Numerical analysis of stiffener for hybrid drive unite

Lenka Jakubovičová[1,*], *Milan* Sága[1], *Marián* Handrik[1]

[1]University of Žilina, Univerzitná 1, 010 26 Žilina, Slovakia

Abstract. The matter of this article is a stress-strain analysis of hybrid drive prototype unit connected directly to convention Concrete Transit Mixer Gearbox. The unite was developed with intention to do field test on existing convection machines with possibility to use existing interfaces. The hybrid drive unit consists from electric and hydrostatic motor connected through addition mechanical transmission gearbox. The question is if today standard interface is good enough or need additional support a "stiffener". Two engineering design were analysed. The first one includes using the stiffener to fixate the construction of hybrid drive unite connected to the planetary gear. The second one is without the stiffener. For strain-stress analysis, a finite element software ANSYS Workbench was used.

Keywords: finite element method/FEM, hybrid drive unite, ANSYS Workbench

1 Introduction

In order to test this new technology on existing machines was necessary solved several challenges [1, 2, 3]. One of that challenge was do the field test on existing convention solution with possibility to connect hybrid drive unit to the main gearbox where is the same interface as is today for one motor only, Fig. 1. Designers needed to be sure that the stiffness of the subassembly will be stiff enough and from this reason was proposed to use additional support part „stiffener" see Figure 4. which was further analysed. The finite element method is especially used in the ground vehicle industry [4, 5, 8, 9, 10].

The prototype hybrid drive unit for a mixing drum that is disposed on a motor vehicle which, as compared with the prior art, exhibits a further improvement to the efficiency of the drive system of the mixing drum and offering possibility eliminate unnecessary exhaust gas and noise emissions in a particular working arrears as underground and tunnels. The drive engine, in particular the internal combustion engine of the truck mixer, is capable of being shut down while the rotation of the mixing drum is maintained. The drive system will be capable of implementation inexpensively with little effort and robust and reliable in its realization.

Fig. 1. Concrete Transit Mixer Application standard conventional solution

System was installing on the 4 years standard transit mixer with 9 m^3 drum where the drum drive was updated from hydrostatic to hydroelectric, see Figs 2 and 3.

Fig. 2. Concrete Transit Mixer Application and prototype of hybrid drive unit

This object is achieved as a result of the fact that in addition to driving the mixing drum via a hydraulic drive train with displacement pump and hydraulic motor, the electric motor, with a relatively low output as compared with the hydraulic drive, is or can be permanently connected to the truck mixer gearbox in such a way that the mixing drum can be driven solely by the electric motor (Fig. 3).
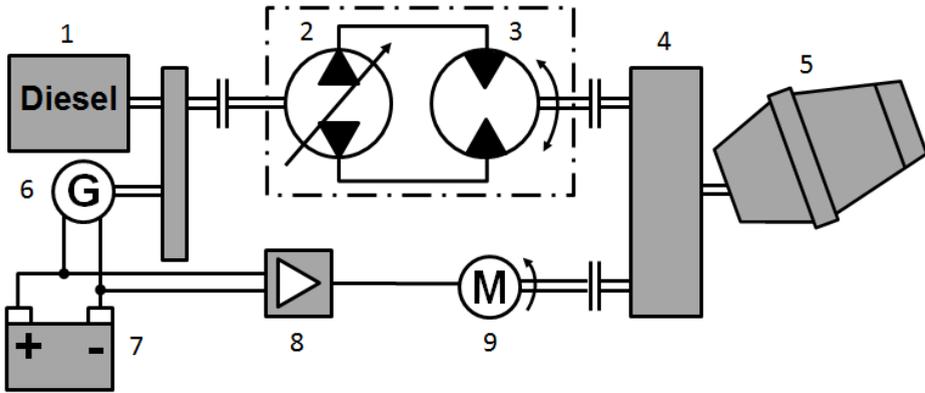
Fig. 3. The main components of a drive unit in a schematic illustration
1- Diesel engine, 2- Hydraulic pump, 3- Hydraulic motor, 4- Gearbox, 5- Drum,
6- Alternator, 7- Electric battery, 8- Inverter, 9- Electric motor

2 Numerical analysis of stiffener for hybrid drive unite

The main components of hybrid drive unite are on Figure 4.
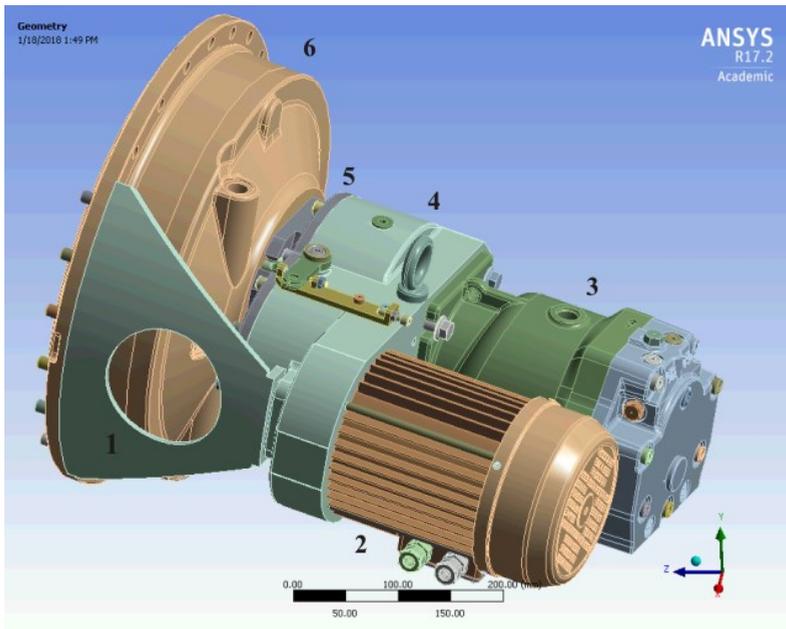
Fig. 4. The main components 1 – Stiffener, 2 – Electric motor, 3 – Hydrostatic motor,
4 – Sandwich Gearbox, 5 – Flange, 6 – Planetary gear cover

In the finite element analysis, only the main part consisted of stiffener, flange, planetary gear cover and sandwich gearbox was considered, Fig. 5. The mass of electric motor and hydrostatic motor was replaced with the resultant gravitational force acting in the centre of gravity, Fig. 5.
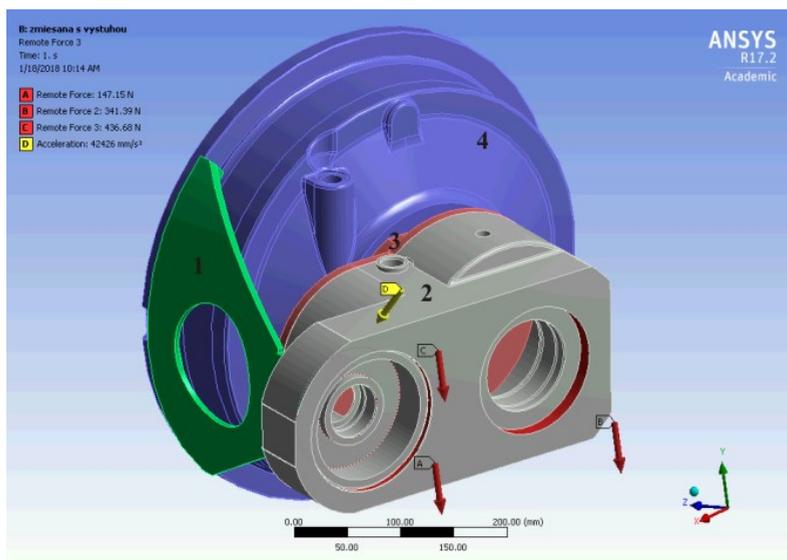
Fig. 5. The main components 1 – Stiffener, 2 – Gearbox, 3 – Flange,
4 – Planetary gear cover

At the planetary gear cover all degrees of freedom were defined - fixed support, the cover is firmly attached to the planetary gear box attached to the drum drive, Fig. 6. Through the concrete transport was considered horizontal and vertical acceleration, Fig. 5.
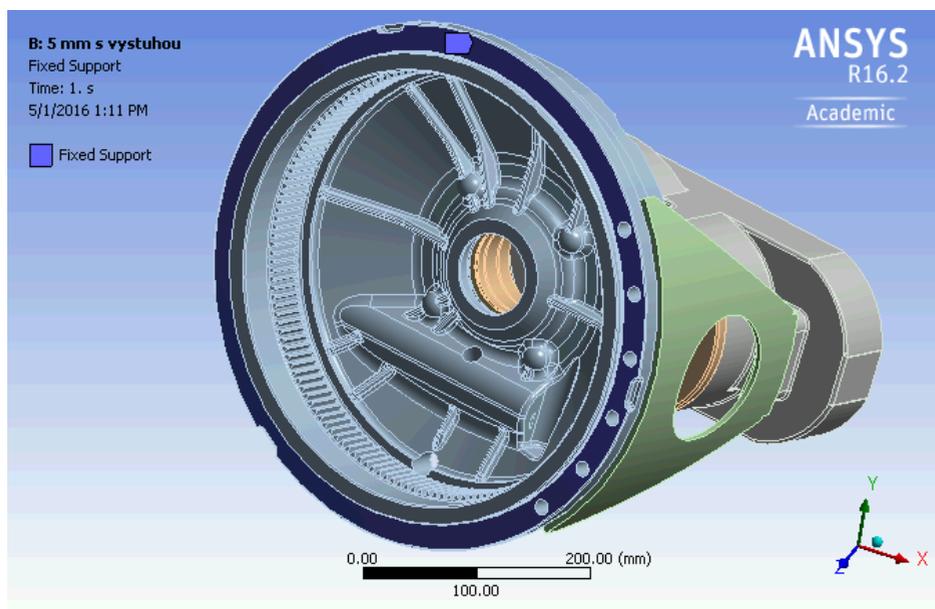

Fig. 6. Boundary condition – fixed support

Stress-strain analysis was carried out using the Ansys Workbench 16.2 software program, into which the model was imported and subsequently modified to a model suitable for finite-element analysis. The finite-element mesh was create by quadratic tetrahedron elements. Figure 7 shows flange and stiffener finite-element mesh and figure 8 shows planetary gear cover and gearbox finite-element mesh.
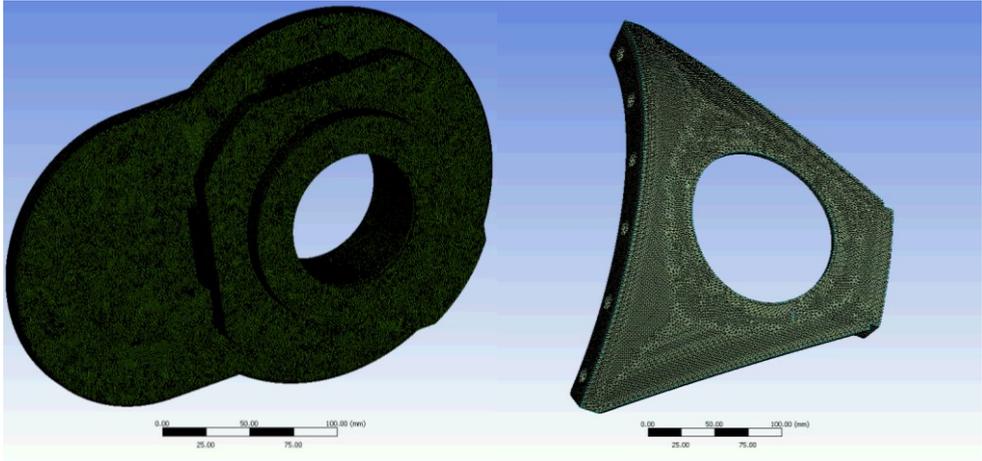
**Fig. 7.** Flange and stiffener finite-element mesh
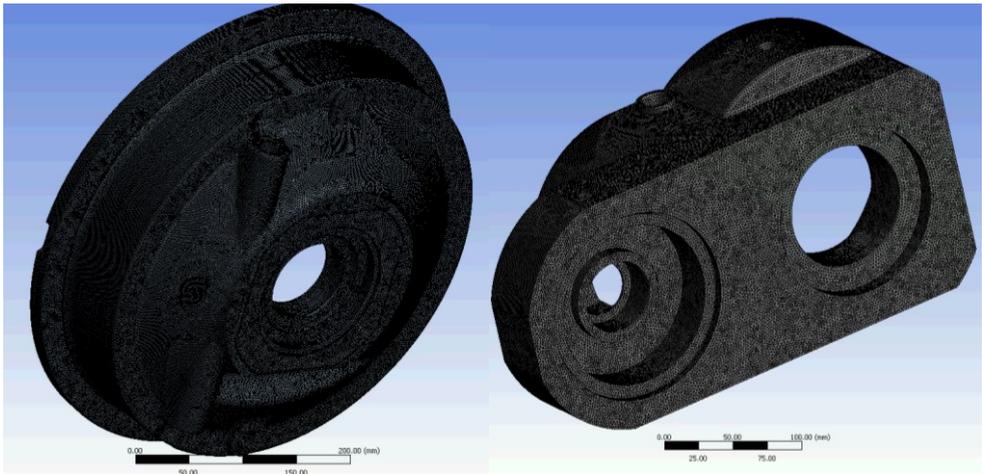
**Fig. 8.** Planetary gear cover and gearbox finite-element mesh

3 Results

The finite element analysis generated the maximum von Misses stress at the flange, see Figures 9 – 12. For first design with stiffener von Misses stress reached 8.3599 MPa and for second one von Misses stress reached 14.018 MPa, Table 1. Use the stiffener can increase stiffness of the subassembly by 40 percent. The maximum stress without the stiffener is enough below the permissible maximum value, and then the stiffener is no necessary to use and the prototype hybrid drive unit without the stiffener can withstand the load with the required safety level [6, 7].
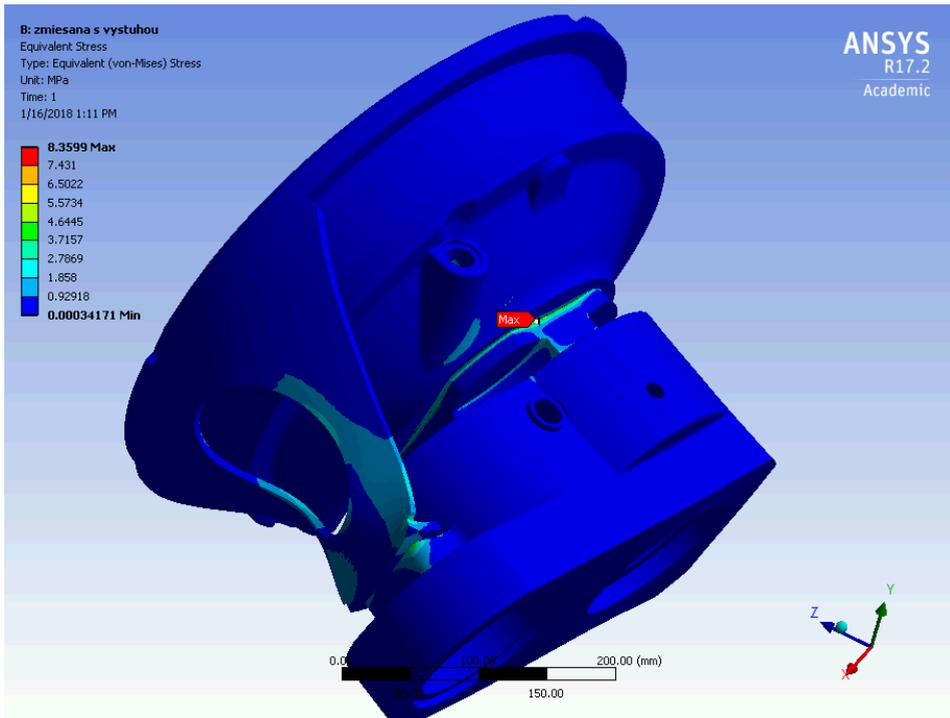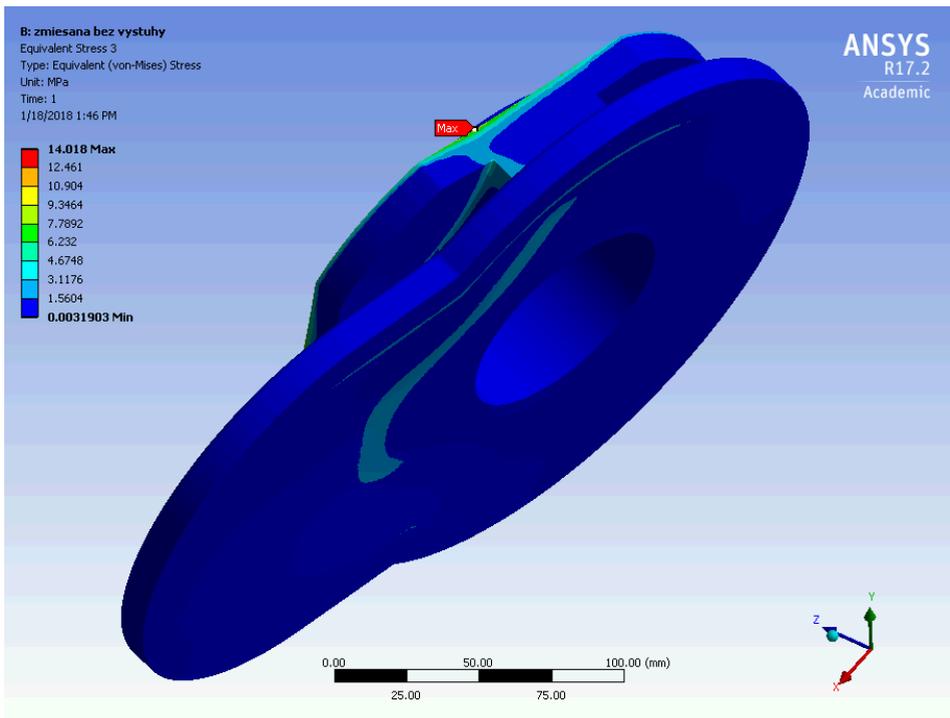
Fig. 9. Von Misses stress – block (with stiffener)
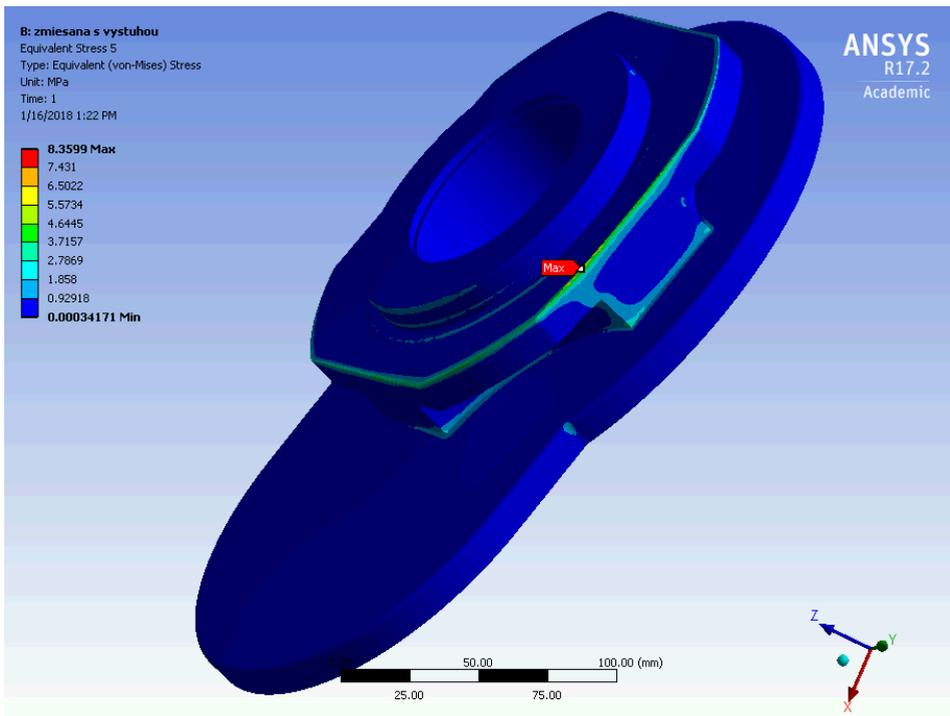
Fig. 10. Von Misses stress – flange (with stiffener)
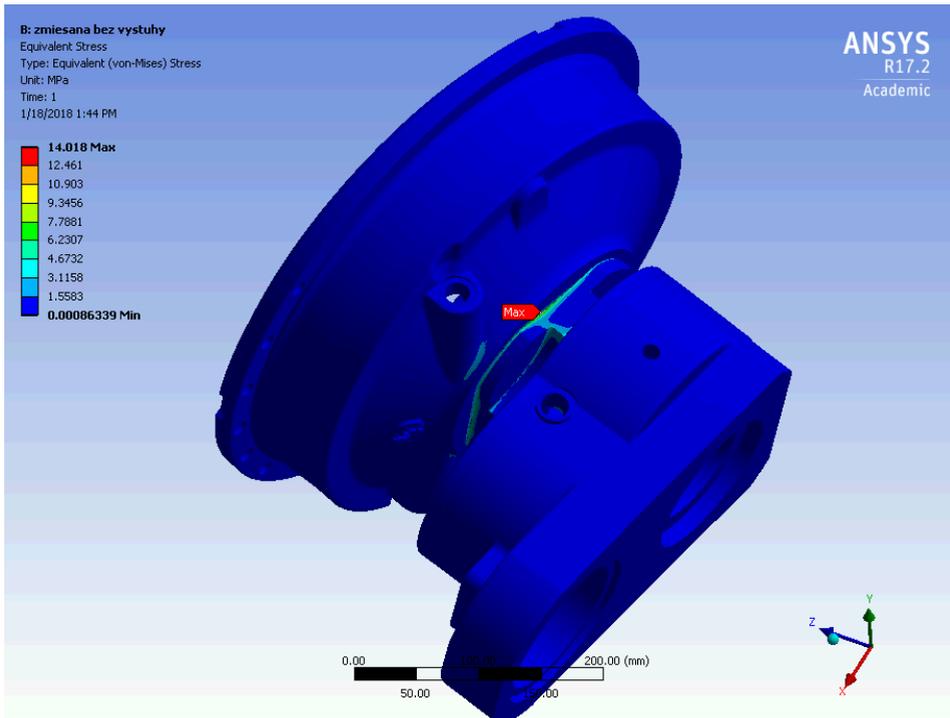
Fig. 11. Von Misses stress – block (without stiffener)

Fig. 12. Von Misses stress – flange (without stiffener)

Table 1. Equivalent (von-Misses) stress

	Equivalent Stress
With stiffener	8.3599 [MPa]
Without stiffener	14.018 [MPa]

Conclusion

The request was find out if the design proposal of the first prototype developed for field tests on existing machines is stiff enough or will be needed update stiffness or use a support part. Based on this request was developed stiffener, Fig. 5.

However at the end we can see based on result in table 1 that the design of prototype is stiff enough and is not necessary to do additional update was confirmed as well that with simple design proposal of stiffener can increase stiffness of the subassembly by 40% percent. This discovery can to the developing engineers possibility for future optimization and weight reductions if will be needed.

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