TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 57, Issue IV, November, 2014

REDESIGN OF "SAFETY RING" WORKPIECE FROM PROTECTION ASSEMBLY OF AN OFFICE CHAIR

Daniela POPESCU, Florin POPIŞTER, Răzvan CURTA, Călin NEAMȚU, Arnold ELES

Abstract: *The paper presents the redesigning process of a plastic component named "safety ring" that is a part of the protection system of the hydraulic cylinder of an office chair. The main objectives of the redesigning process were to reduce the weight of the workpiece and increase the clamping strength in assembly between "safety ring" and the first segment of the telescopic tube of the hydraulic cylinder protection assembly. After the workpiece was analyzed together with the working conditions, it has been redesigned such that to keep its functional role, as well as the shape and dimensions of the part on which it is mounted (the first segment of the telescopic tube). To validate the concept, the 3D model was first printed and then assembled together with the initial parts of the protection assembly of the hydraulic cylinder, to check its functionality. Because the "safety ring" piece is one obtained by plastic injection molding process, a simulation of the injection process was performed in order to validate the 3D model in terms of the manufacturing process. Using Catia V5R21 software was designed the injection mold for the "safety ring" piece, and with SolidCam 2013 was designed the manufacturing technology for the active plates of the mold. Finaly, the mold active plates were manufactured using Challenger Microcut 2418 vertical milling machine and the new variant of "safety ring" was obtained.*

Keywords: *3D printing, injection simulation, mold design, mold manufacturing*

1. INTRODUCTION

Nowadays, one of the most common processes for economically mass producing of plastic parts of various complex geometries and shapes is plastic injection molding process [1]. Over 30% of all the plastic polymer parts manufactured are by injection molding [2].

How to reduce the manufacturing time in order to achieve lower costs, part warpage and shrinkage are some of the major problems facing injection molders today.

Plastics industry is in a permanent growth due to the emergence of many new polymers with different characteristics and/or development of their processing technologies.

Due to this development, polymer injection techniques is the subject to new standards of high quality and to reduce manufacturing costs by automating lines injection molding optimization grooves distribution and thermal regime, so that the loss of material to be as low as possible. For this purpose instruments are used CAD / CAM / CAE in mold design and manufacture, and items printed in the manufacture of molds.

Ergonomic office chair is composed of several plastic parts where the most important are: the support or backrest, seat support, foot base and wheels same as protection system of hydraulic cylinder.

The protection of the hydraulic cylinder has both functional and aesthetic role. Functional point of view, it prevents dust and dirt on the rod hydraulic cylinder and prevents direct contact between the rod and the user.

Aesthetically the rod protection gives the seat stiffness, given that its diameter is 3 or 4 times higher than the hydraulic cylinder. In most models of office chairs, hydraulic cylinder adjusts seat height by changing the cylinder stroke. Protection system must adjust automatically depending on the length of the hydraulic cylinder rod position, without requiring user intervention. The problem was solved by most manufacturers by creating telescopic assembly, Figure 1, which is mounted by tightening the cylinder body on its rod.

Figure 1. Plastic protection of telescopic assembly

This paper aims to develop the analysis and optimization of the polymer part called "safety ring". This part goes into design of office chairs with adjustable piston. The piece is made of black polypropylene and it represents a ferrule of the defenders that are covering the telescope of the adjustable seat.

2. METHODOLOGY AND OBJECTIVES

The objectives of this paper are the redesign of a “safety ring”, so it would diminish its weight in the conditions of maintaining functionality and increase the grip strength between the ring and the telescopic mechanism, by maintaining the shape for the rest of the parts from the protection system of the hydraulic cylinder.

In order to reach the upper mentioned objectives, the authors followed the steps:

- **issue analysis**: identify the issues which appear during the identification of the problems which appear during the working phase of the protection system of the cylinder;
- **redesign**: redesign of the safety ring part so it would maintain the functionality and the design of the components of the protection system of the hydraulic cylinder;
- **model validation (3D printing)**: the redesigned solution was printed in 3D and was fixed in a real ensemble in order to verify its functionality;
- **validation of the manufacturing process (plastic injection)**: after the 3D model confirmation, it was verified using the Moldflow software in order to determine the contraction and the potential problems which could appear during the process of plastic injection;
- **mold design and manufacturing**: using a CAD solution/ dedicated, the authors have designed the mold for the plastic injection, and by using the SolidCAM solution was designed the manufacturing technology and were manufactured the active plates of the mold.

The above mentioned phases of the entire work employed in this paper are presented in Figure 2.

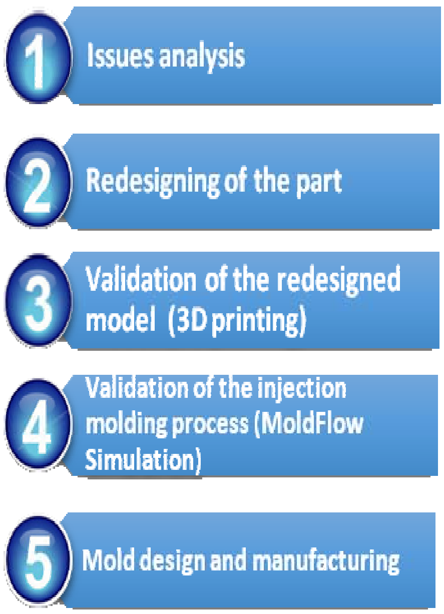

Figure 2. Work methodology

3. CASE STUDY AND RESULTS

3.1 Issues analysis

Safety ring has a cone-shaped exterior surface through which it is fixed the telescopic tube and it ensures a grip strength which allows maintaining a functional ensemble. The second important element is represented by the fixation system of the safety ring to the body of the cylinder. Through this fixation, the lower part of the telescopic system will be fixed by the body of the cylinder and the leg support during the shareholders of the hydraulic cylinder.

Therefore, the main problem of this version was that, after a longer use of the seat, due to wear of the conical part of the side wall, the ring loses its functional characteristics.

In order to lower the weight of the part and the material consumption (economically efficiency), the part will be redesigned so that the part of the telescopic tube to be maintained without modifications.

Considering that it will reduce the amount of the plastic which is injected, the manufacturing cycle will be lower, the part will be cheaper and the material consumption and the labor for manufacturing the active plates will be cheaper.

It was observed that the fixation system of the safety ring on the cylinder body is efficient and doesn't require it's modification during the redesign of the part.

Safety ring is placed inside the protection system by gripping it on the cone-shaped exterior surface and it has two functional roles:

- fixing the entire telescoping protection system on the cylinder frame;
- fixing the first element of the telescoping system

As it can be seen in figure 3, the taper angle of the side wall of the original "safety ring" was the only functional element with a role in assembling the piece.

Moreover, the constructive solution of the active plates of the injection mold can be greatly simplified by a more efficient redesigning of the injection molded part "safety ring". Thus, this it would lead to a reduced manufacturing time of the mold, and therefore at a lower cost of fabrication of the active plates.

3.2 Redesign of the part

Following the analysis made by the authors on the originally piece it was set to be redesigned in order to eliminate the conical area which present the initial form.

Figure 3: “Safety ring” workpiece

There are several “rules” that have to respect in order to design plastic parts that are to be obtaining using injection molds [3]. These important aspects have to be known by the designs in order to achieve the desired result. The most important of these “rules”, in the author's opinion, it may be mentioned as follows:

- **Wall thickness has to be uniform** - in order to avoid turbulent flow injection;
- **Avoid so-called "hot spots"** with clumps of material for thick walls - prolongation the injection cycle as a result of increasing the cooling time in the mold;
- **Proportion between rounding radius / thickness** of the wall should not be less than 0.6 (R / S> 0.6);
- **Design pieces slanted walls** - the parts in the mold core shrinks during the cooling process;
- **The addition of stiffening ribs** - molded parts are often designed with reinforcing

ribs for increased mechanical strength and rigidity;

After measuring the first segment of the telescopic tube, protection system of hydraulic cylinder, there was established a new form for the safety ring as shown in Figure 4.

As part of the initial redesign results led to obtain a piece of plastic that has a cylindrical zone with the termination block area as a collar. Area at the base of the piece, top view in Figure 3, one that will serve to get into another cylindrical part will have on the termination 4 stopping collar areas, marked in red zones in Figure 4, which will act as blockers.

The part was design at nominal rate, taking into account the coefficient of contraction for polypropylene EPP 0.5%-1% [4], factor that was taken into account in dimensioning active plates.

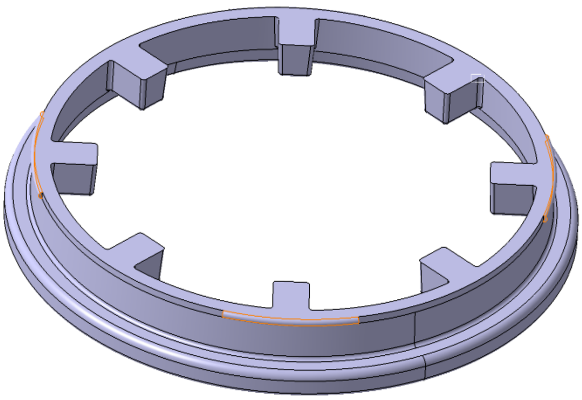

Figure 4. The resulted part after the redesigning process

The difference in weight between the two versions of the safety ring is 4.70 g, (weight of initial part is 9.9g ±0.05 g), redesigned model was lighter by 47.5%.

3.3 Validation of the redesigned model - 3D printing

After determining the final shape of the safety ring, it was printed using melting plastic 3D Techniques. After obtaining the printed piece, it was installed and tested on a real assembly to check its functionality. 3D printer used is shown in the Figure 5 below and the model results in Figure 6.

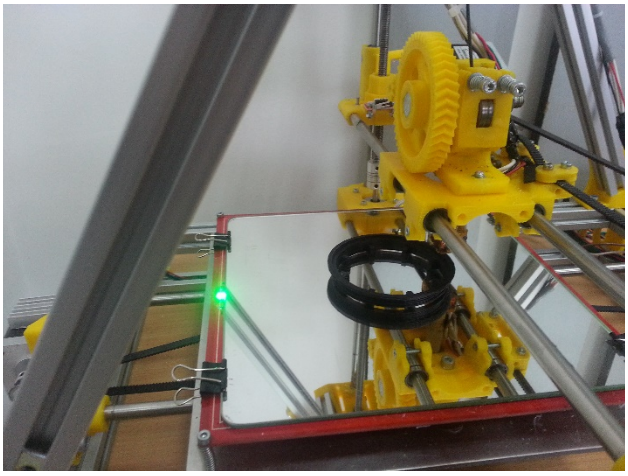

Figure 5: 3D printing process

Figure 6: 3D printing result

The material used in the 3D printing process was an ABS 1.7 mm filament. It is consider being the proper material that can be used in this process due to its mechanical proprieties having a good rigidity, high surface hardness and good dimensional stability, easy to process it can be painted. Also it presents a very good stability at heat.

3.4 Validation of the injection molding process

Validation of the 3D model is not only functionally, but also in terms of manufacturing processes: injection molding. The part can be redesigned to be injected without undergoing deformation or other defects specific on parts manufactured by injection molding process. This can be verified by simulation of the injection process in specialized software such as Moldflow.

This step is very important because with it we can identify positive and negative aspects of the process of injection. Results of such analysis may have an effect on the mold and can be directly applied in the design process of it. Thus is to be eliminated the possibility of having wrong designed molds and also to identify the entire process time in order to establish the productivity.

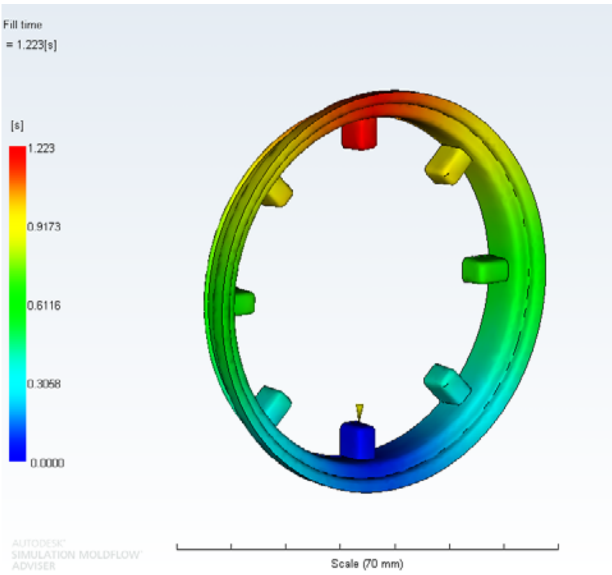

Figure 7: Fill time

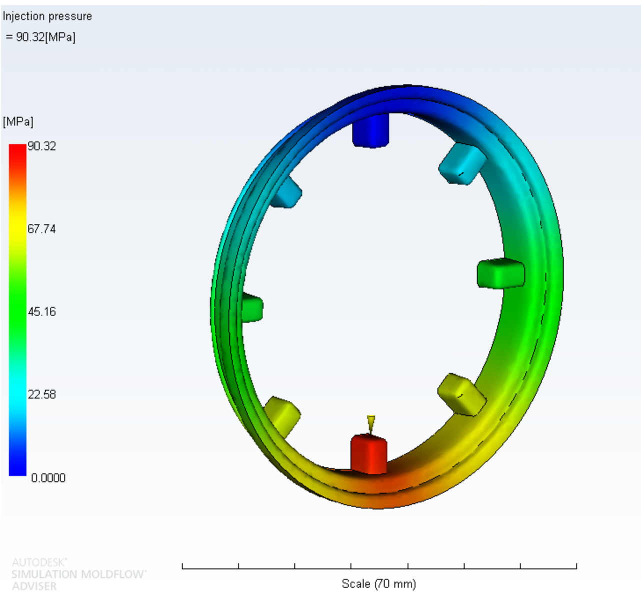

Figure 8: Injection pressure

Within the Moldflow software application that was used by the authors in this case study some of the important aspects that were to be taken into consideration are fill time (Figure 7), the injection pressure (Figure 8) present on the entire injected part or if the cooling quality (Figure 9) it is to be at the same value on the entire part.

3.5 Mold design and manufacturing

After creating the 3D model in Functional Molded Part module of CATIA, the separation plan was created that is needed to separate Core and Cavity formation of the active plates of the injection mold. After that, the designing of the mold in Mold Tooling Design module was made, where the resizing of each part of the mold is possible (Figure. 10).

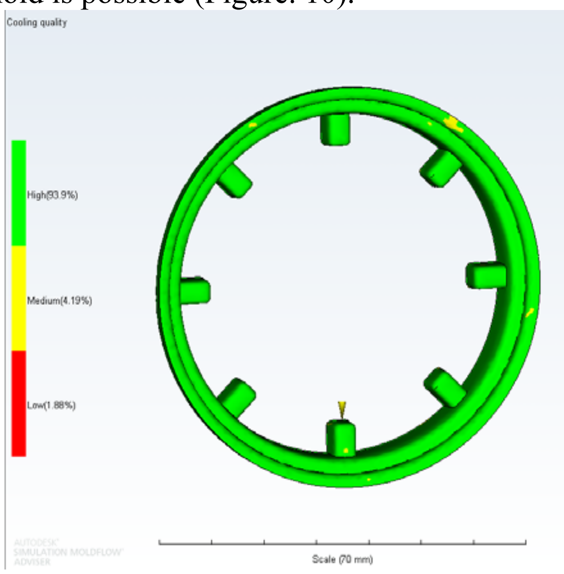

Figure 9: Cooling quality

The mold is composed besides her active plates, by guidance columns, bushings, screws of various sizes, ejection etc. (Figure 10, 11). All these components are found in a wide range of standardized libraries, where they can be used according to the needs and the designing requirements.

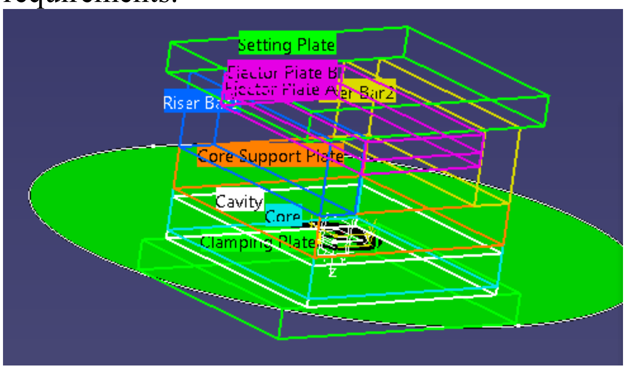

Figure 10: Dimensioning the mold elements

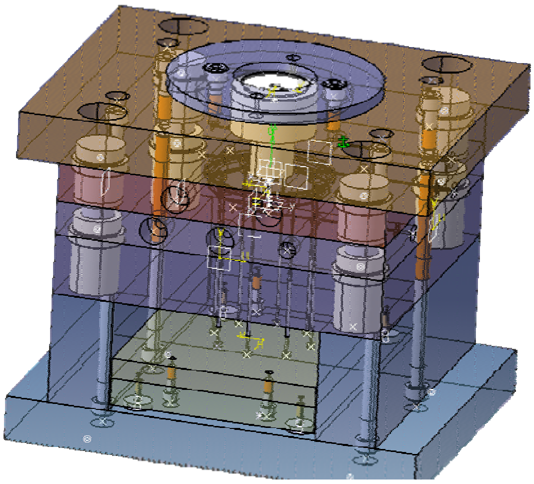

Figure 11: The assembly of the designed mold

In Figure 11 it is illustrated the final injection mold assembly, together with all the elements used, designed in CATIA software.
For designing the manufacturing technology for the active plates and generating the NC code, SolidCAM 2013 was used within SolidWorks software.

After studying the size and the operating environment of the active plates of the mold, the A2017 aluminum alloy was chosen as a material for the plates with the chemical composition presented in Table 1:

Table 1: chemical composition of A2017 alloy [5]

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
0.2–0.8	max. 0.7	3.5–0.1	0.4–0.8	0.4–0.8	max. 0.1	max. 0.25	max. 0.15

The manufacturing of the plates was carried out using a Challenger Microcut 2418 vertical milling machine, with automatic tool-change capabilities (max number of tools = 16), equipped with a maximum spindle speed of 10000 rpm and with 7.5 KW spindle motor power.

Figure 12: The manufactured mold plates

Figure 13: The new workpiece resulted from mold injection process

Figure 12 presents the Core and Cavity active plates of the mold after manufacturing on Challenger Microcut 2418 machining center and in Figure 13 it is illustrated the new workpiece resulted after mold injection process was made.

Figure 14. Intial version (up) and redesigned version

4. CONCLUSIONS

This paper presents a simple and efficient way of optimization method of an existing part, resulted from plastic injection molding process. The entire methodology employed in this paper present how certain modern instruments, design and/or manufacturing, can be correlated together in order to obtain a part closer to a correct and improved one. 3D Printing technology is to be considered a significant validation instrument nowadays of a redesign broken part that has functional problems before staring the properly mold design process. In this way it can be corrected some unwanted aspects. Also simulating the injection process using modern CAD instruments proves to be a reliable solution before starting the design and manufacturing the final mold.

ACKNOWLEDGEMENT AND DISCLAIMER

This paper has benefited from the support of the project "Cercetare pentru proiectarea si realizarea de repere din mase plastice pentru industria mobilei", contract no. . 12.P01.001 11 C1, beneficiary Proeli Concept SRL Cluj-Napoca, partner Technical University of Cluj-Napoca. The project is part of the Competitiveness Pole 12 P01 001 "Transylvanian Furniture Cluster" financed through the Sectorial Operational Program "Increase of Economic Competitiveness 2007-2013" by the European Regional Development Fund. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

5. REFERENCES

[1] Omar A. Mohamed, S.H. Masood, Abul Saifullah, A Simulation Study of Conformal Cooling Channels in Plastic Injection Molding, International Journal of Engineering Research, Volume No.2, Issue No. 5, pp : 344 – 348, ISSN: 2319 – 6890, 1 Sept. 2013.

[2] D. Mathivanan, M. Nouby and R. Vidhya, Minimization of sink mark defects in injection molding process – Taguchi approach, International Journal of Engineering, Science and Technology, Vol. 2, No. 2, 2010, pp. 13-22.

[3] Teodor Daniel Mîndru, ContribuŢii la studiul Şi modelarea proceselor de injecŢie a pieselor ranforsate din materiale plastice, P.hD. Thesis. UNIVERSITATEA TEHNICĂ "GHEORGHE ASACHI" DIN IAŞI Facultatea de Construcții de Maşini şi Management Industrial IAŞI - 2013

[4] http://www.mase-plastice.ro/downloads/Ghid-densitate-coeficient-contractie.pdf CoeficienŢi de contracŢie a PPE.

[5] http://www.kaiseraluminum.com/customers/products/ extrusions/bar/

REPROIECTAREA PIESEI "SAFETY RING" DIN ANSAMBLUL DE PROTECTIE A UNUI SCAUN DE BIROU

Abstract:
Lucrarea prezintă procesul de reproiectare a unei componente de plastic care face parte din ansamblul de protecție a cilindrului hidraulic a unui scaun de birou. Obiectivele procesului de reproiectare sunt reducerea greutății piesei şi creşterea forței de strângere la asamblarea safety ring cu primul segment al tubului telescopic al ansamblului de protecție a cilindrului hidraulic. După

analiza piesei şi a condițiilor de funcționare, aceasta a fost reproiectată astfel încât să se păstreze atât rolul funcțional al acesteia, cât şi forma şi dimensiunile piesei pe care aceasta se montează (primul segment al tubului telescopic). Pentru validarea conceptului, modelul 3D s-a printat şi mai apoi a fost asamblat împreună cu piesele inițiale ale ansamblului de protecție pentru a verifica functionalitatea lui. Deoarece piesa este una obținută prin procedeul de injecție mase plastice, s-a realizat o simulare a procesului de injecție astfel încât să se valideze modelul 3D şi din punct de vedere al procesului de fabricație. În Catia V5 s-a proiectat matrița pentru piesa "safety ring" şi utilizând soluția SolidCAM s-a generat codul NC necesar realizării celor două placi active pe centrul de prelucrare Challenger Microcut 2418.

Daniela POPESCU, dr. eng., professor, Technical University of Cluj-Napoca – Department of Design Engineering and Robotics. daniela.popescu@muri.utcluj.ro

Florin POPIŞTER, dr. eng., assistant professor, Technical University of Cluj-Napoca – Department of Design Engineering and Robotics. florin.popister@muri.utcluj.ro

Răzvan CURTA, dr. eng., assistant professor, Technical University of Cluj-Napoca – Department of Design Engineering and Robotics. razvan.curta@muri.utcluj.ro

Călin NEAMȚU, dr. eng., associate professor, Technical University of Cluj-Napoca – Department of Design Engineering and Robotics. calin.neamtu@muri.utcluj.ro

Arnold ELES - eng. phd student, Technical University of Cluj-Napoca – Department of Design Engineering and Robotics, eles_arnold@yahoo.com