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STATIC ANALYSIS OF GEARBOX DRIVE SHAFT

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Abstract: In this paper, the structural analysis of the drive shaft of manual six-speed gearbox DMB 6.80.235 manufacturers Famos was performed. Static analysis was done in Ansys Workbench software, with the previously modeling of the mentioned shaft and the definition of boundary conditions and generating a finite element mesh. At the supports site, or bearings, springs are set and are presented by the final element COMBIN 14 whose stiffness is equivalent to stiffness of the supports.
Keywords: static analysis, drive shaft, Ansys Workbench, COMBIN 14

1. INTRODUCTION

Elements for rotational movement play a very important role. Elements of rotary motion are shafts, axles, couplings and bearings [1]. Shafts are machine elements with rotation and serve as elements cantilevers for torque transmission, such as wheels, drums, gears, pulleys, etc. So, in addition to its own weight and the weight of rotating parts to wear and to load them, shafts, also, need to transfer torque. Therefore, the shafts are exposed to torsion and bending moment. The main difference between the shaft and the axle is that the shafts are loaded to the twisting and bending, but axles only to bending. In other words, the shaft transmits power, while an axle transmits only rotary motion [1]. In this paper, the structural analysis [2] of the drive shaft of manual six-speed gearbox DMB 6.80.235 manufacturers Famos was performed (Figure 1).

Figure 1. Drive shaft

The drive shaft is separated from the gearbox assembly (indicated by a red in Figure 2), and is manufactured together with the gear to second gear.

The front part of the shaft enters the engine flywheel flange through the connecting plate and relies on ball bearing, while the rear part of the shaft relies on the roller bearing which is located in the front part of the housing [3]. The back of the drive shaft is an opening of bearing upon which the main shaft relies. The front part of the shaft is toothed to achieve strong links with the disc couplings hub. Static analysis was done in Ansys Workbench software, with the previously modeling of the mentioned shaft and the definition of boundary conditions and generating a finite element mesh. At the supports site, or bearings, springs are set and are presented by the final element COMBIN 14 whose stiffness is equivalent to stiffness of the supports, whereby each spring represents a roller body, and the total stiffness is divided by the number of rolling bodies by linear model of distribution. There are numerous examples of the static analysis of drive shafts, axles and the like [4,5].

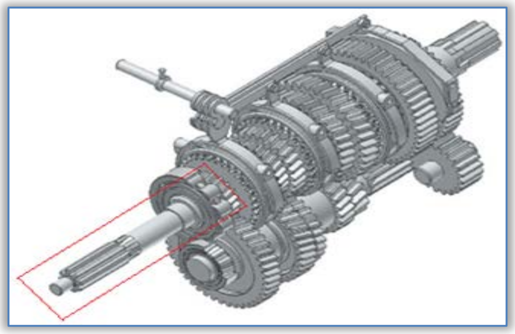


Figure 2. Gearbox DMB 6.80.235-downloaded from [3] and modified

2. APPLIED METHODS

2.1.Static analysis

The effects of static structure loading are calculated by the static analysis [6], while the inertia and damping effects are not taken into consideration. Static analysis may, of course, include inertial forces unchangeable in time (gravity or constant angular velocity) and loads variable in time that can be approximated by static load. Static analysis is used to calculate the displacement, stress and strain resulting from static loads. In a static analysis are defined:

1) Boundary conditions

The boundary conditions are used for limiting the translation and rotation of certain parts of the structure depending on the structure. They occur as the effects of neglected parts of the structure in a symmetric load of symmetric parts. Limit of one of the degrees of freedom can be in some interval or absolute (e.g. in the supports).

2) Limitations of one or more degrees of freedom
3) Planned (required) movements of certain parts of the structure that are different from zero
4) Temperature

The effects of temperature changes, as the structure load, provide for a result the thermal expansion or contraction, which allows the calculation of stress and strain in the static analysis.

5) Loads

Forces are concentrated loads, usually applied to the outside of the model, while pressure is a surface load, also applied to the outside of the model. Fixed inertial forces affect the entire structure and do not change in time or can be approximated by a constant forces. As an example the force of gravity may be given.

In this paper, analysed shaft is loaded to bending and twisting. The twisting loading occurs because of the transfer of torque from the engine flywheel (526,7 Nm) [3] and bending occurs due to the force of the gear components (radial and tangential). The radial force bends the shaft in the vertical plane, while tangential force bends the shaft in the horizontal plane. Given that a pinion with straight teeth is located at shaft, the axial component of the force is equal to zero.

Static analysis is the most frequently used form of structural analysis, and it can be said that almost all software packages meet all analysis requirements, so, for static analysis, it is very important to define the problem properly, to have knowledge of finite element method and knowledge of software package that is used.

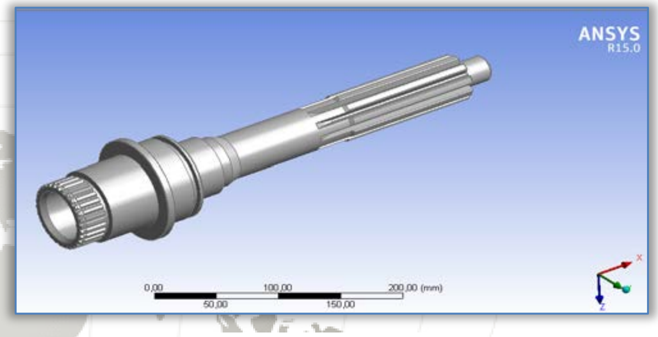


Figure 3. Shaft model

Table 1. Material properties

Density	7,85e-009 tonne·mm^{-3}
Coefficient of Thermal Expansion	1,2e-005 C^{-1}
Specific Heat	4,34e+008 mJ·tonne^{-1}·C^{-1}
Thermal Conductivity	6,05e-002 W·mm^{-1}·C^{-1}
Resistivity	1,7e-004 ohm·mm

Table 2. Geometry properties

Object Name	Geometry
State	Fully Defined
Definition	
Length Unit	Meters
Bounding Box	
Length X	420, mm
Length Y	98, mm
Length Z	98, mm
Properties	
Volume	7,6015e+005 mm^3
Mass	5,9672e-003 t
Scale Factor Value	1

2.2.Static analysis of DMB 6.80.235 gearbox drive shaft

The first step which was essential for the structural analysis of shaft in this paper was the modeling of the shaft (Figure 3) based on the workshop drawing and selection of materials (Table 1) and other properties of geometry (Table 2).

At the supports site, or bearings, springs are set and are presented by the final element COMBIN 14 whose stiffness is equivalent to stiffness of the supports, whereby each spring represents a roller body, and the total stiffness is, by linear model of distribution, divided by the number of rolling bodies, in this case by the number of springs. The outer bearing is a single row roller bearing NU1016-M1 (Figure 4). The total stiffness of the support at the outer bearing place is 418·103 N/mm, respectively 17433 N/mm per roller body.

The inner bearing is a single row roller bearings NU1005-M1 (Figure 5). The total stiffness of the support at the inner bearing place is 290·103 N/mm, respectively 20757 N/mm per roller body. After modeling the shaft, finite elements mesh was generated (Figure 6). Mesh properties are shown in Table 3.

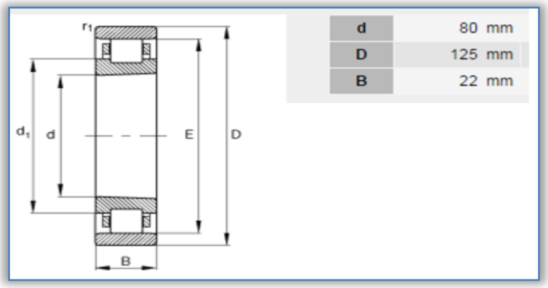


Figure 4. Roller bearing NU1016-M1[7]

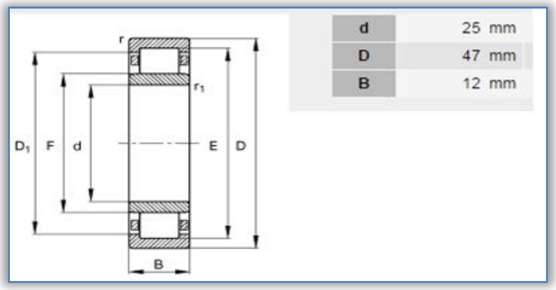


Figure 5. Roller bearing NU1005-M1[8]

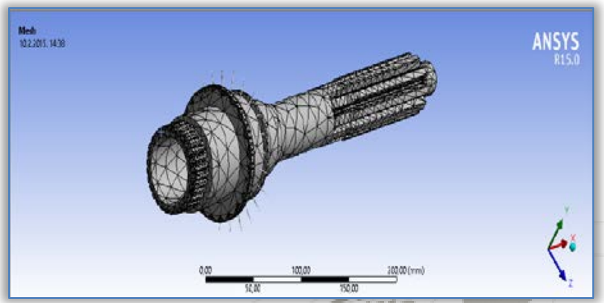


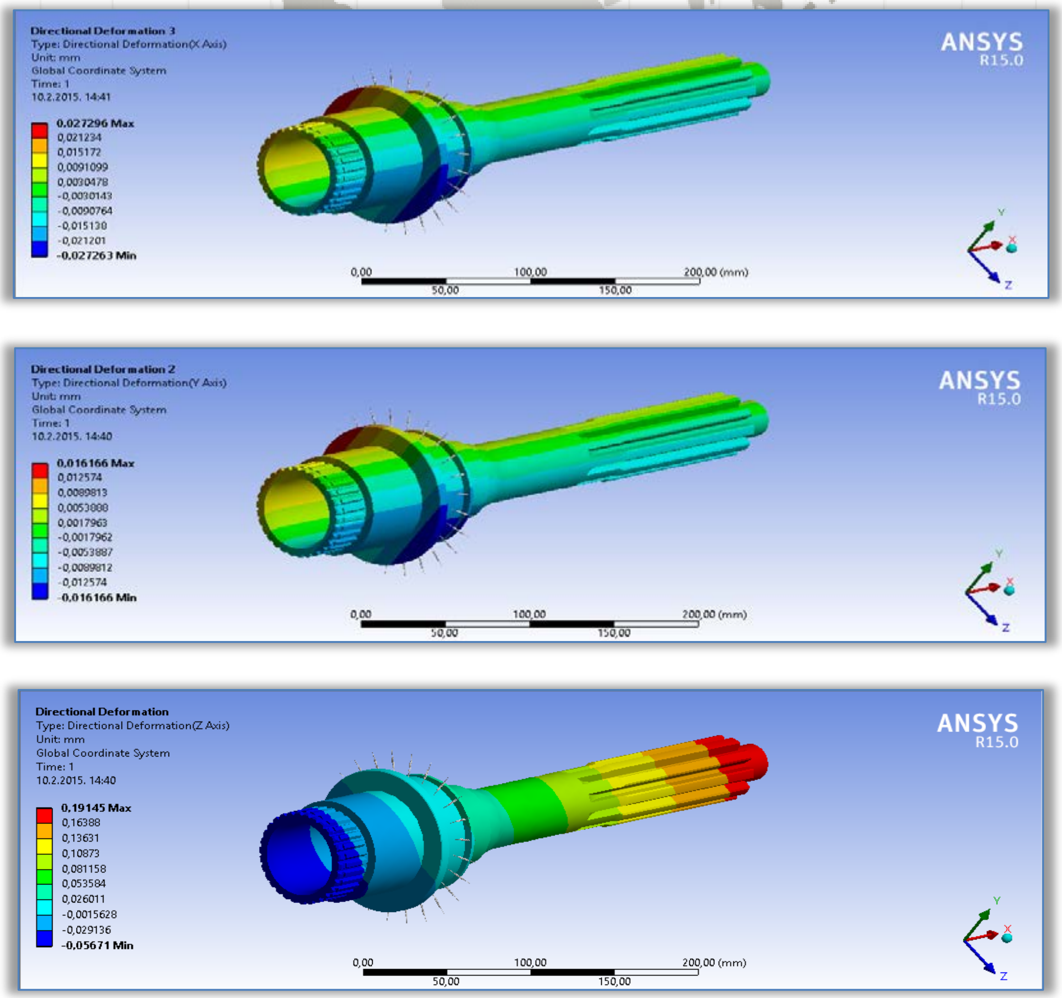
Figure 6. Shaft finite elements mesh generating

Table 3. Finite elements mesh properties

Object Name	Mesh
State	Solved
Sizing	
Element Size	Default
Smoothing	Medium
Transition	Fast
Minimum Edge Length	0,200740 mm
Statistics	
Nodes	39562
Elements	22381

3. RESULTS AND DISCUSSION

With the known supports stiffness represented by the system of springs using finite element COMBIN 14 and with known load, deformations of the x, y and z axis directions are obtained (Fig. 7). The results are shown in Table 4.



a)

b)

c)

Figure 7. Deformations in the direction of: a) x axis; b) y axis; c) z axis;

Table 4. Results of drive shaft static analysis

Object Name	Directional Deformation	Directional Deformation 2	Directional Deformation 3
State	Solved		
Definition			
Type	Directional Deformation		
Orientation	Z Axis	Y Axis	X Axis
Results			
Minimum	-5,671e-002 mm	-1,6166e-002 mm	-2,7263e-002 mm
Maximum	0,19145 mm	1,6166e-002 mm	2,7296e-002 mm
Minimum Value Over Time			
Minimum	-5,671e-002 mm	-1,6166e-002 mm	-2,7263e-002 mm
Maximum	-5,671e-002 mm	-1,6166e-002 mm	-2,7263e-002 mm
Maximum Value Over Time			
Minimum	0,19145 mm	1,6166e-002 mm	2,7296e-002 mm
Maximum	0,19145 mm	1,6166e-002 mm	2,7296e-002 mm

4. CONCLUSION

In this paper, the structural analysis of the drive shaft of manual six-speed gearbox DMB 6.80.235 and the use of software Ansys Workbench in the analysis of the same were shown. Static analysis is the most frequently used form of structural analysis, and it can be said that almost all software packages meet all analysis requirements, so, for static analysis, it is very important to define the problem properly, to have knowledge of finite element method and knowledge of software package that is used. After the static analysis, from the table with the results, it can be concluded that the maximum deformations are in the direction of the shaft z axis, which was to be assumed, because the load is centered exactly in the direction of z axis. Minimum deformation of 0,056 mm in the z axis direction of the shaft is close to the inner bearing. In this part, the distance between the two shaft bearings is very small, so that the obtained deformation is in accordance with that. The maximum deformation of 0.19 mm in the direction of z axis is at the top of the shaft (the side opposite the bearings), which is a very realistic and expected data. In contrast to the deformations in the direction of the z axis of the shaft, the deformations in the direction of the y axis and the longitudinal x axis are considerably less. Deformation in the direction of the shaft y axis is 0,016 mm, while the deformation of 0.027 mm in the direction of the longitudinal x axis is minimum, which is, of course, to be expected.

Note

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