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# INVESTIGATION ON QUALITY OF RAPID PROTOTYPING FDM METHOD

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**ABSTRACT**
*The paper presents a part of investigation witch main goal is determination of FDM rapid prototyping method and printing parameters on quality of manufactured elements. The evaluation needs measurements of geometrical accuracy, comparing measured values to nominal values (dimensions in CAD model). Carried out experiments show, that FDM method makes possible to obtain geometrical accuracy of linear dimensions about 0,1 mm and angle accuracy about 0,4˚.*
**Keywords:** Rapid Prototyping, Fused Deposition Modeling, accuracy.

## 1. INTRODUCTION

Rapid Prototyping (RP) technology is very useful in a lot of branches of industry. High accuracy of printed models is often required. This is the reason why the research on accuracy and costs of individual rapid prototyping methods are necessary. The results of investigations should be the Instructions for the selection of Rapid Prototyping method and parameters that enable to obtain the optimal model parameters.

Presented research is preliminary investigations to determine the basis for selection the method of investigation and criteria indicators. Next part of investigations will be the tests to associate the production parameter with criteria indicators.

## 2. RESEARCH

### 2.1. Aim of investigations

Main goal of this part of investigations is to determine the dimensional errors and quality (surface roughness) of elements made with Fused Deposition Modelling method. Within the framework of research was specified the influence of form of elements (linear and angular dimensions, curvatures) for accuracy and surface roughness of prototypes. Research were made on two prototypes called "model I" and "model II".

***Model I***

"Model I" (Fig. 1.) were made on basis of file in .stl format from PC-ABS. In this case were compared linear dimensions of input prototype .stl with CAD model generated in CATIA (Fig. 2.) on basis of direct measurement of printed detail.

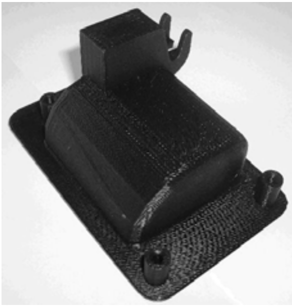

*Figure 1. Prototype of „model I" printed with FDM method.*

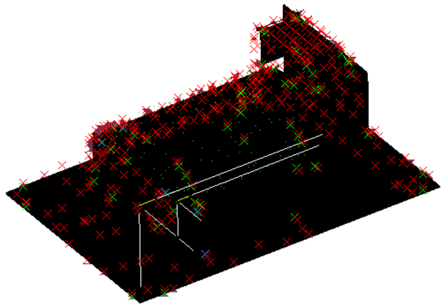

*Figure 2. Prototype „Model I" imported to CATIA in IGES format.*

***Model II***

Second prototype was designed as CAD model (Fig. 3.). Basing on it was generated .stl file which were used to print element on FDM Rapid prototype machine. After the geometry measure of the prototype, the CAD model in IGES format was generated in CATIA (Fig. 4).

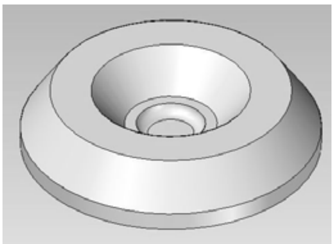

*Figure 3. Model II in CAD format.*

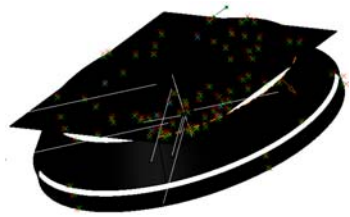

*Figure 4. Prototype "Model II" in IGES format.*

With prototype "Model II", the valuation of the accuracy consisted in comparison of geometry from input CAD model and model generated on basis of geometrical measurement.

### 2.2. Measuring position

Geometry measurement was made on coordinate measuring machine CNC ZEISS C400. Measuring range of this machine :X axis - 380 mm, Y axis – 450 mm, Z axis – 300 mm. Measuring accuracy – 0,5 μm.

## 3. RESULTS

### 3.1. Results of accuracy investigation of „Model I".

Results of accuracy comparison of prototype "Model I" are shown in table 1.

*Table 1. 1Results of geometry measurement (linear dimensions) of "Model I"*

| dimension designation | Nominal [mm] | Real [mm] | Deviation [mm] |
|---|---|---|---|
| 1-01 | 24,892 | 24,820 | - 0,272 |
| 1-02 | 25,382 | 25,243 | - 0,139 |
| 1-03 | 19,558 | 19,633 | 0,075 |
| 1-04 | 42,926 | 43,058 | - 0,132 |
| 1-05 | 60,198 | 59,960 | - 0,202 |
| 1-06 | 42,221 | 42,384 | - 0,163 |

Nominal values of the dimensions shown in table 1 were received based on the dimensions from input prototype in .stl format (effect of triangulation).

### 3.2. Results of accuracy investigation of „Model II".

Results of accuracy comparison of prototype "Model I" are shown in table 2 and 3 and figure 5, 6.

*Table 2. Results of geometry measurement (radial dimensions) of "Model II"*

| dimension designation | Nominal [mm] | Real [mm] | Deviation [mm] |
|---|---|---|---|
| 2/38 - R 15 | R 15 | R 14,936 | -0,064 |
| 2/38 - R 20 | R 20 | R 20,078 | 0,078 |
| 2/38 – R 34,466 | R 34,466 | R 34,665 | -0,001 |
| 2/38 – R 52,242 | R 52,242 | R 52,145 | -0,097 |
| 2/38 – R 65 | R 65 | R 65,016 | 0,016 |
| 2/39 – R 20 | R 20 | R 20,030 | 0,030 |
| 2/39 – R 30 | R 30 | R 30,020 | 0,020 |
| 2/39 – R 40 | R 40 | R 40,098 | 0,098 |
| 2/39 – R 50 | R 50 | R 49,988 | -0,012 |
| 2/39 – R 60 | R 60 | R 60,087 | 0,087 |
| 2/39 – R 65 | R 65 | R 65,061 | 0,061 |

*Table 3. Results of geometry measurement (angular dimensions) of "Model II"*

| dimension designation | Nominal [°] | Real [°] | Deviation [°] |
|---|---|---|---|
| 2-1/40 | 130° | 130,057° | 0,057° |
| 2-2/40 | 146,31° | 146,516° | 0,206° |
| 2-3/40 | 123,690° | 123,635° | 0,057° |
| 2-4/41 | 135° | 134,597° | -0,403° |
| 2-5/41 | 153,435° | 153,326° | -0,109° |
| 2-6/41 | 45° | 45,615° | 0,385° |
| 2-7/41 | 123,690° | 123,830° | 0,140° |
| 2-8/41 | 26,565° | 26,582° | 0,017° |

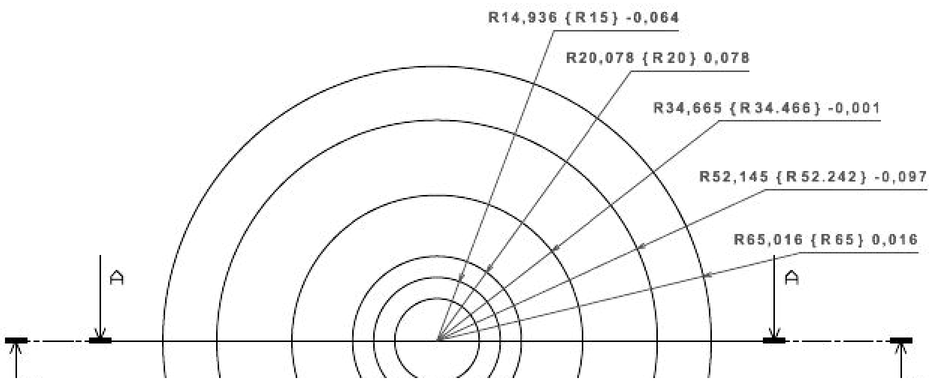


*Figure 5. Example results of radial dimensions measurement of „Model II" (nominal values in brackets).*

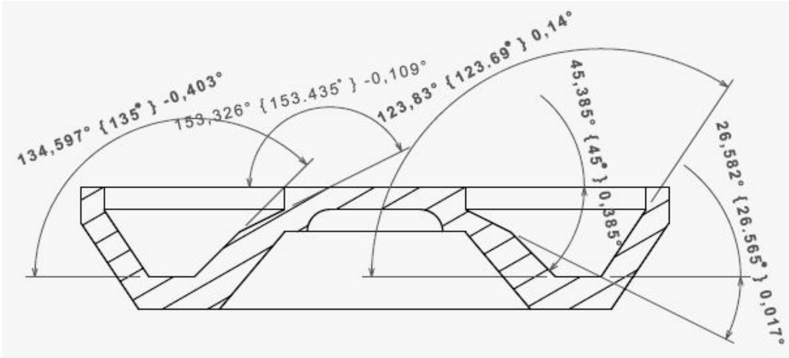


*Figure 6. Example results of angular dimensions measurement of "Model II" (nominal values in brackets)*

## 4. SUMMARY

- In models performed in Rapid Prototyping FDM technology with the nozzle T16 (modeling layer thickness 0,254 mm), total error for linear dimensions should not exceed the level of 0,1 mm.
- Total angular error for details performed in Rapid Prototyping FDM technology with the nozzle T16 (modeling layer thickness (MLT) 0,254 mm), should not exceed the level of +/- 0,4˚.
- For printing the prototypes the nozzle T16 was selected. To perform models with higher accuracy, the smaller nozzle should be chosen, e.g. T12 (MLT - 0,178 mm), T10 (MLT - 0,124 mm). But it results in longer printing time and higher costs. Not in every case this choice from economical point of view is correct. In every case we should take into consideration the geometry complexity and expected accuracy.

## 5. REFERENCES

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