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# Optical Investigation of 3D Prints Behavior Under Compressive Load

M. Jurčišin [1,*], M. Blažo [1], J. Slota [2]

[1] *MCAE systems s.r.o., Knínická 1771, Kuřim, Czech Republic*
[2] *KPPT, Faculty of Mechanical Engineering, TUKE, Mäsiarska 74, 040 01 Košice, Slovakia*
[*] *miroslav.jurcisin@mcae.cz*

**Abstract:** 3D printed plastic parts are nowadays frequently used parts in all areas of industrial sphere. The main advantage of 3D printed plastic parts is quick manufacturing process, price and also possibility of producing complex parts. This paper is aimed to the 3D prints from the view of their strength. Specially designed chair was loaded by different weight and the maximum load before fracture was measured. Chair was under inspection of two different optical strain measurement systems working on different principles. System PONTOS working on the principle of digital photogrammetry and system ARAMIS working on the principle of digital image correlation were used. These systems were used in order to investigate and identify weak places of this chair.

**Keywords:** FDM; Photogrammetry; Digital Image Correlation; Strength; 3D Prints.

## 1 Introduction

One of the most common used technologies in the area of 3D printing is fused deposition modelling (FDM) technology. This technology is fast growing rapid prototyping technology due to its ability to build complex parts in reasonable time period [1]. FDM technology process was firstly established by Stratasys [2]. By the reason of price decreasing, there has been large growth in 3D printers since 2003. This technology gradually became a part of all different industrial fields [3]. Since this technology is frequently used, it is necessary to meet the requirements which are thereon imposed. One of these requirements is strength requirement. Good number of works in FDM strength modelling is devoted to study the effect of processing conditions on the part strength but no significant effort is made to develop the strength model in terms of FDM process parameters for prediction purposes [4]. In this paper, behavior of printed plastic chair under compressive load was investigated using different optical systems – system PONTOS and ARAMIS. System PONTOS is mobile optical system for dynamical measurement of the discrete point motion, vibration and deformation. PONTOS is equipped with two cameras that are synchronized. This system is developed by GOM [5]. For purposes of strain measuring within the parts of chair was used second system developed by GOM – ARAMIS. ARAMIS works on the principle of digital image correlation, where stochastic pattern is applied to the surface where strain measurement takes place. Principle of digital image correlation is described in several scientific publications [6].

## 2 Experimental Procedure

Specially designed chair illustrated on the Fig. 1 was loaded by testing machine Zwick/Roell Z100. Chair was made of polycarbonate (PC) material. PC is widely used in automotive, aerospace, medical and many other applications. Mechanical properties of PC are in the material properties report [7]. Chair was printed on the 3D printer Fortus 400mc with the layer thickness of material 0.254 mm. Loading direction was perpendicular to the plastic layers. Dimensions of the chair are approximately 140 $\times$ 115 $\times$ 190 mm. For an optical measurement procedure were used two CCD cameras DALSA FALCON 4M60 with maximal sensing frequency 60 images per second. Cameras were equipped with lens of 20 mm focal length.

## 3 Results and Discussion

Displacements of points during measurement with PONTOS system are illustrated on the Fig. 1. Course of force applied on the chair is illustrated on the Fig. 2. Maximum force which was applied to the chair before failure was 4179.95 N.

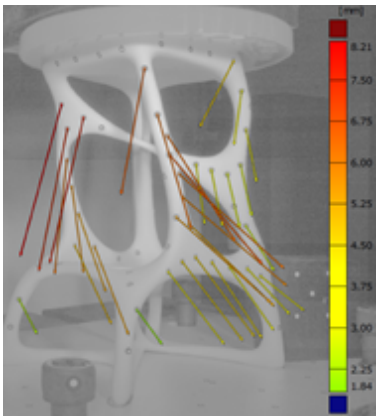

Fig. 1: Design of the chair and points displacement during load (Chair designed by Martina Šebková).

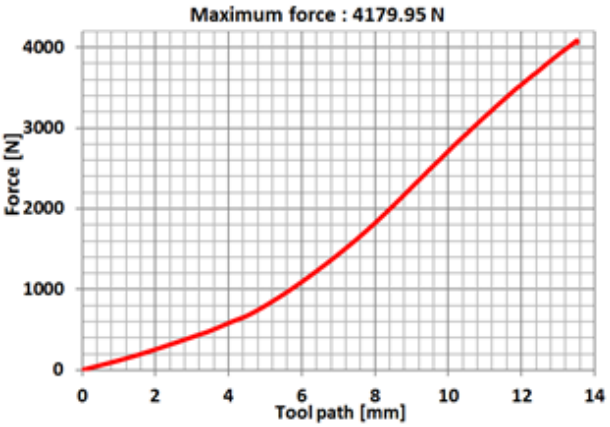


Fig. 2: Progress of the force applied on the chair during loading process.

## 4 Conclusion

As was mentioned, value of the maximal force is more than 4.1 kN. Measuring using PONTOS system proves that the point's displacement before failure was in critical places equal to the 10 mm. System ARAMIS shown that there were no changes in cross-sectional areas of the chair parts. This experiment shown, that plastic prints are capable of absorbing high values of loading force without failure. This fact makes 3D prints not only design or ergonomically solution, but also solution for the industrial spheres where on the strength requirements is placed great emphasis.

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