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Finite Element Analysis of variable load acting worm gear drive

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Abstract. *Finite element analysis shows whether a product will break, wear out, or work the way it was designed. Worm and worm wheel gearbox is checked for different loads acting on it. Requirement of gearbox is that for 60 Kg applied load, output torque and factor of safety should be 6000 Nm and 1-2 resp. Design is checked in ANSYS for selected gear pair, 1/55/8/5 and applied normal human being load from 20 to 60 Kg. It concludes that for selected gear pair and required applied load of 60 Kg, design is safe and efficient.*

Key Words: Finite Element Analysis, Static Analysis, von-Mises stress, Moment, Equivalent stress.

1. INTRODUCTION

Analysis of stress induced on various components of worm gearbox due to torque transmitted from handwheel through shaft is done. Individual components are analyzed to see worm and worm wheel gearbox design is safe or not. Worm gearbox is not in continuous working conditions and load is gradually applied on it. After specific time, applied force remains constant. That's why worm gearbox works in static conditions. Worm and worm wheel gearbox components are analysed in ANSYS18 in static analysis.

F.L. Litvin et. al.[1] have proposed the solution to basic problems of design, generation and simulation of meshing and contact of hybrid worm and worm wheel gear box. Software is developed for simulation of meshing and contact of misaligned worm and worm wheel gear drive. They generate computer program, Tooth Contact Analysis for testing of bearing contact and transmission errors developed in loaded and unloaded gear drives. Bearing contact of drive is localized. Also parabolic functions of transmission errors are applied. Hence by reducing sensitivity of gear drive to errors of alignment improved version of worm gear drive has been developed.

Claudiu-Ioan Boanta et al.[8] have presented results on performance of the same type gear reducer mounted the same but the combination of hardened steel materials (worm) - steel heat treatment improvements (worm wheel).They analyzed thermal limit of the reducers equipped with worm face gear with asymmetric flanks is about 50% higher than the worm face gear with cylindrical worm symmetrical flanks. Also thermal limit for driving on the convex side for both couples is more favorable material situation. This paper presents mathematical model for generating kinematic and numerical simulation of worm face gear with simplified geometry. Simplified geometry means thread or tooth profile is trapezoidal in cross section and tooth flank angles are symmetrical, in this case it is 20°.

2. Finite Element Analysis using ANSYS

Moment is applied to periphery of handwheel.
Moment = force * acceleration due to gravity * radius of handwheel.

1. For 20 kg load, moment is 68.69 Nm. This moment is applied on periphery of handwheel.

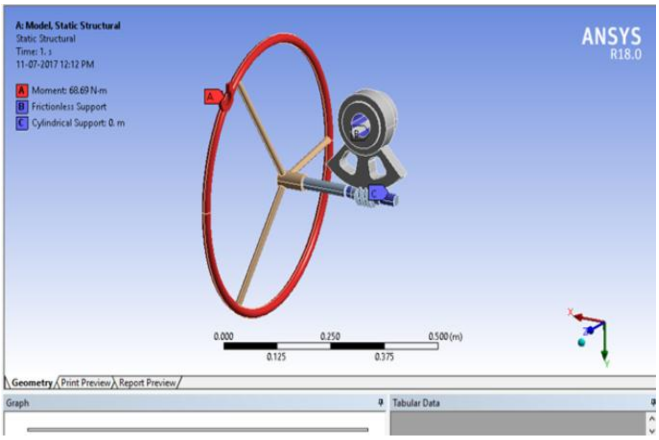

Fig -1: Moment applied for 20 Kg load

2. Equivalent (von-Mises) stress found for 20 kg load on handwheel is 57.36 MPa, on shaft is 112.40 MPa, on worm is 10.043 MPa and on worm wheel is 10.043 MPa.

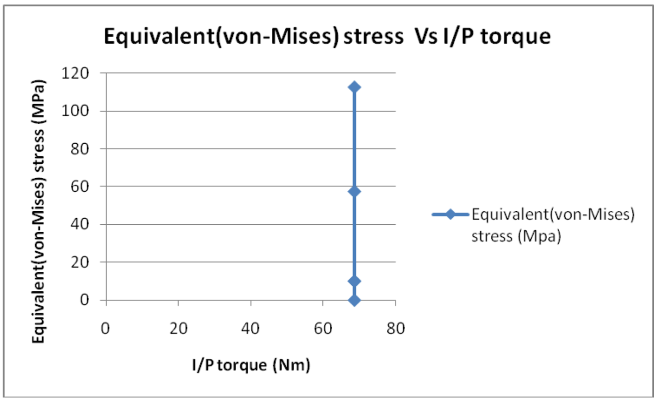

Chart -1: von-Mises stress Vs I/P torque for 20 Kg applied force

3. Moment 103 Nm is applied on periphery of handwheel for 30 kg load.

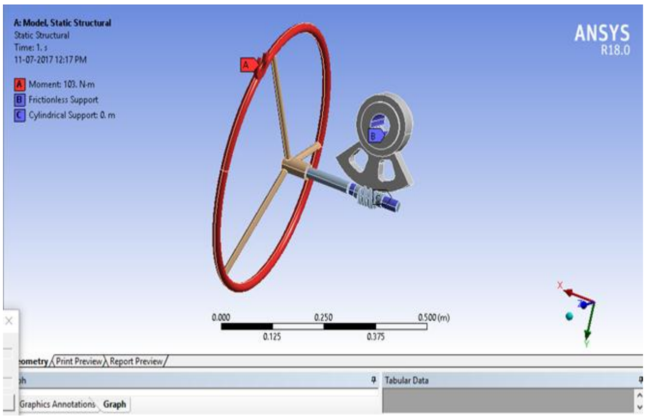

Fig -2: Moment applied for 30 Kg load

4. Equivalent (von-Mises) stress for 30 kg load on handwheel is 114.21 MPa, on shaft is 145.86 MPa, on worm is 46.286 MPa and on worm wheel is 28.375 MPa.

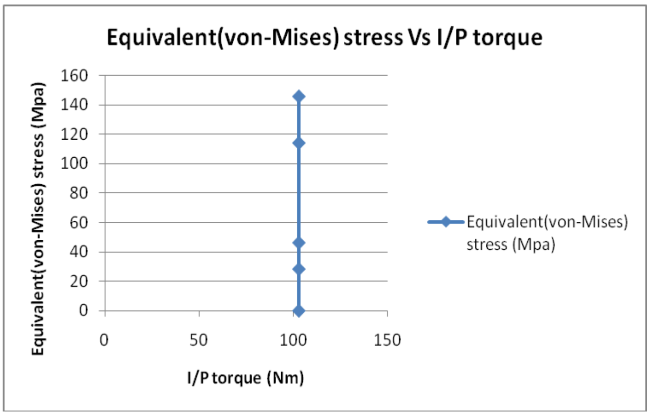

Chart -2: von-Mises stress Vs I/P torque for 50 Kg applied force

5. Moment is applied on periphery of handwheel for 40 kg load is 137 Nm.

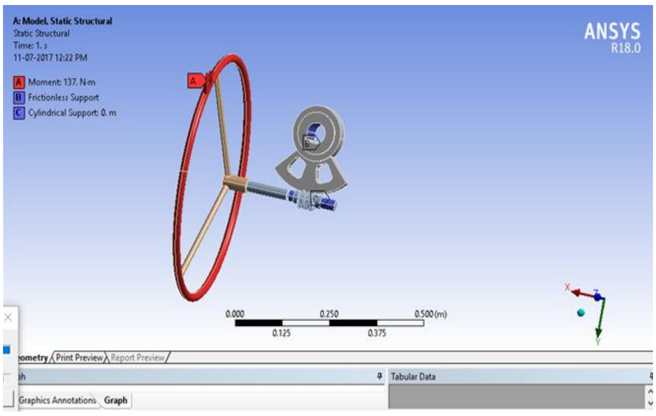

Fig -3: Moment applied for 40 Kg load

6. Equivalent (von-Mises) stress found for 40 kg load on handwheel is 146.19 MPa, on shaft is 184.74 MPa, on worm is 42.627 MPa and on worm wheel is 58.398 MPa.

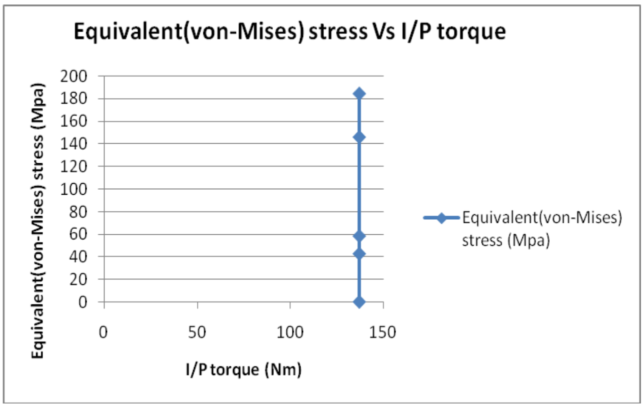

Chart -3: von-Mises stress Vs I/P torque for 40 Kg applied force

7. Moment is applied, 172 Nm for 50 kg load on periphery of handwheel.

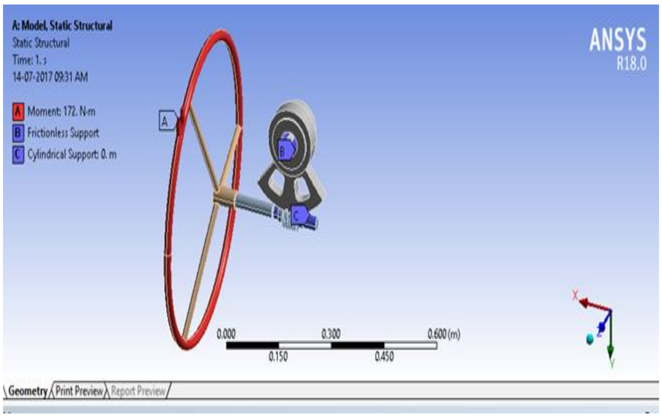

Fig -4: Moment applied for 50 Kg load

8. Equivalent (von-Mises) stress found on handwheel is 197.19MPa, on shaft is 192.17 MPa, on worm is 56.597 MPa and on worm wheel is 77.704 MPa.

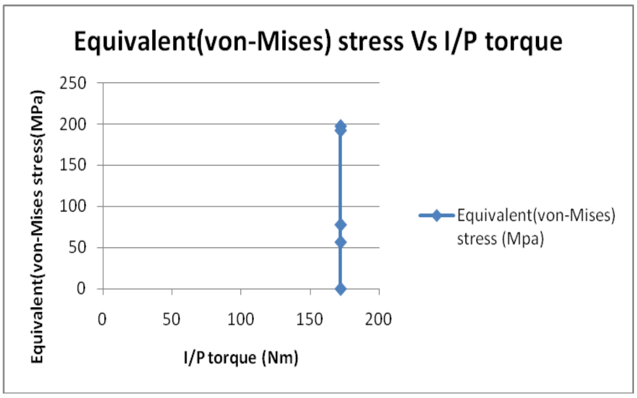

Chart -4: von-Mises stress Vs I/P torque for 50 Kg applied force

9. Moment applied on periphery of handwheel for 55 kg load is 189 Nm.

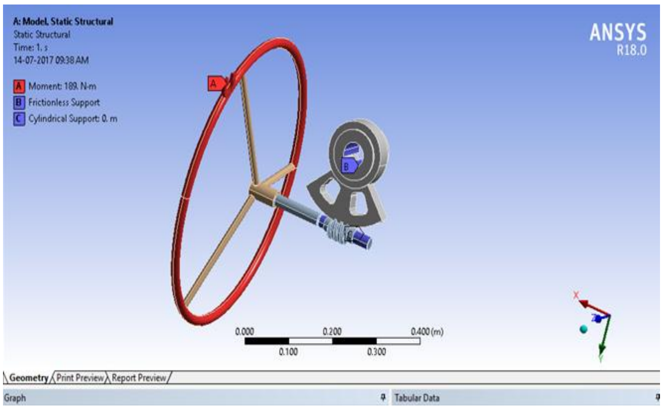

Fig -5: Moment applied for 55 Kg load

10. Equivalent (von-Mises) stress found on handwheel is 226.51 MPa, on shaft is 253.69 MPa, on worm is 84.968 MPa and on worm wheel is 84.968 MPa.

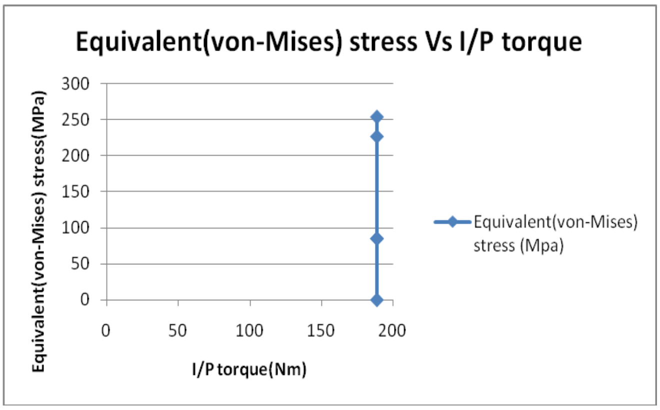

Chart -5: von-Mises stress Vs I/P torque for 55 Kg applied force

11. Moment applied for 60 kg load on periphery of handwheel is 206 Nm.

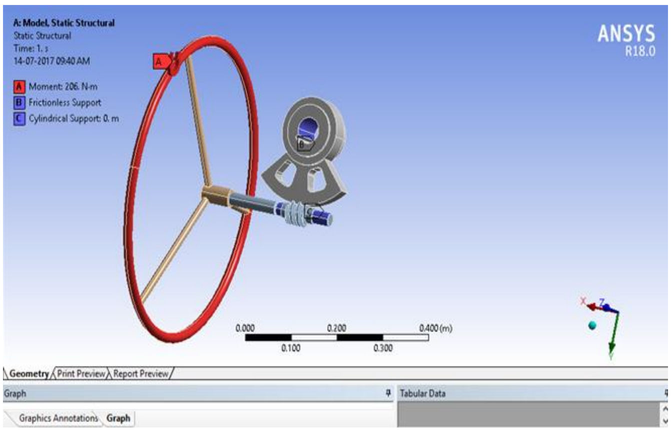

Fig -6: Moment applied for 60 Kg load

12. In solution, equivalent (von-Mises) stress found on handwheel is 249.99 MPa, on shaft is 261.21 MPa, on worm is 74.25 MPa and on worm wheel is 91.39 MPa.

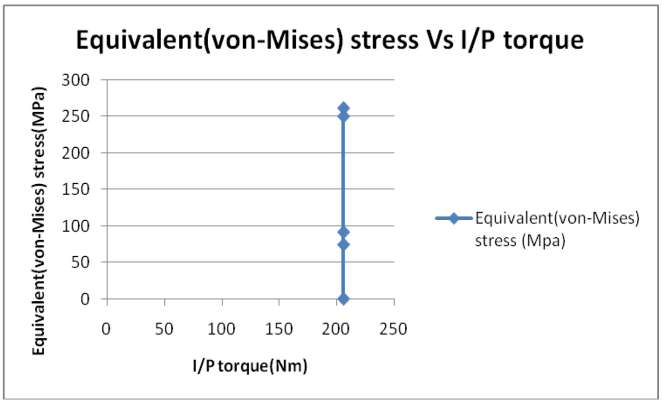

Chart -6: von-Mises stress Vs I/P torque for 60 Kg applied force

13. When 60 Kg load is applied on handwheel of gearbox for selected gear pair, axial force obtained is 43933 N as per design calculation on walls of worm body.

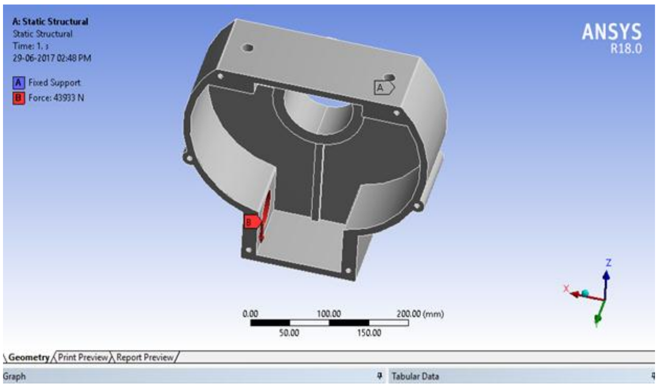

Fig -7: Axial force of worm 43933 N applied

14. Equivalent (von-Mises) stress for 43933 N is 150.55 MPa.

15. When 60 Kg load is applied on handwheel of gearbox for selected gear pair, radial force obtained is 16332N as per design calculation on cover hub.

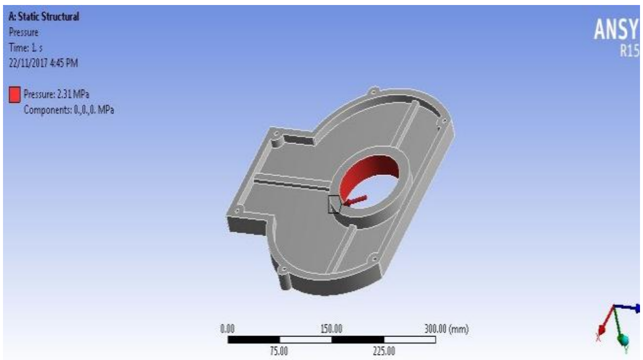

Fig -8: Radial forces of worm gear pair 16332 N applied

16. Equivalent (von-Mises) stress for 16332 N is 11.565 MPa.

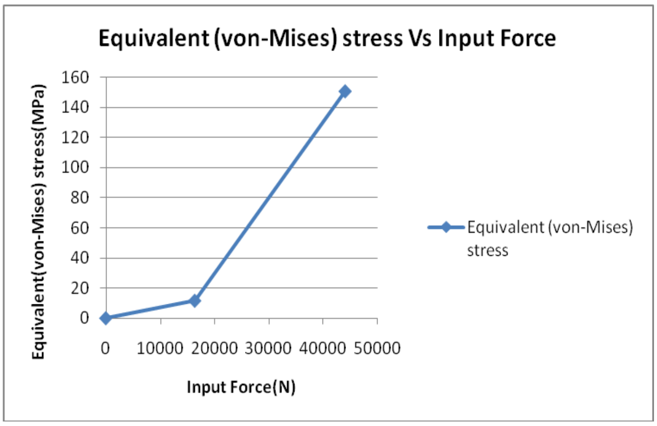

Chart -7: von-Mises stress Vs Input force of body and cover

3. CONCLUSIONS

Table -1: Resultant strength (N/mm2) of selected gear pair components

Components	Yield strength	Tensile strength	Input torque	Input Force	Equivalent (von-Mises) stress
Shaft	380	-	206.01	-	261.21
Worm	380	-	206.01	-	74.25
Handwheel	-	260	206.01	-	249.99
Worm Wheel	-	260	206.01	-	91.396
Body	-	260	-	43933	150.55
Cover	-	260	-	16332	11.565

Tensile and yield strength of material is compared with strength of components of worm gear drive found in Finite Element Analysis. It is concluded that, Equivalent (von-Mises) stress of all the components of worm and worm wheel gearbox are within safe limit comparing strength of material of component.

4. REFERENCES

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