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STATIC FEM ANALYSIS OF GEARBOX

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Abstract: *Our department was asked for some support during gearbox development. This support took in performing static FE analysis of gearbox and, of course, in experimental verification of results obtained by FEM solution. Loading states of the gearbox were set by submitter – the first loading state describes "maximum torque loading in input shaft" and the second one "maximum loading during breaking".*

Keywords: *FEM, static FE analysis, Ansys, Ansys/Workbench, gearbox*

1. Introduction

Actual trend in machine parts and whole machines design is the maximum material usage, while the function is guaranteed. So, it is necessary to perform more detailed components and assemblies analysis during their development. FEM is very suitable for it, because it is much faster and cheaper to do only virtual analysis and experiment. One example of FEM integration in new product design is described in this paper.

2. Progress of Work

First, CAD model of analysed gearbox was created in Pro/Engineer according to drawings which were provided by submitter. CAD model consisted of both halves of gearbox and test jig for breaking force application. Caps and bearings were not included into analysis – it had not been requested (the FE analysis should be performed due to state of stress determination in places which are not in the vicinity of bearing holes).

Then, FE model of gearbox assembly was generated in FEM software Workbench. The analysis was performed there too. Results evaluation was done in FEM software Ansys.

The last step of our department support was FEM results experimental verification. The experiment consisted of strain-gauges measurement in both loading states.

3. CAD model

CAD model (see fig.1) was generated according to drawings which were provided by submitter, as mentioned above. CAD model did not consist of e.g. small chamfers and technological radiuses, because FE analysis of the whole gearbox was performed. The reason is the whole FE model size (number of elements and nodes). Bearing holes were created "one after the other", so the individual bearing loads was allowed to be applied.

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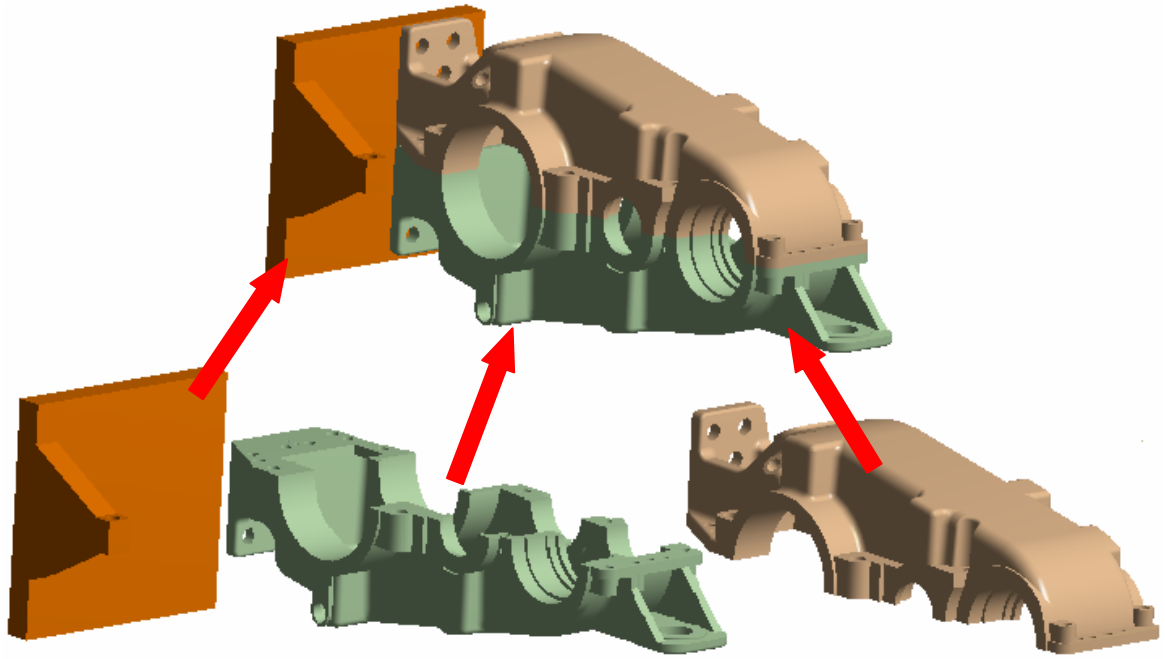

Fig. 1. CAD model of analyzed gearbox assembly.

4. FE model and FE analysis

FE model of the gearbox (see fig.2) was generated in Workbench and was based on CAD model geometry created in Pro/E. The whole FE model consisted of approx. 110 000 volume elements (ten-nodes tetras) of global element size set to 5mm (gearbox length is about one meter).

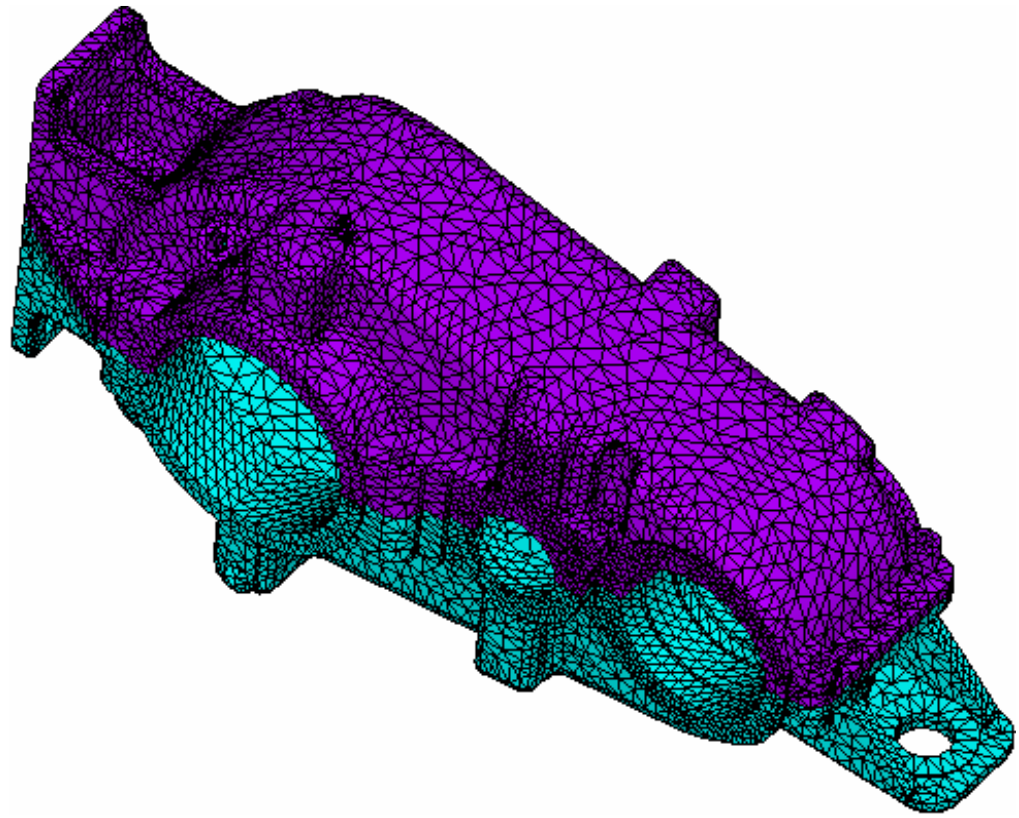

Fig. 2. FE model of the gearbox without test jig.

Top and bottom half of the gearbox, as well as test jig for breaking load application, were bonded in the connection screws places (here, on whole gearbox place of separation). The reason for this simplification is the whole FE model size and some possible difficulties during FE model solution. But, this simplification can be done, because there are many screws in the plane of separation (see fig.3).

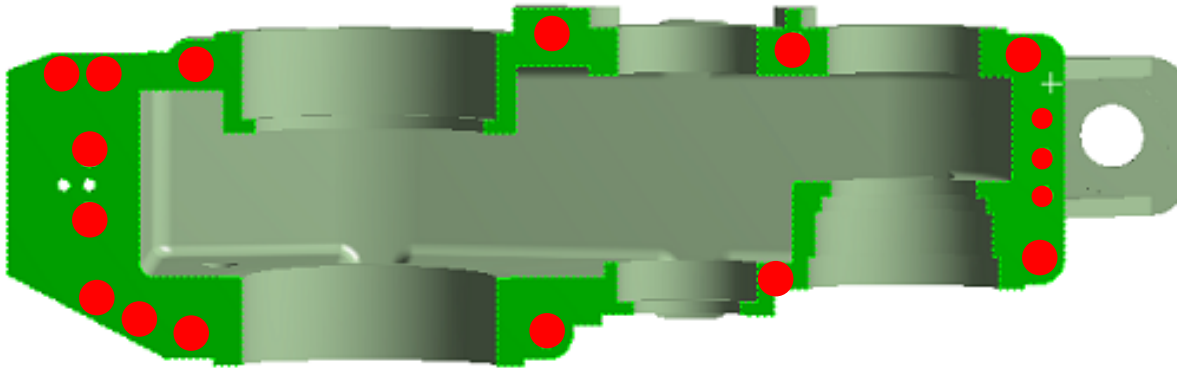

Fig. 3. Screws positions in the place of separation.

Material model which was used in the FE analysis was chosen as linear elastic isotropic with material parameters according to the real material properties (Young's modulus of elasticity and Poisson's ratio).

As mentioned above, loading states conditions were provided by submitter and describe "maximum torque loading in input shaft" and "maximum loading during breaking". Boundary conditions which describe gearbox placement in the space were applied as bound. cond. "Remote Displacement", loading of bearings as bound. cond. "Bearing Load" and breaking force as bound. cond. "Remote Force". "Bearing load" bound. cond. was applied on both halves of bearing hole simultaneously. Regular shape of elements on bearing hole surface is shown in fig.4.

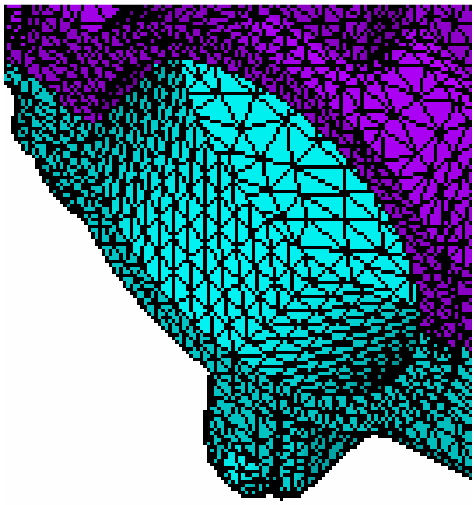

Fig.4. Regular elements shape on surface of bearing hole.

After FE model generation and all necessary bound. cond. application, FE static analysis was performed. Results evaluation was done in Ansys and consisted of some pictures creation and numerical evaluation of some interesting places.

5. Experimental verification of FEM results

The last step of our department support during gearbox development was experimental verification of FE analysis results (strain-gauge measurement). Strain-gauges placement were suggested according to FE analysis performed earlier (the places were more intensively loaded places and ribs). Loading during experimental verification was equal to loading states provided by submitter. Every loading state was measured three-times and then the average value was compared with FE analysis results.

FE analysis results and experimental results were in deuce.

6. Conclusion

Static FE analysis of gearbox was performed. Experimental verification of FE analysis results was done too. FE analysis and experimental results were in deuce.

Next improvement of the FE analysis can be more detailed gearbox geometry description (using more powerful hardware, using substructuring or submodeling technique), considering of pre-tensioned screws of caps and plane of separation, considering of caps and bearings stiffness etc.

Because there is a possibility that our department will give a support during another gearbox development, a new study is in preparation. The topic of the study is more realistic description of gearbox and acceptable whole FE model size. It should lead to FE model which will describe the gearbox more precisely (also in the vicinity of bearing holes etc.).

References

[1] ANSYS/Workbench electronic manual.

[2] ANSYS electronic manual.