of hollow figures the client gave us. We digitalised the samples with a Roland PIX4 type touching scanner *(Figure 4)*.

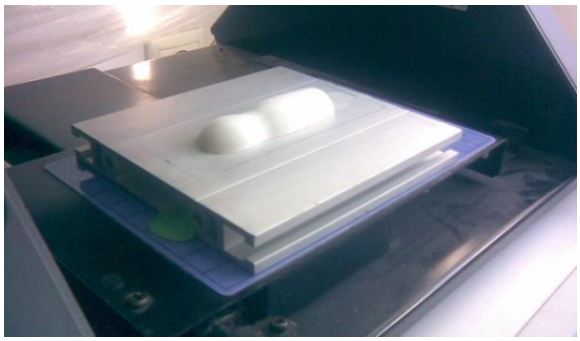


Figure 4. Scanning the gypsum sample of the 9 grams hollow figure with Roland PIX4 scanner

We could see the created surface in the controller software *(Figure 5)*. The scanning was made with 0.3 mm subdivisions in all the three directions.

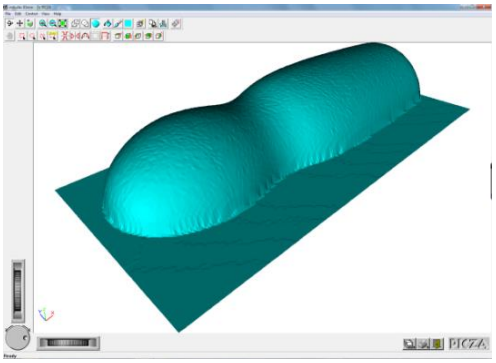


Figure 5. The scanned shape in the Picza software

The controller software can export the digitalized data to several file formats CAD systems can read (for example: step, igs, stl).

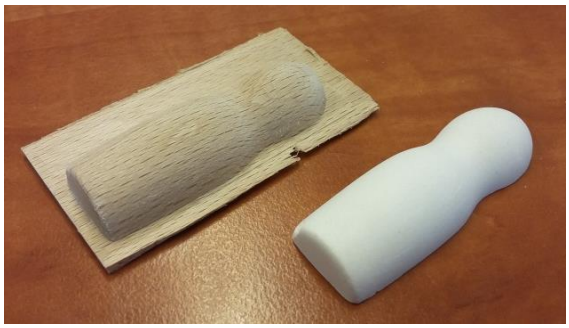


Figure 6. The manufactured sample with Roland MDX650A (left) and the original gypsum sample (right)

We chose stl format to use in our further work. This file format can be read by the CAD software (Solid Edge ST5) we used. Furthermore, the prototype printers can print directly from this file format. We made a sample from the scanned data, without any modification. The manufacturing of this sample was made with MDX 650A prototype milling machine. Our aim was to compare the dimensions of the original gypsum sample and the manufactured sample *(Figure 6)*.

3. MEASURING THE DIMENSION ACCURACY OF THE SCANNED SURFACES

We compared the originally gypsum sample and the manufactured sample. We choose easily measurable dimensions to examine the dimension differences between gypsum sample and manufactured sample. The chosen dimensions were the length and the height of samples. In the next two figures *(Figure 7, 8)* the measuring of the length can be seen. We made the measuring with digital calliper.



Figure 7. The length of the manufactured sample



Figure 8. The length of the gypsum sample

We got 0.52 mm differences between the two samples (average of multiple measuring). This difference is the 0.88% of the original length. We measured the height of the gypsum sample (9.66 mm), and the manufactured sample (9.8 mm) too. The difference was 0.14 mm. This is 1,4% difference. We had to validate the two differences on the contour of the tools. We decided to use just one modification value in

both directions, 1%. We made an offset operation on the contour of the polishing trough to reduce the dimensions to approximate the contour of the original gypsum sample *(Figure 9).* Several publications pay attention to the dimension differences of scanning geometries, [2] for example.

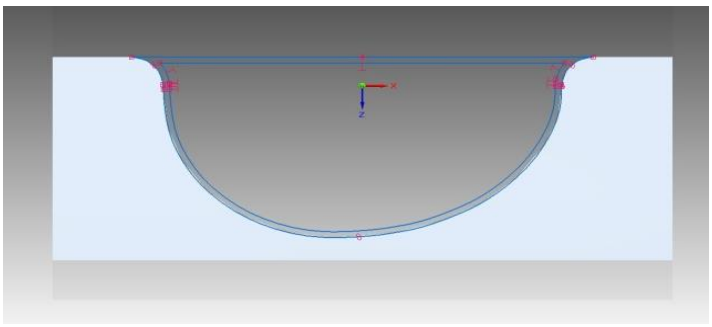


Figure 9. Offset of the contour

4. DESIGN OF THE PACKAGING TOOLS AND MANUFACTURING TESTING SAMPLES

After checking the dimensions and determine the modification we could begin the designing process of the packaging tools. We started the design process with the determination of the polishing trough contour. We had to pay attention to the thickness of the padding which is in the polishing trough. The padding has two layers. A 4 mm thick rubber foam is connected to the trough and a 0.9 mm thick plastic textile is connected to the rubber foam. We considered the 4.9 mm distance of the contour with an offset. We made the offset movement of the contour to decrease the cross section of trough. We made an 80 mm long piece from steamed beech material. This length of the piece is long enough to make at least one revolution with the gypsum-sample. The next step was to glue the rubber foam and the plastic textile into the trough. We had to make two gluing between two different materials twice. We had to glue wood to rubber and rubber to plastic. In conjunction with the client Pattex Palmatex contact glue was chosen.



Figure 10. The short version of the trough (form and press)

To make perfect gluing, we had to grant the fat free and solid surface. To get a perfect connection between the elements we had to press them. The strength of the gluing greatly depends on the magnitude of the pressing force [1]. The pressure has to affect the whole surface of the trough.

To solve this task, we designed a pressing tool. We determined the dimensions of the pressing tool, on the basis of the ready size of the polishing trough. It can be seen in *Figure 10* in the vice of the prototype milling machine. The one in the left is the body of the trough the one in the right is the pressing tool. We made the gluing on the short version of the trough and the pressing tool. The glued and pressed elements can be seen in the *Figure 11*.



Figure 11. Gluing and pressing of the short version of the trough (for 17,5 g chocolate egg)

The short version of the trough was examined by the client with a chocolate figure if the aluminium foil is tight enough on the figure. The answer was positive.

5. MANUFACTURING THE PARTS OF THE FINAL VERSION OF PACKAGING TOOLS AND ASSEMBLING THEM

After the client accepted the final version of the tools' profile, we could start to make the body of the packaging tools. We had to choose such material for the body of the tools that can be glued.



Figure 12. Parts of the packaging tool made from PA6

It was necessary to glue the parts of the tools, because the length of the tools was 750 mm, but our milling machine can manufacture just 530 mm long parts (because of the limitation of working area). We chose the PA6 material for the body of tools, without glass fiber strengthening. We had to find glues with that PA6 materials can be glued to each other and the rubber foam can be glued to the PA6. To choose the right type of glues we asked for help from the Henkel Magyarország Kft. They recommended the Loctite 401 for the PA6 material, for the rubber foam and the plastic textile they suggested the Pattex Palmatex. We had to make some rework on the parts to connect them perfectly to each other. The parts of the packaging tools that were made with MDX-650 milling machine can be seen in *Figure 12*.

We milled the outside surfaces of the parts to reach the prescribed dimensions; parts were turned face-to-face to each other *(Figure 13)*. The manufacturing was made by a Wemomill FUS32 type milling machine, which is equipped with linear encoder.

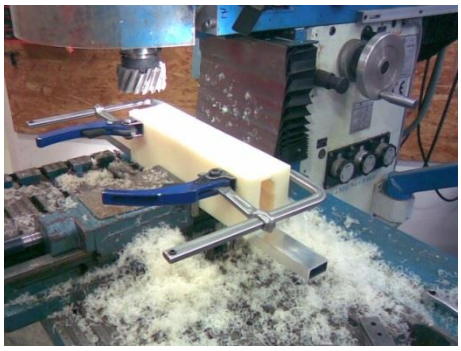


Figure 13. Manufacturing of the parts of the trough with milling machine

After the parts were ready, we started to glue them to each other. Parts were laid down to a planar surface (ILSE T-slot table) to provide the right connection of the profiles. We degreased connecting surfaces with pure alcohol then glued them to each other with Loctite 401 type glue *Figure 14*.



Figure 14. Gluing the parts of the polishing trough

The strength of the gluing can be increase by pressing the parts of the trough to each other. Pressing was made on a planar surface *(Figure 15)*.



Figure 15. Pressing the parts of the trough

After the curing process the pressing was unlocked and the trough was ready *(Figure 16)*.



Figure 16. The glued polishing trough

We made the pressing tool for the polishing trough as well. We chose steamed beech for the material of the pressing tool. The pressing tool operates after gluing, during curing process. A prototype of the trough and a pressing tool can be seen in *Figure 17* and *18* both made from steamed beech. Both of them were strengthened with aluminium sections.



Figure 17. The top view of the tools



Figure 18. The bottom view of the ready polishing trough and pressing tool. Aluminium strengthening can be seen here

6. DESIGNING AND MANUFACTURING OF PUSHING/LIFTING TOOLS

Pushing/lifting tools work in the beginning of the packaging process of chocolate hollow figures. These tools directly touch the chocolate figures, so the material of the tools must suit to hard specifications. We had to choose a material that corresponds to 1935/2004/EK regulation, which is "on materials and objects intended to meet foodstuffs". Furthermore, the material corresponds to strength, cutting and clean-ability viewpoints. Think of the viewpoints, we chose the PTFE material. Tools have to hold precisely and firmly the chocolate figures; should not make any harm for the figures, but should hold chocolate figures in the right position. During pushing-in it is not allowed to rotate the chocolate figure except around its own axle. To reach the above mentioned requirements we designed sinks for the lifting and pushing tools. The shape of the sink is the same as the shape of the hollow figures (based on the gypsum sample). We made prototypes of the lifting/pushing tools of steamed beech, as you can see in *Figure 19–21*. The prototypes are tested in the factory.



Figure 19. Lifting tool made of steamed beech



Figure 20. Pushing tool made of steamed beech

After a short test, the client asked a little modification in the position of the sink. After modification we made the tools of PTFE material (Figure 2).



Figure 21. Pushing and lifting tools made of steamed beech and the packed chocolate egg

7. SUMMARY

In the process of designing packaging tools, we got result with the application of nowadays engineering methods (CAD, 3D scanning, prototype manufacturing). It is important to give the knowledge of these skills to the mechanical engineer students. It is not allowed to forget about the importance of mechanical drawing.

8. ACKNOWLEDGMENTS

Our colleague Attila Potyka had an important role in the design and manufacturing process. We are grateful to him.

"The described article/presentation/study was carried out as part of the EFOP-3.6.1-16-2016-00011 "Younger and Renewing University – Innovative Knowledge City – institutional development of the University of Miskolc aiming at intelligent specialisation" project implemented in the framework of the Szechenyi 2020 program. The realization of this project is supported by the European Union, co-financed by the European Social Fund."

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