Technological and Constructive Considerations on the Realization of Components and Parts Using 3D Printing FDM-Type Technology

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Abstract: *The work is addressed both the constructive considerations and the analysis of specific deformations generated by gaseous or liquid medium on specific components of the pneumatic or hydraulic installation. The work is structured on several part that addresses at first the general considerations after that considerations for classifying the analysed components and at the end of the generation, realization of components through 3D printing and final the analysed of constructive elements generated to the medium used for functional activity. The analysis of the material behaviour on requests from an effective point of view will be the subject of a subsequent work, starting from the considerations of analysing deformations and modifying the structure and shape of components based on the elements observed where this is required.*

Keywords: *Repair, 3D printing, hydraulic/pneumatic, constructive modelling*

1. Introduction

In this paper there was conducted a study on the possibilities of replacement of components or assemblies used in hydraulic/pneumatic installations with components made by generation methods of 3D printing FDM system. Both parts of a hydraulic/pneumatic installation and sub-assemblies, which may be replaced by a single component, shall be concerned with the improvement of both the technological precision of the component, but also the provision of a component with a much better structure than that of the assembly achieved by conventional technological processes. At the same time by using the 3D printing technology, the old parts or assemblies, obtained with polluting technologies, are replaced with some at which the generating part is clean, the energy consumption is reduced and the costs of regenerating the parts, or smaller sub-assemblies than those obtained by more polluting traditional technologies [1]. For example, we will take a component of a hydraulic/pneumatic made of aluminium or cast iron, two types of polluting materials both in the raw material, but also in the phase of realization itself, through the technological methods of casting. If the same milestone is achieved through 3D printing through the FDM method with PLA material, we can see the following. The PLA is a material with mechanical properties is like those of aluminium to compression [2, 3]. It can also be observed that FDM as a material generation technology that is a method that does not pollute the environment, being the lowest degree of volatile particles emitted in the workspace relative to other 3D printing technologies.

It can also be observed that for replacing the aluminium or cast iron, with another aluminium or cast iron or with the same marker, we can have the following solutions:

- technological variant welding for repair, relatively polluting method;
- recycle of melting and casting, method also polluting.

For the FDM case, the marker is broken into pieces with a tooth mill, a method with a low level of pollution, is introduced in a proportion of 50% new material and reused and the creation of a new files, with which the new part will be achieved through the process called FFF method the same unpolluting method.

If the comparison is made at the level of the cost of realisation only if we are to consider the costs of achieving the melting of aluminium minimum 700 degrees Celsius, with the plasticizing of the PLA maxim 220 degrees Celsius, we will clearly realize the advantages FDM technology.

The achievement of 3D printed parts is ensured by its variants, which are numbering five type [4] and involving lower or higher output costs [3] primarily dependent on the raw material used in the performance of the 3D printed component, but also by how to achieve printing so the technology used.

It should be noted that by any of the five solutions, the obtaining of components can be made technologically efficient, with reduced manufacturing costs, low energy consumption and not least with the use of renewable materials and/or biodegradable. Some of these technologies because they use size particles of the order of tens or hundreds of microns and can produce particulate matter and thereby pollution of the working space.

2. Classification of types of hydraulic/pneumatic components from a dimensional and functional point of view

A hydraulic/pneumatic installation can be distinguished, the existence of several types of components, which may be demanded from the point of view of static but also dynamic applications. We can thus classify them:

- part with functional or no functional or positional and unsolicited role;
- functional parts which are little requested, and which do not encounter in contact with the pressure environment;
- functional parts that encounter with the pressure environment and are required by it.

A few of these parts are presented in the paper and a brief analysis of their main characteristics is being made.

2.1 Part with functional or no functional or positional and unsolicited role

For their case, precision is the element that has an important role in constructive and functional terms. Precision is provided by the 3D printing technology by making dimensional corrections at the level of the quotas that must ensure the required dimensional precision. At the same time, depending on the orientation of the usual static and wear of the surface, the structure used is for printing with a heterogeneous or homogeneous component, with a lower or higher density of the 3D printed interior structure. From among these elements, the coupling elements of the ducts must be presented to the components of the hydraulic or pneumatic circuit of the type coupling part (Figure 1).

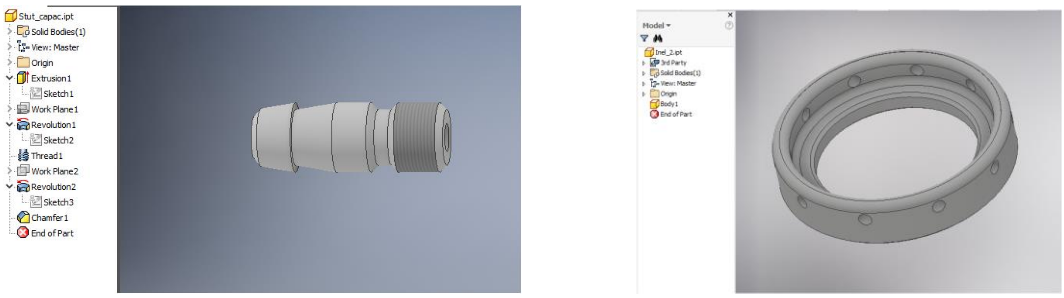

Fig. 1. Coupling pneumatic/hydraulic part 4 mm inner diameter at left and ring for pneumatic/hydraulic sealing at right

For the coupling part case, a FEA modeling was made using the inner-specific load of the central tube with a pressure of 10 MPa and the threaded side and the surfaces that is in contact with the connection tube were loaded with a pressure of 1 MPa (Figure 2). From the analysis for compressed air pressure the requests are small deformities being insignificant by the order of micron. For higher hydraulic pressures of order 10 MPa the deformations become larger and, in some areas, approaching the limit resistance of the material. It should be noted that due to the specificity of the material and the mode of generation FEA modeling must be accompanied by the mechanical test to validate the model.

The 3D modeled part is saved in STL format and is then processed to generate layers and numerical command. Great importance in the process of made the part that is subject to the process of generating the numerical command, is the verification from several viewpoints of the STL part generated.

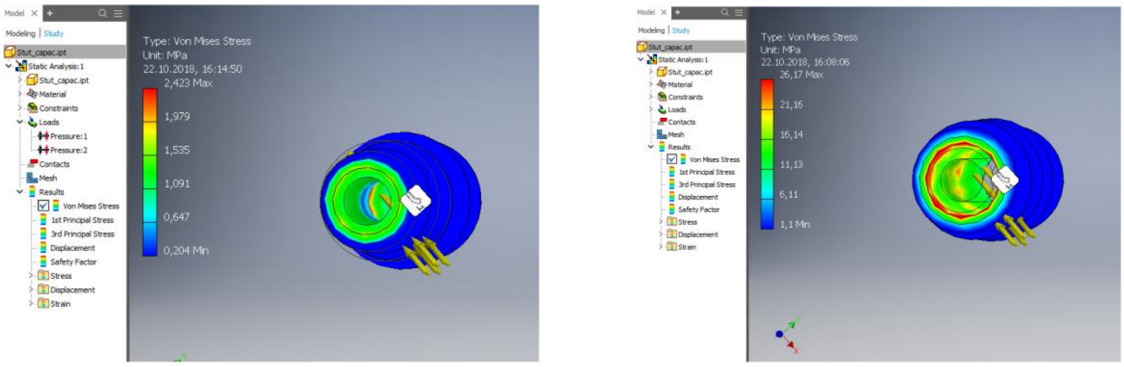

Fig. 2. Coupling pneumatic 1 MPa left / hydraulic 10 MPa right part 4 mm inner diameter

It must be shown at this point that there are two important phases. The first is related to the implementation of the STL file which must respect both the dimensional conditions and the resolution of the implementation of the STL generation of the triangle generated. The second is the verification of how to generate are and correct the errors.
The generation of the part was carried out with the Fabrikator Mini printer, which provides the processing of part with the size of 80 mm^3 and to which the program for generating is Cura for layers generation and under Repetiter Host was used for generation of them. It should be noted that both previously mentioned programs are of FREE type. In (Figure 3) you can see the settings for generation and on the right side of generation with the generation of 1 minute and 1 second, with a thread length of 1 metre and a number of layers of 2 pieces. The track generated can be seen in (Figure 4).

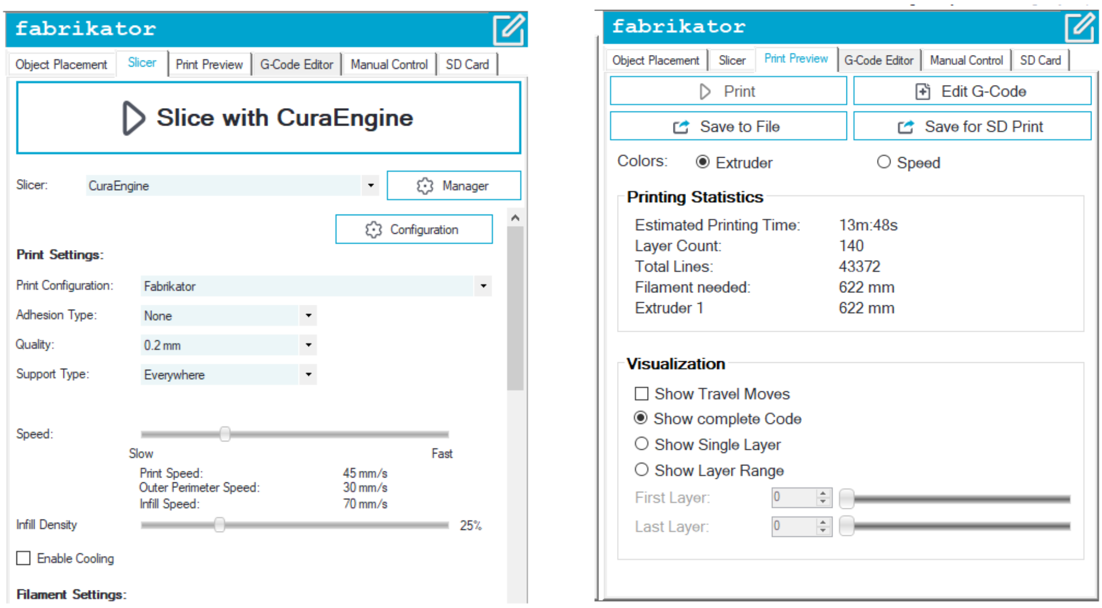

Fig. 3. Coupling pneumatic slice generated parameter at left and printing statistic at right

It can therefore be concluded that for parts without a functional role the realization through this process is very good at low pressures and satisfactory at high pressures, where it begins to be recommended to use the achievement of parts through the processes of 3D printing SLS.

2.2 Functional parts that are low in demand and do not encounter the pressure medium

This type of components is those that are medium requested, but that do not come or come into direct contact with the hydraulic or pneumatic medium. For these components function the interconnection mode with the other components, an important role has both the dimensional component for the achievement of the games and/or centres and the tightening of the conjugated components, but also the direction and the way in which forces appear at surface level and in the structure of 3D printed components. The major advantage of 3D printing from other materials processing technologies through traditional procedures is given by the fact that it allows for the replacement of several components made by traditional technological methods, with a single component, achieved through 3D printing.

Fig. 4. Coupling pneumatic at left and printing statistic at right generated by FDM 3D printing solution

One of the elements which is in this category is the cap of the body of a cylinder for a hydraulic or pneumatic installation (Figure 5) shall be presented from among these items. The generation of both components was carried out in the INVENTOR in the light of their functional role.

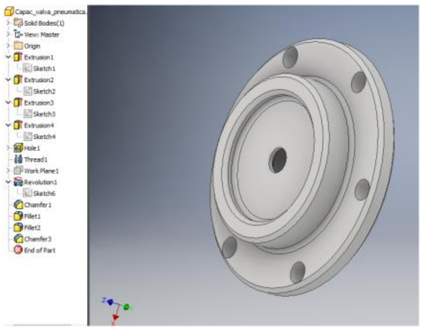

Fig. 5. Cap of a cylinder for a hydraulic or pneumatic installation

It must be shown at this point that there are two important phases. The first is related to the implementation of the STL file which must respect both the dimensional conditions and the resolution of the implementation of the STL generation of the triangle generated. The second is the verification of how to generate are and correct the errors.

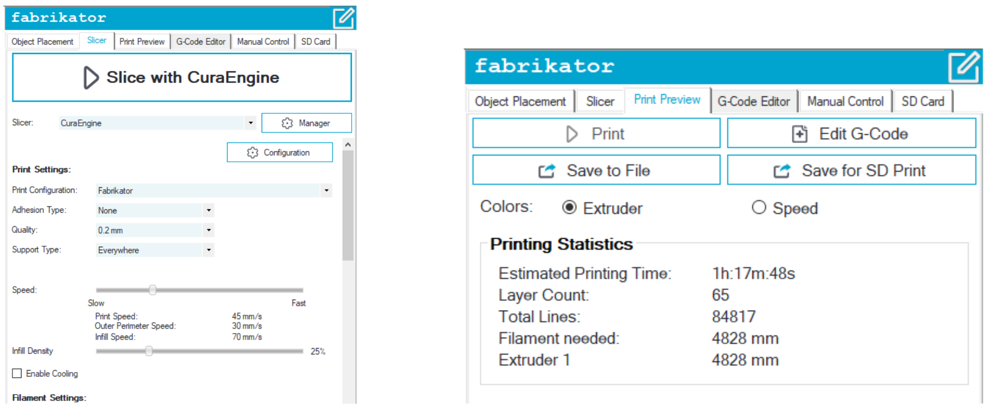

Fig. 6. Cap of a cylinder for a hydraulic or pneumatic installation slice generated parameter

The generation of the part was carried out with the Fabrikator Mini printer, which provides the processing of part with the size of 80 mm^3 and to which the program for generating is Cura for layers generation and under Repetiter Host was used for generation of them. It should be noted that both previously mentioned programs are of FREE type. In (Figure 5) you can see the settings for generation and on the right side of component for one of this elements. The track generated can be seen in (Figure 7).

The 3D modeled part is saved in STL format and is then processed to generate layers and numerical command. Great importance in the process of made the part that is subject to the process of generating the numerical command, is the verification from several viewpoints of the STL part generated.

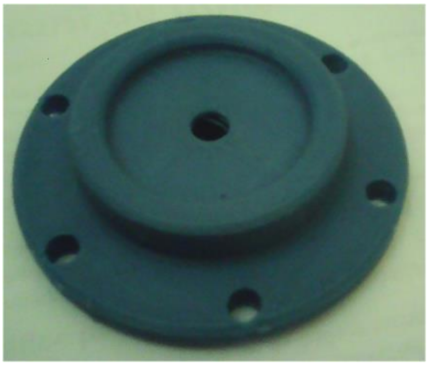

Fig. 7. Cap of a cylinder for a hydraulic or pneumatic installation slice generated parameter

To solve the modelling problem with the finite element was defined in the program INVENTOR 2019 educational variant. The material from which the part was made is the PLA [5] to which the resistance characteristics have been considered (Figure 8).

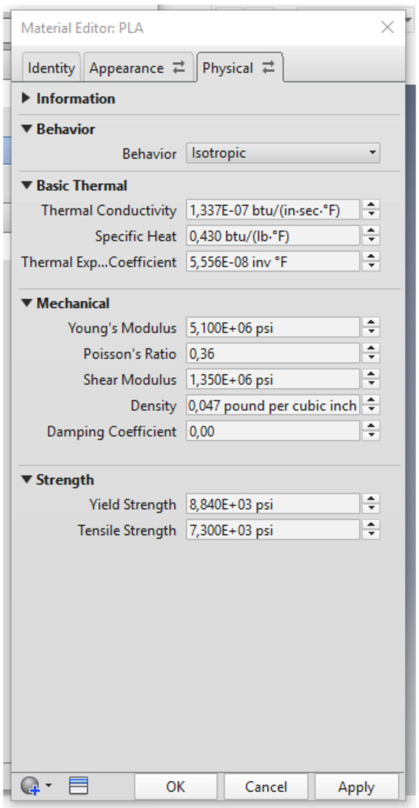

Fig. 8. Cap of a cylinder for a hydraulic or pneumatic installation PLA definition characteristics

For the cap of a cylinder, a FEA modeling was made using the frontal load force with a pressure of 1 MPa or 10 MPa and fixed part of the orifice (Figure 9). From the analysis for compressed air pressure the requests are small deformities being insignificant by the order of micron. For higher hydraulic pressures of order 10 MPa the deformations become larger and, in some areas, approaching the limit resistance of the material. It should be noted that due to the specificity of the material and the mode of generation FEA modeling must be accompanied by the mechanical test to validate the model.

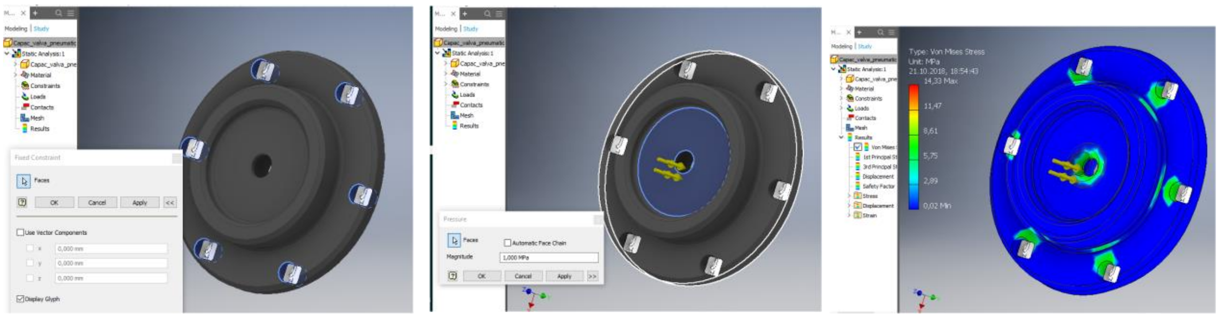

Fig. 9. Cap of a cylinder for a hydraulic or pneumatic installation PLA load force, fixed point and deformation

The numerical value of the FEA modelling it is presented in (Figure 10). At left for 1 MPa and at right for 10 MPa. The displacement is 2 microns for small pressure and 20 microns for medium pressure.

Result Summary

Name	Minimum	Maximum
Volume	20519,6 mm^3	
Mass	0,0266781 kg	
Von Mises Stress	0,0244432 MPa	14,3325 MPa
1st Principal Stress	-6,83642 MPa	16,8795 MPa
3rd Principal Stress	-22,6833 MPa	5,89777 MPa
Displacement	0 mm	0,0048324 mm
Safety Factor	4,25253 ul	15 ul
Stress XX	-19,6933 MPa	14,7601 MPa
Stress XY	-5,68141 MPa	4,79292 MPa
Stress XZ	-5,33529 MPa	5,29277 MPa
Stress YY	-17,1446 MPa	12,604 MPa
Stress YZ	-4,78528 MPa	4,79641 MPa
Stress ZZ	-10,6271 MPa	8,19982 MPa
X Displacement	-0,00105085 mm	0,00104971 mm
Y Displacement	-0,00109794 mm	0,00110114 mm
Z Displacement	-0,0047991 mm	0,000140194 mm
Equivalent Strain	0,000000634278 ul	0,000399103 ul
1st Principal Strain	0,000000315894 ul	0,000335701 ul
3rd Principal Strain	-0,000466294 ul	-0,000000413172 ul
Strain XX	-0,00035065 ul	0,000253731 ul
Strain XY	-0,000219738 ul	0,000185374 ul
Strain XZ	-0,000206351 ul	0,000204707 ul
Strain YY	-0,000351884 ul	0,000257688 ul
Strain YZ	-0,000185079 ul	0,000185509 ul
Strain ZZ	-0,000138585 ul	0,000172857 ul

Result Summary

Name	Minimum	Maximum
Volume	20519,6 mm^3	
Mass	0,0266781 kg	
Von Mises Stress	0,244432 MPa	143,325 MPa
1st Principal Stress	-68,3642 MPa	168,795 MPa
3rd Principal Stress	-226,833 MPa	58,9777 MPa
Displacement	0 mm	0,048324 mm
Safety Factor	0,425253 ul	15 ul
Stress XX	-196,933 MPa	147,601 MPa
Stress XY	-56,8141 MPa	47,9292 MPa
Stress XZ	-53,3529 MPa	52,9277 MPa
Stress YY	-171,446 MPa	126,04 MPa
Stress YZ	-47,8528 MPa	47,9641 MPa
Stress ZZ	-106,271 MPa	81,9982 MPa
X Displacement	-0,0105085 mm	0,0104971 mm
Y Displacement	-0,0109794 mm	0,0110114 mm
Z Displacement	-0,047991 mm	0,00140194 mm
Equivalent Strain	0,00000634278 ul	0,00399103 ul
1st Principal Strain	0,00000315894 ul	0,00335701 ul
3rd Principal Strain	-0,00466294 ul	-0,00000413172 ul
Strain XX	-0,0035065 ul	0,00253731 ul
Strain XY	-0,00219738 ul	0,00185374 ul
Strain XZ	-0,00206351 ul	0,00204707 ul
Strain YY	-0,00351884 ul	0,00257688 ul
Strain YZ	-0,00185079 ul	0,00185509 ul
Strain ZZ	-0,00138585 ul	0,00172857 ul

Fig. 10. Cap of a cylinder for a hydraulic or pneumatic installation displacement and stress value

It can therefore be concluded that for parts with a functional role the realization and contact with the medium through this process is good at low pressures and satisfactory at medium pressures, where it begins to be recommended to use the achievement of parts through the processes of 3D printing.

2.3 Parts with a functional role that encounter the pressure medium and are required by it

This type of components is those that are required by the active working environment at maximum values and come into direct contact with it. For these components function the interconnection

mode with the other components, an important role has both the dimensional component for the achievement of the games and/or centres and the tightening of the conjugated components, but also the direction and the way in which the applications appear at the surface level and in the structure of the 3D printed components.
The part it is the body of this cylinder (Figure 11). The generation of both components was carried out in the INVENTOR in the light of their functional role.

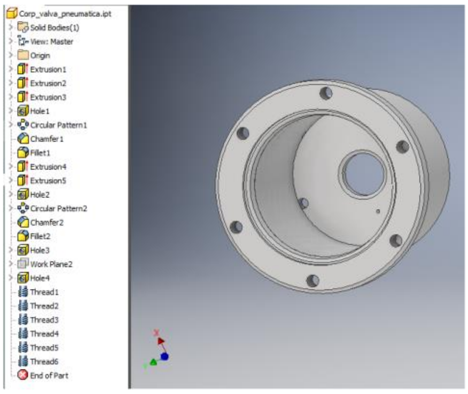

Fig. 11. Body of a cylinder generated in INVENTOR

The generation of the part was carried out with the Fabrikator Mini printer, which provides the processing of part with the size of 80 mm^3 and to which the program for generating is Cura for layers generation and under Repetiter Host was used for generation of them. It should be noted that both previously mentioned programs are of FREE type (Figure 12). In (Figure 13) can see the load for FEA model generation. At left fixed point and force load and on the right side the deformation for this elements.

Fig. 12. Body of a cylinder for a hydraulic or pneumatic installation 3D printed

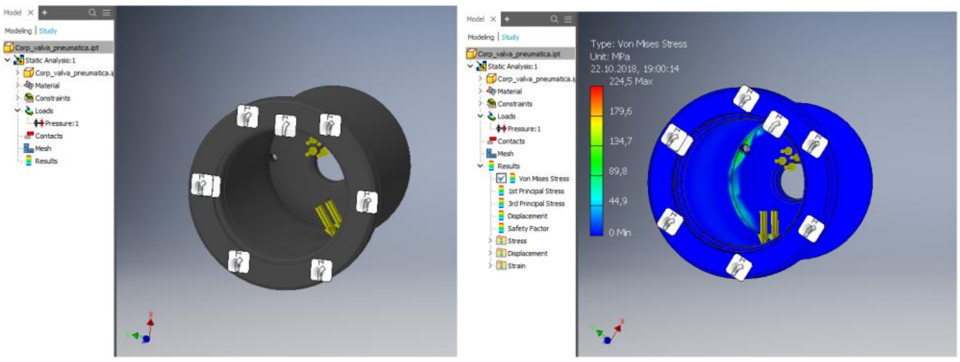

Fig. 13. Body of a cylinder for a hydraulic or pneumatic installation load for FEA modeling

In view of the deformations that occur, the construction of the analysed element has been changed (Figure 14) and it has been concluded that without the use of metallic material solutions in the outer or inner area will not withstand the requests.

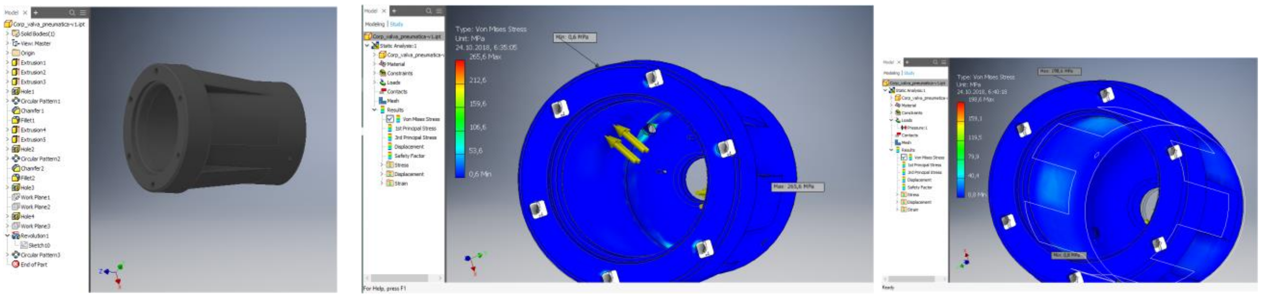

Fig. 14. Body of a cylinder modify for a hydraulic or pneumatic installation load for FEA modeling

It can therefore be concluded that for parts with a functional role for this construction is satisfactory for modified structure at low pressures and mot satisfactory at medium pressures, where it begins to be recommended to use the metallic part for construction of part made by 3D printing.

3. Conclusions

In view of the observations made at the end of each subchapter, it may be concluded that parts generated by 3D printing in hydraulic or pneumatic installations may be used in part. The research will continue with the achievement of the benchmarks according to the results recommendations and the attempt in their work process.

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