Design and Simulation of a respirator with Altair Simsolid

By Raquel Sanz

The first step before performing the calculation is to define the material of the model. Nylon 66, also known as Polyamide 66 or PA66, was chosen. It is characterized by a good mechanical resistance, high impact resistance, good cushioning and light. It is also difficult to damage from chemical agents such as solvents or oils.

The material library of the software allows to enter new parameters to perform the calculation with the desired material and in this case, the following were introduced:

Poisson coefficient	Density (kg/m^3)	Expansion termal coefficient (1/°C)	Thermal conductivity (W/(m*K))	Ultimate tensil stress (Mpa)	Tensil yield stress (Mpa)	Compresive yield stress (Mpa)
0,35	1130	0,0000558	0,24	82	58	58

Tabla 1. Nylon 66 properties

It is also a material that is marketed in filament suitable for 3D printing, which is one of the objectives of the project.

The analyses that were applied to the model were:

- Modal analysis

- Static analysis

- Dynamic analysis

MODAL ANALYSIS

In general, modal analysis can be defined as a way of estimating the frequencies to which a set is subjected. It is a study of proof and verification of the model.

In the first place, a modal analysis of the free-free type is applied, where the model moves in space without movement restrictions or fasteners and maintaining the glued contacts between the different pieces that make up the set.

The purpose is to perform a check of the model where a wrong assembly can be identified. Any part that moves within the subassembly does so because it does not have a high enough stiffness, that is, as if it were loose.

Attention must be paid to the values of the frequencies in the first six modes, having a value of zero Hz.

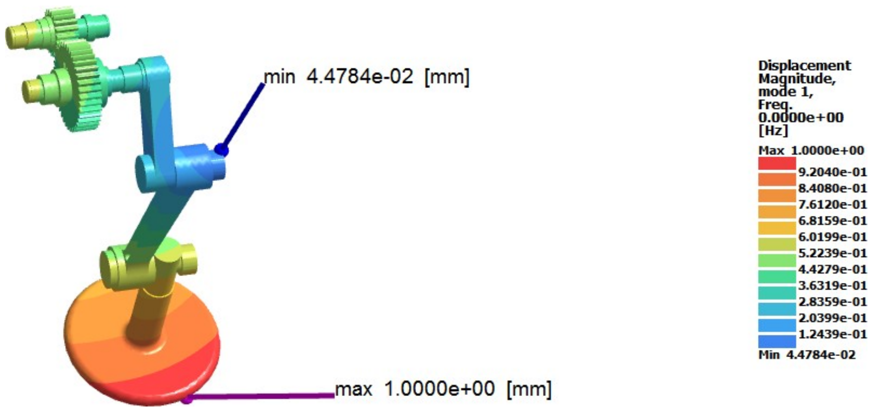

Figure 1. Free-free analysis mode 1

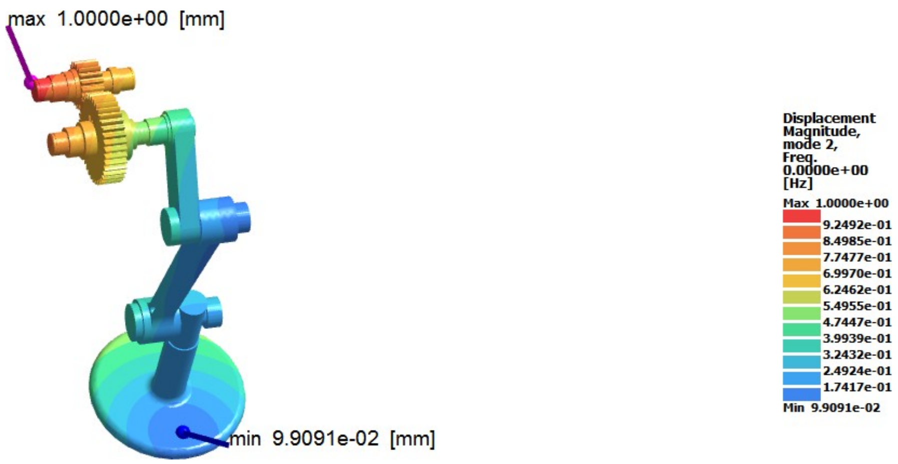

Figure 2. Free-free analysis mode 2

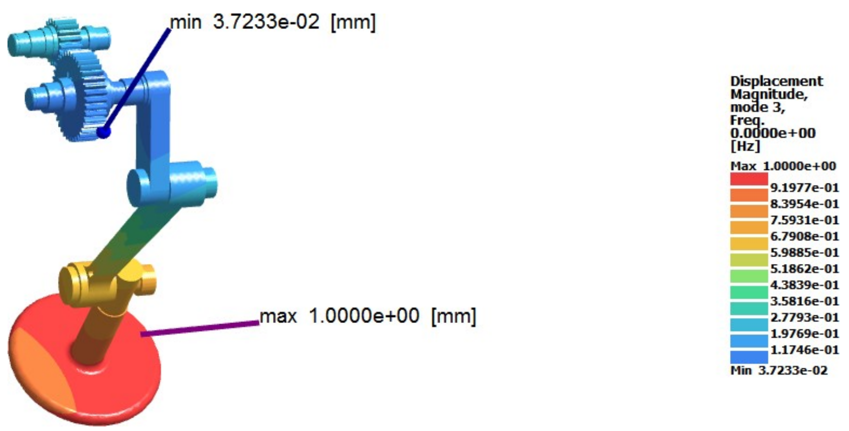

Figure 3. Free-free analysis mode 3

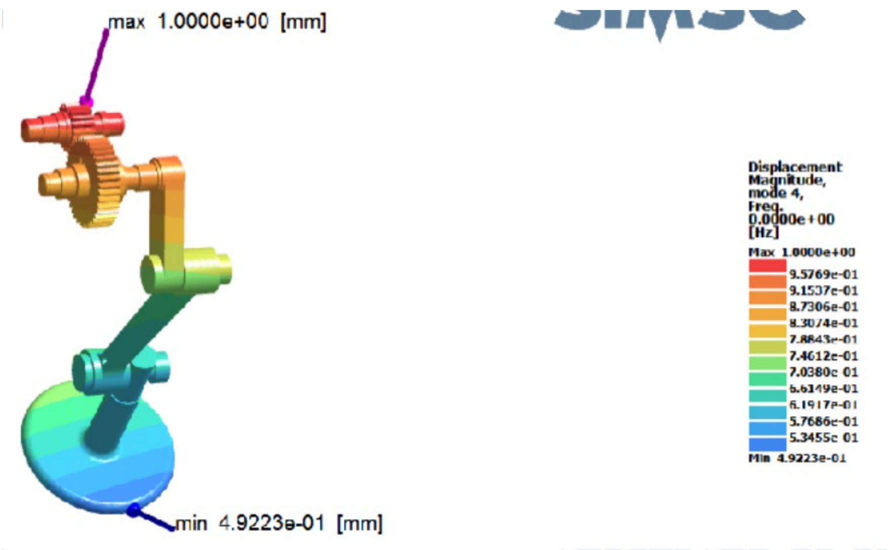

Figure 4. Free-free analysis mode 4

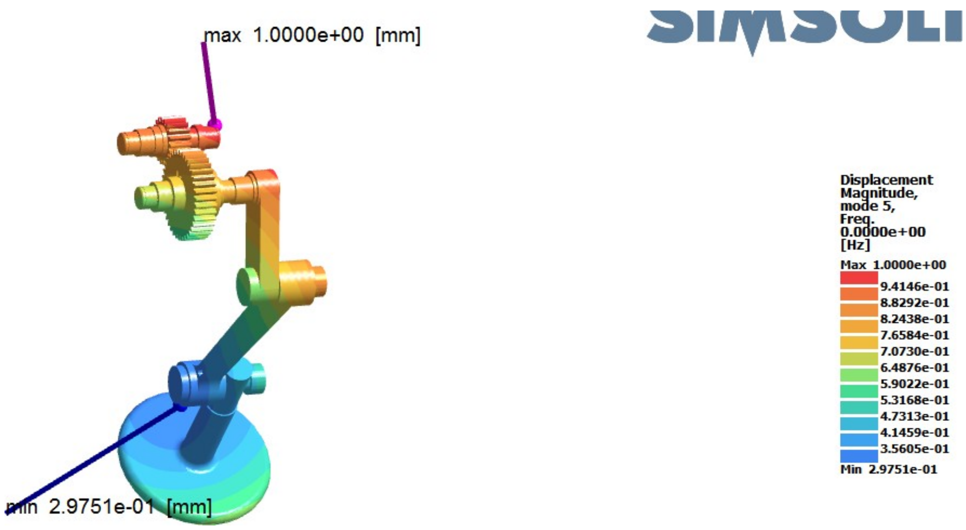

Figure 5. Free-free analysis mode 5

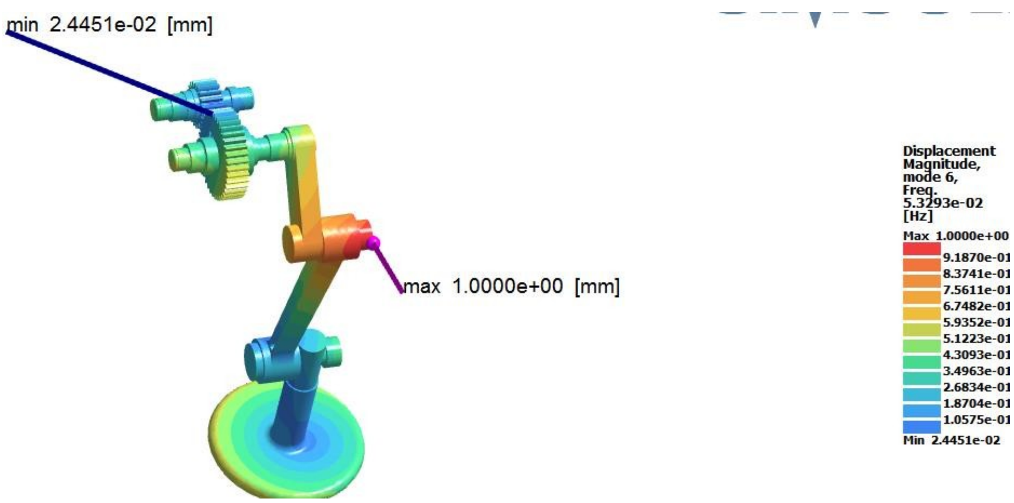

Figure 6. Free-free analysis mode 1

Once this study is done, movement restrictions are applied to the model and real property is assigned to the contacts between the parts that make up the mechanism.

The purpose is to check that there is no resonance. For this, the value of the frequency of the first mode must be compared with the value of the frequency of the exciter, in this case the electric motor that drives the mechanism.

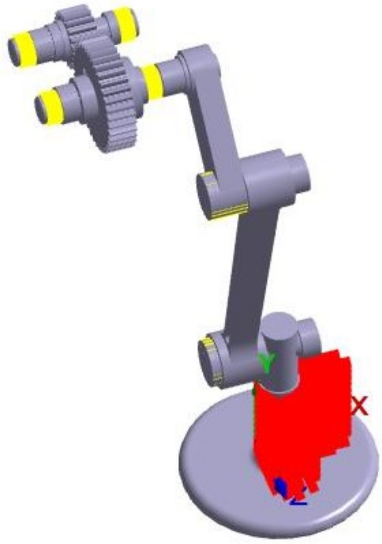

Figure 7. Modal analysis with movement restrictions

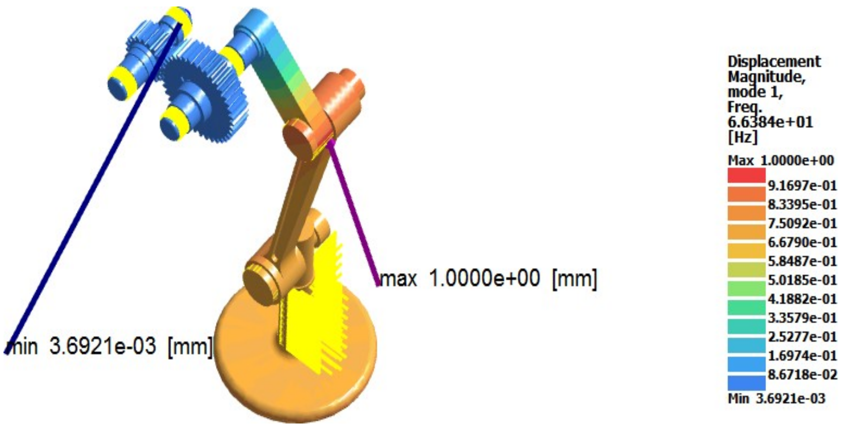

Figure 8. Modal analysis with movement restrictions mode 1

LINEAR STATIC ANALYSIS

Through static analysis, the model is subjected to load applications where internal forces that indicate whether the applied material will resist these efforts are generated.

For this, the linear and rotational movement in all axes on the face of the plunger that would be in contact with the air bag has been restricted, since it is the most restrictive condition to which the mechanism can be subjected.

By applying a torque, previously calculated, at the end of the input shaft of the reducer, favorable results are obtained as can be seen in the following images.

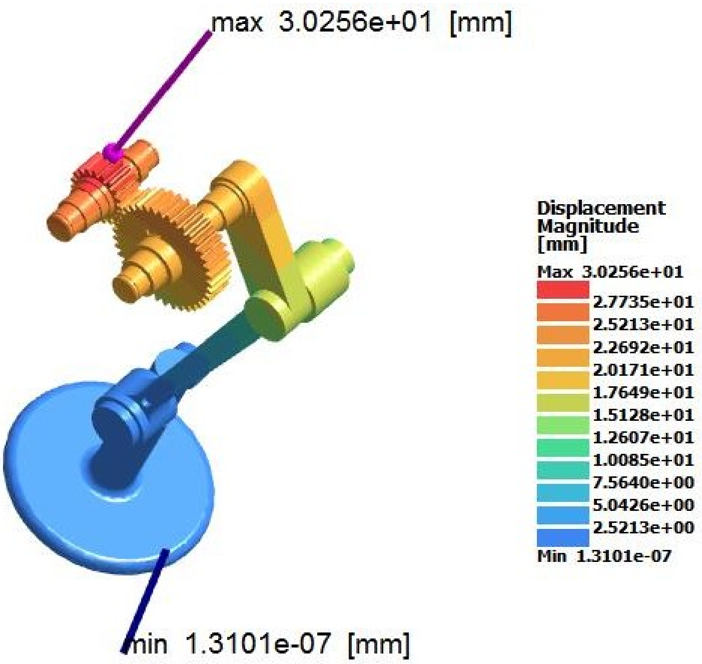

Figure 9. Static analysis: displacements

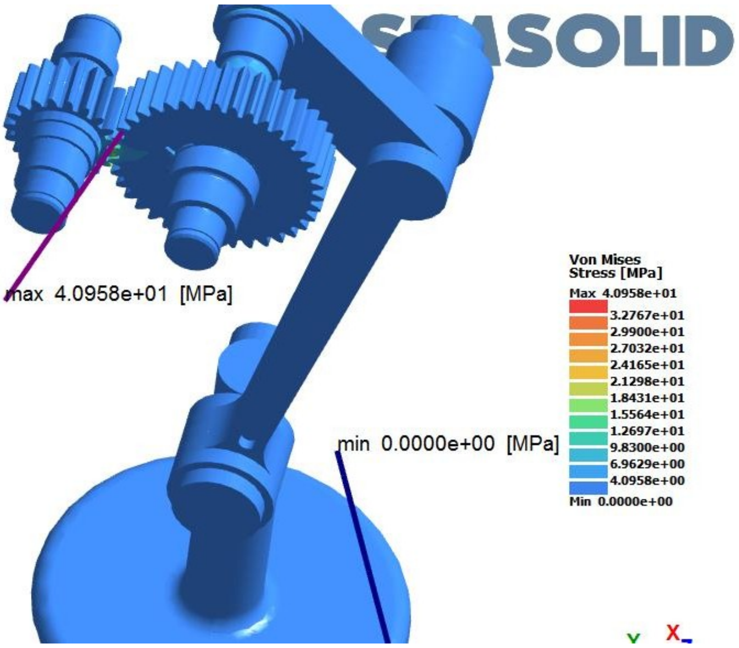

Figure 10. Static analysis: Von Mises Stress

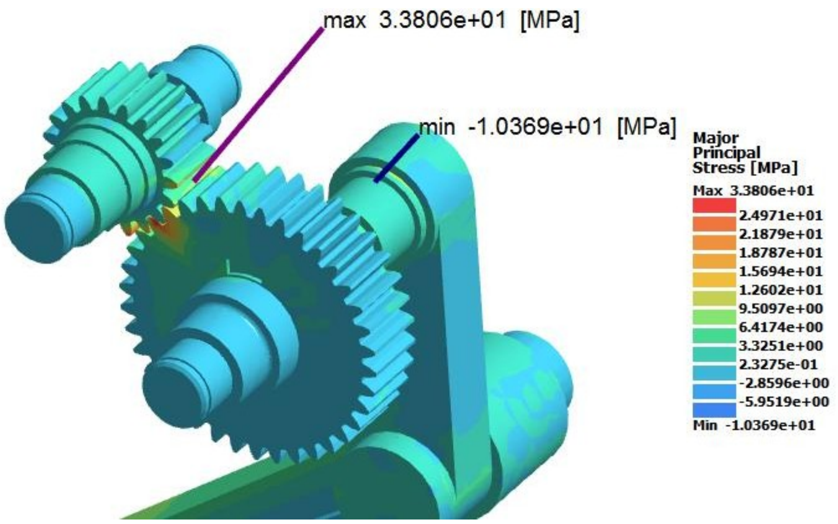

Figure 11. Static analysis: major principal stress

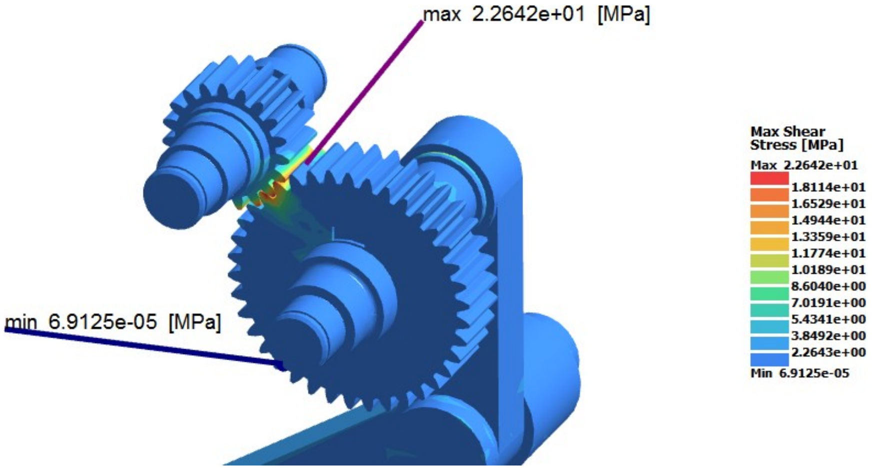

Figure 12. Static analysis: maximum shear stress

DYNAMIC ANALYSIS

Finally, a dynamic analysis is applied in the time domain (transitory) and in the frequency domain, where the moving behavior of the model is studied, in order to improve the approximation to the reality of the results obtained in the static study.

In the time domain analysis, the aim is to find whether the material is suitable in addition to the response stabilization time.

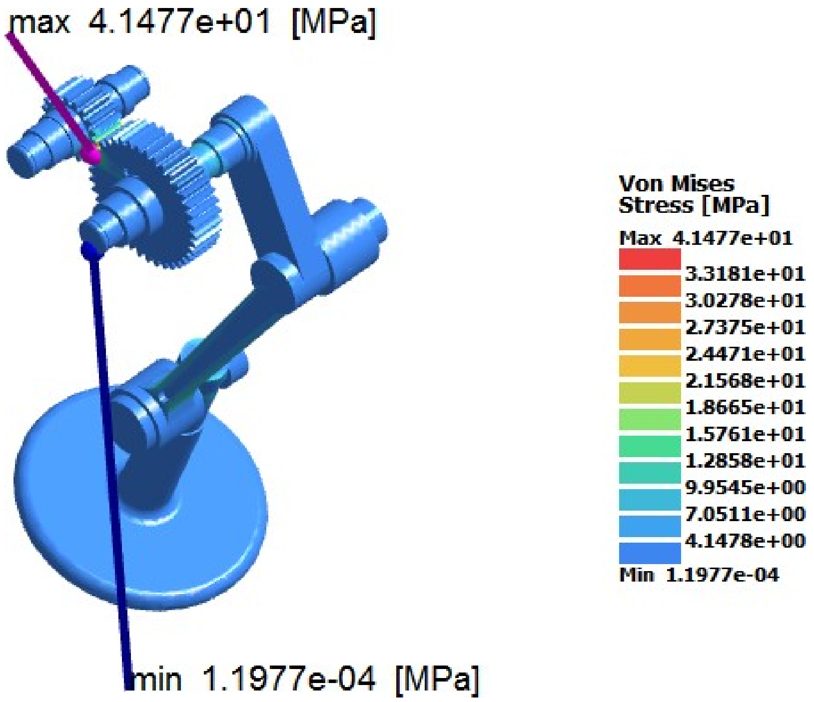

Figure 13. Análisis dinámico transitorio: tensión de Von Mis

The following graphs correspond to the time of stability of the force and the moment in the applied restrictions

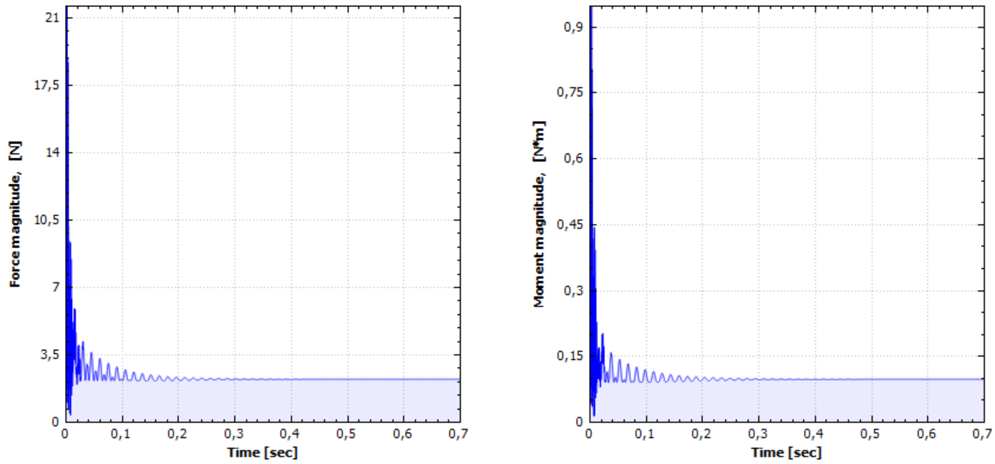

Figure 14. Transient dynamic analysis: piston displacement restriction

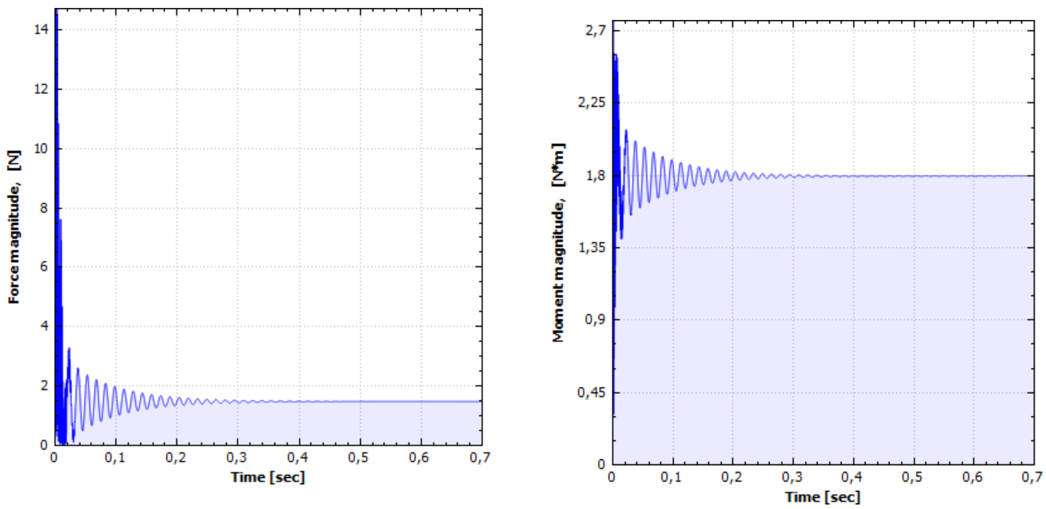

Figure 15. Transient dynamic analysis: rod end bolt displacement restriction

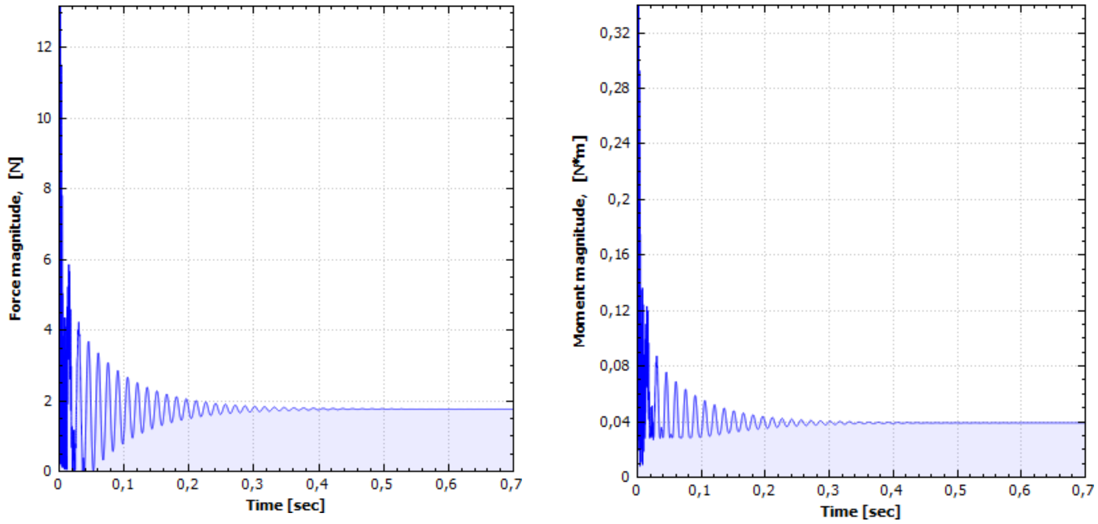

Figure 16. Transient dynamic analysis: input shaft left bearing

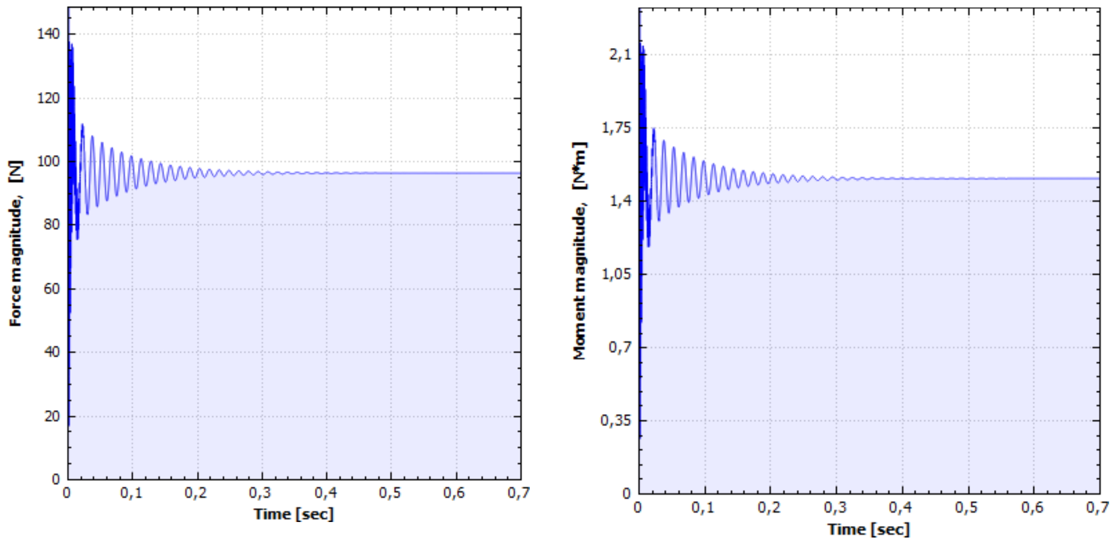

Figure 17. Transient dynamic analysis: displacement restriction of the rod small end

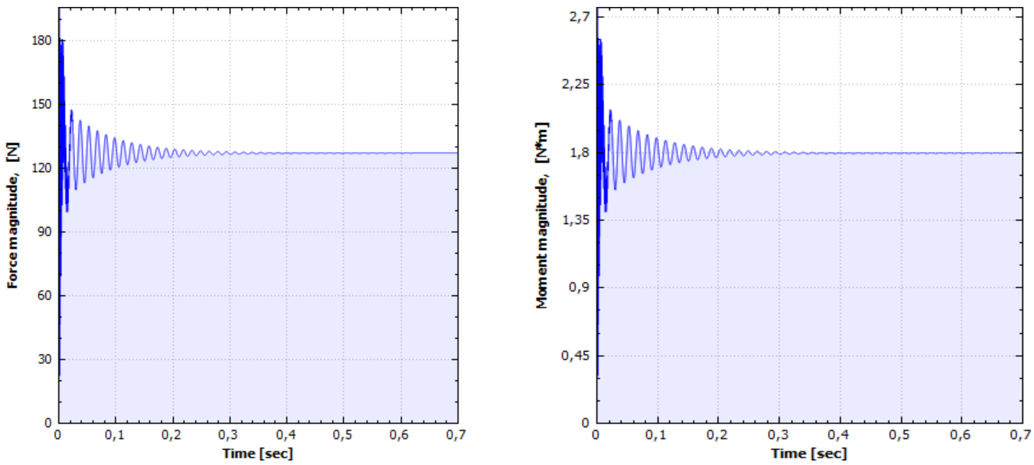

Figure 18. Transient dynamic analysis: input shaft right bearing

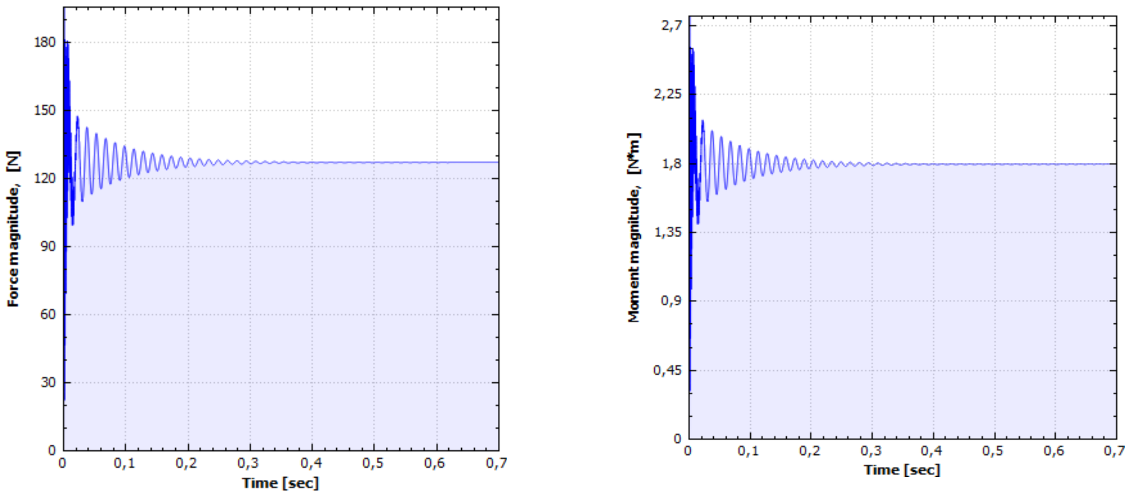

Figure 19. Transient dynamic analysis: left bearing of the output shaft

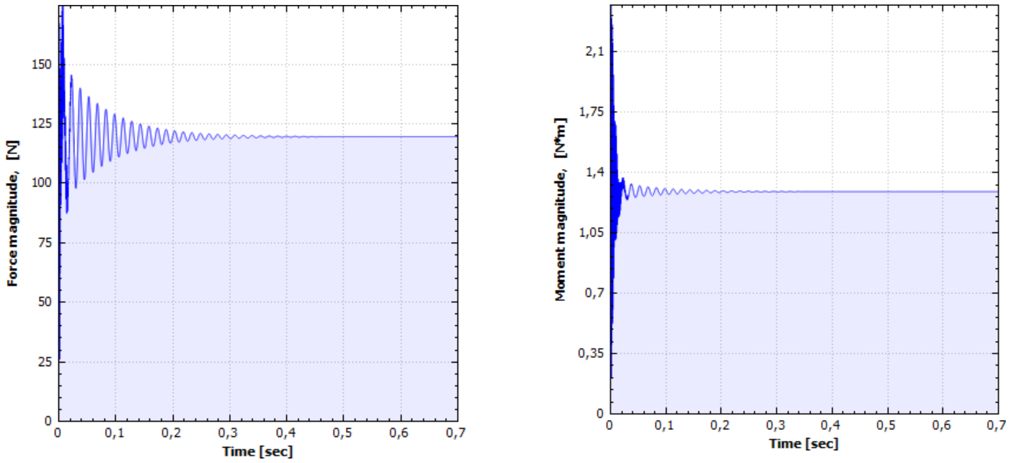

Figure 20. Transient dynamic analysis: right bearing of the output shaft

The results of the modal analysis in the frequency domain are graphs with the following aspect, where it can be seen that the peaks correspond to the values of the frequencies of the free-free modal analysis, thus confirming that the model will resist the load conditions applied to it based on the chosen polymer and the dimensions of the parts in the set.

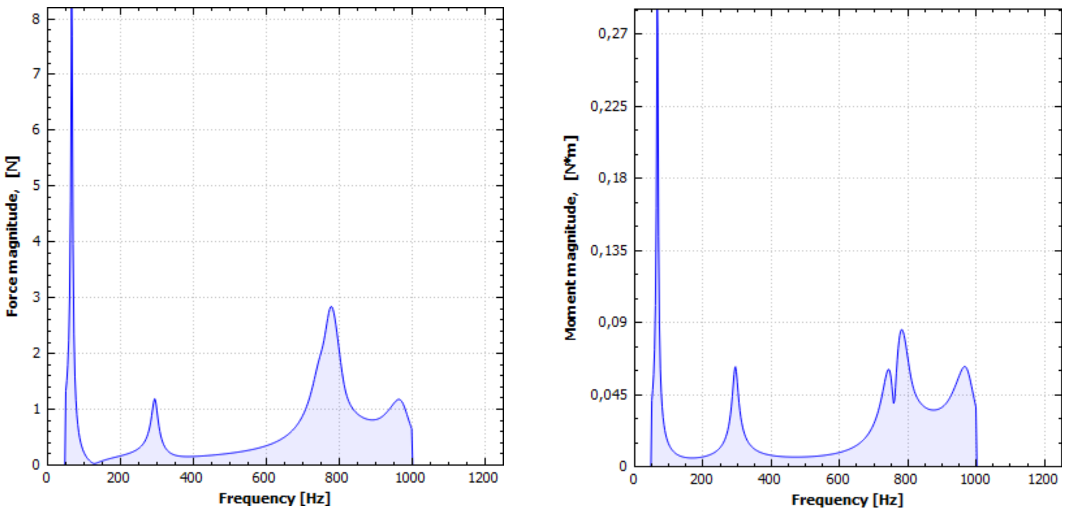

Figure 21. Dynamic frequency analysis: piston displacement restriction

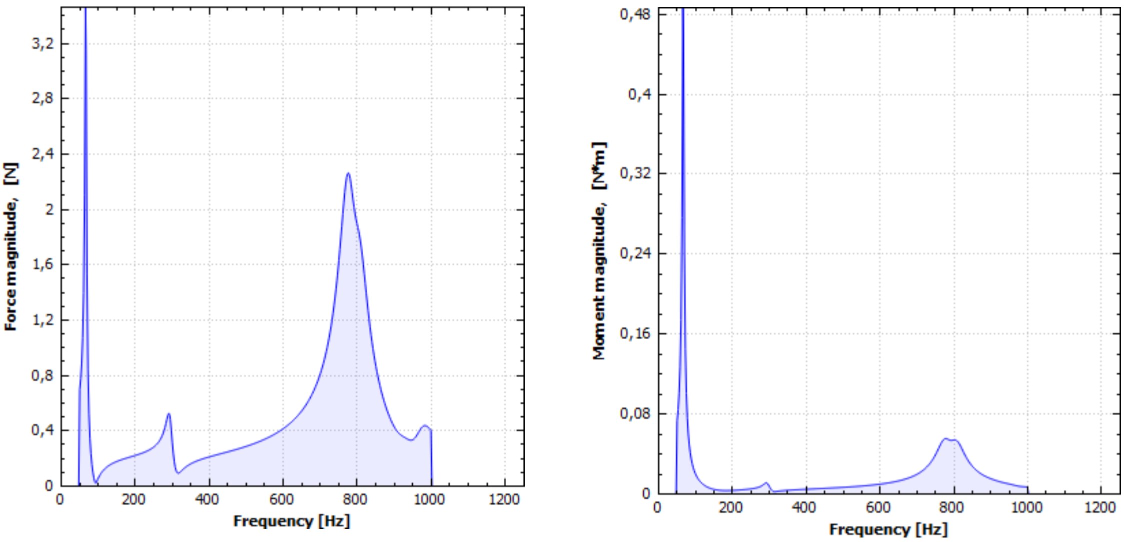

Figure 22. Frequency dynamic analysis: small end bolt displacement restriction

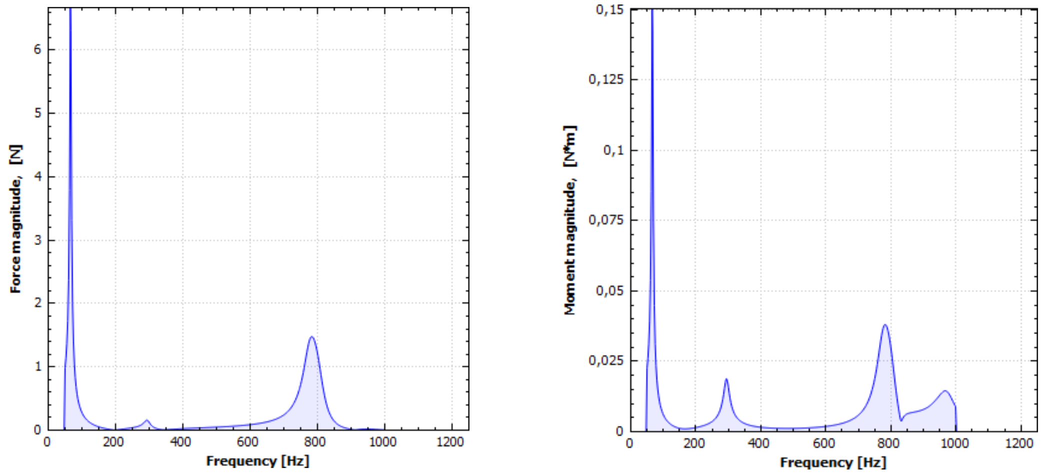

Figure 23. Dynamic analysis in frequency: displacement restriction of the head rod

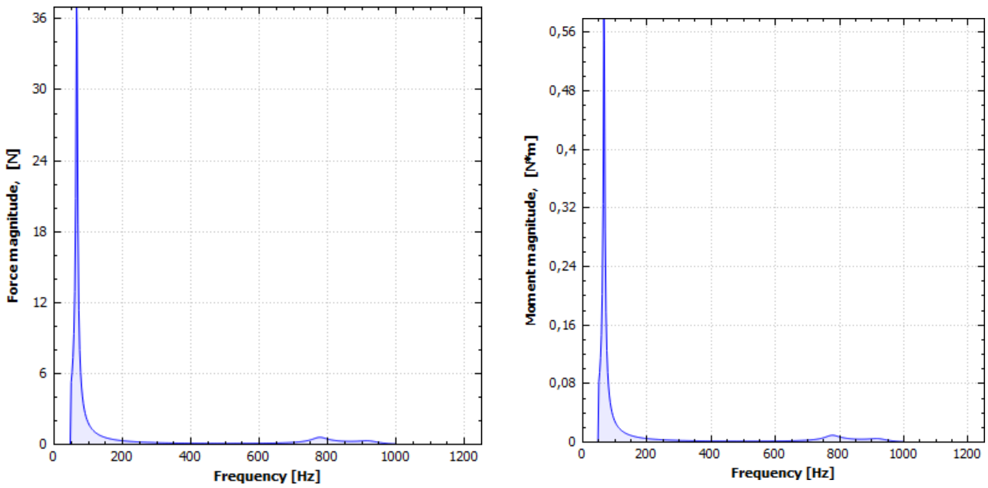

Figure 24. Dynamic frequency analysis: input shaft left bearing

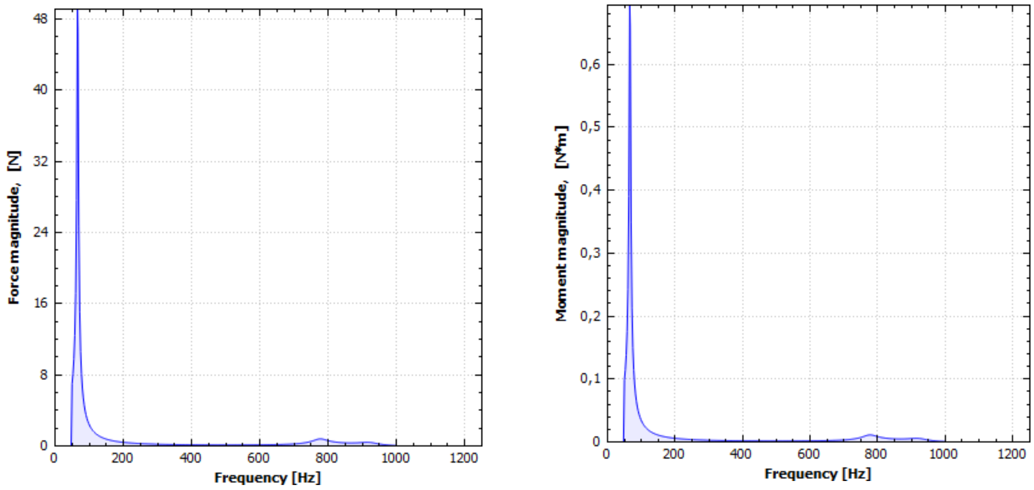

Figure 25. Dynamic frequency analysis: input shaft right bearing

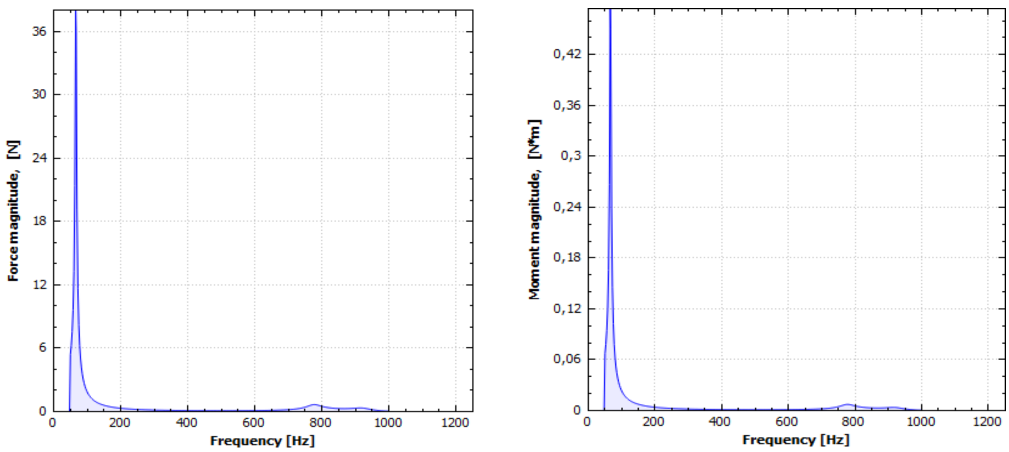

Figure 26. Dynamic frequency analysis: left bearing of the output shaft

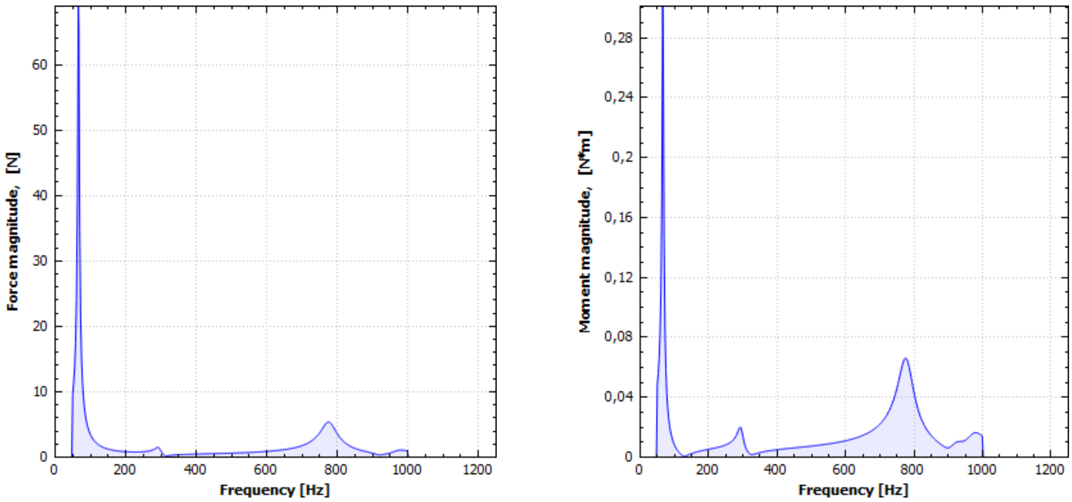

Figure 27. Dynamic analysis in frequency: right bearing of the output shaft