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STRESS ANALYSIS OF SINUSOIDAL CURVED GEAR PROFILES

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Abstract

A gear with sinus curved profile was presented in this paper. The tooth profile was designed according to sinus function for 2π and 4π period. The trace of the gear was chosen as involute profile. Proposed gear types was built and simulated in CATIA software and the results compared with spur gear form simulation results. The stress distribution was investigated for the contact surfaces and tooth root region. It was aimed to obtain optimized gear profile with less stress values. It was concluded that the gear built with 2π period function gave the less stress values because of having bigger contact surface comparing to spur gear.

Keywords: spur gear, sinus curved gear, involute profile, Finite Element Analysis (FEM), Stress Distribution

INTRODUCTION

Gears are the most used machine component for over two thousand years. They were used in the irrigation systems and water mills. Gears generally transfer load and moment between two shaft with using shape dependent [1]. The profile of the gear is an important parameter which affects the efficiency of gear and results less the acoustic emission and vibration [2], [3]. Gear profile studies is very popular topic in recent. So many researcher paid attention and Rincon investigated deformation at the gear contact point according to combination of local and global term with their new model [4]. Leslie et al. analyzed the gear contact and root bending stresses for both spur and helical gears [5]. Dai used the finite element/contact mechanics approach for the static and dynamic tooth root strain analysis of spur gear pairs [6]. Furthermore; Luo modeled a cosine gear drive with cosine profiled pinion gear and built a solid model. He carried out simulations for obtaining basic results about the gear parameters such as contact stresses [7]. Peng et.al. analyzed the contact ratio and bending stresses according to the meshing characteristics, such as the contact ratio, instantaneous transmission ratio for arc-tooth-trace cycloid cylindrical gears [8].

EXPOSITION

To improve the transmission performance, special gears are needed for specific situations with the development of industrial applications. Therefore, new tooth profiles needs to be designed to improve the transmission efficiency. Involute, cycloid and circular profiles are the main type of gear profile commonly used in gear transmission. Gear teeth can fail as a result of dynamic loads causing large tooth root stresses and strains. Main aim is to obtain less contact stress, improved root bending and lower possibility of pitting fault when designing the gear profile. In this study, two different sinus curved profiled involute gears were built and analyzed with CATIA software and stress distribution on contact surfaces was evaluated with structural stress analysis CAD model. CATIA is a software that is commonly used in many important constructions for the reduction of stress for reorganization of damages systems.

Table 1 *Design Parameters of Spur Gear*

	Pressure Angle	Module	Number of Teeth		Gear Face Width (mm)
			Pinion Gear	Main Gear	
Spur Gear	20°	5	15	20	42
Spur Gear with Sinus Profile Func (T=2π)	20°	5	15	20	42
Spur Gear with Sinus Profile Func (T=4π)	20°	5	15	20	42

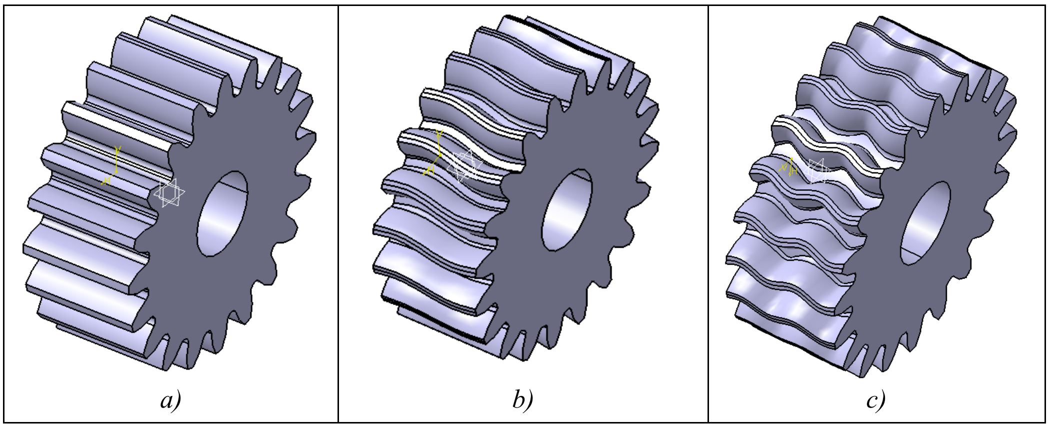


Fig. 1. *Gear Profiles: a)Spur Gear b)Spur Gear with Sinus Func (T=2π) c) Spur Gear with Sinus Func (T=4π)*

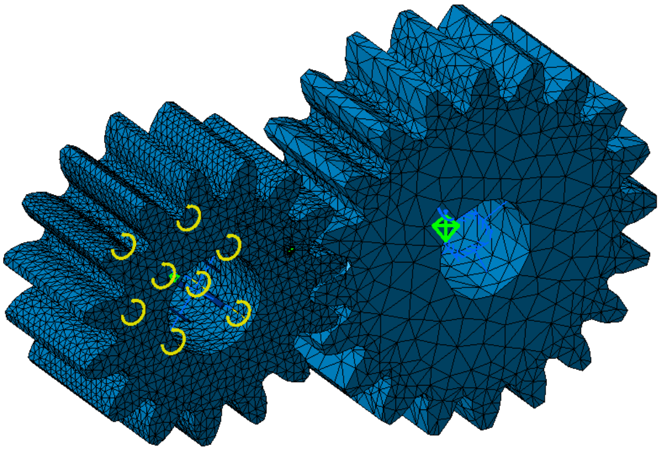


Fig. 2. *Spur Gear Couple Mesh Structure*

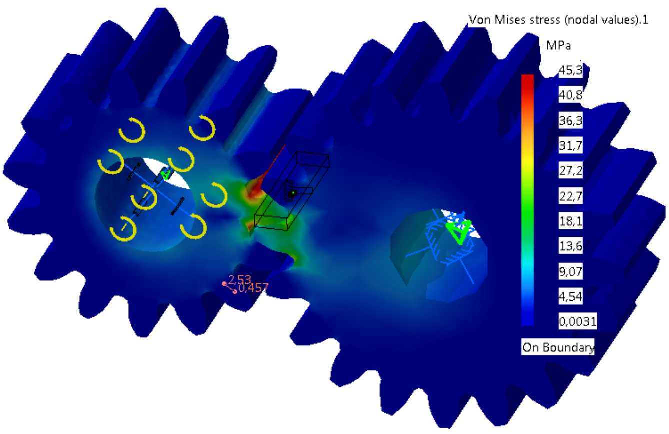


Fig. 3. *Structural Stress Analysis of Spur Gear Couple*

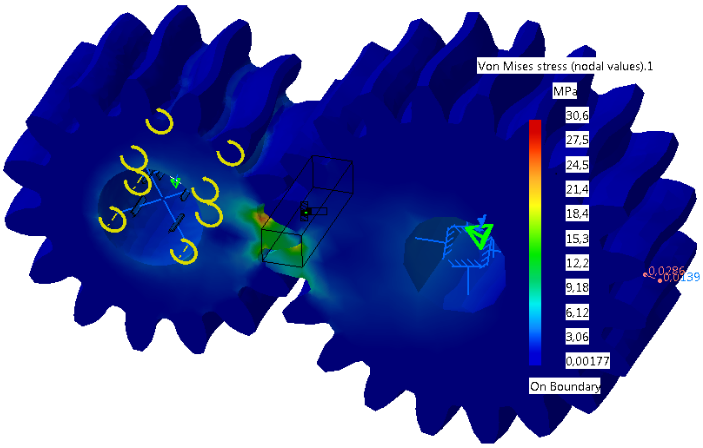


Fig. 4. *Structural Stress Analysis of Spur Gear Couple with Sinusoidal Profile Func. (T=2π)*

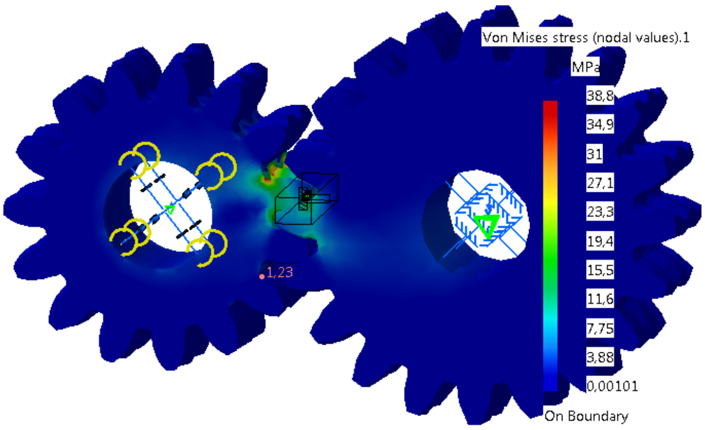
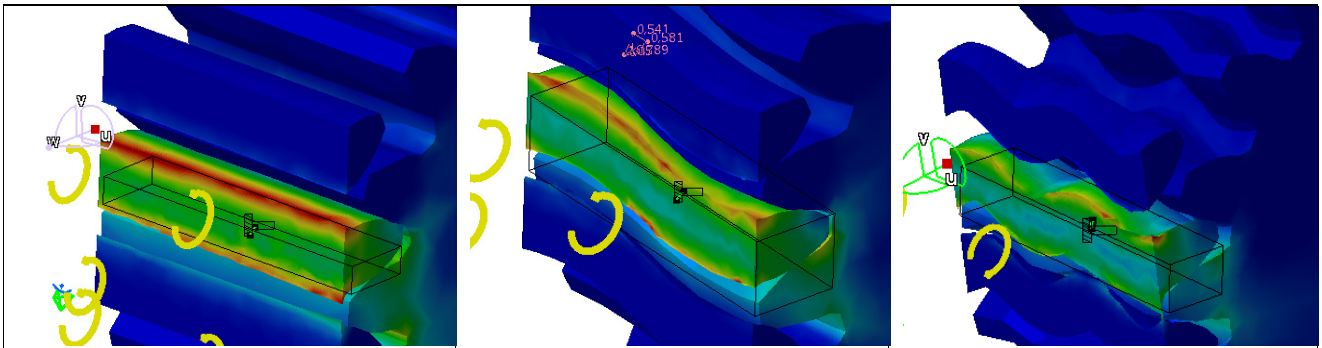


Fig. 5. *Structural Stress Analysis of Spur Gear Couple with Sinusoidal Profile Func. (T=4π)*



a) *b)* *c)*

Fig. 6. *Sectional View of Stress Distribution: a)Spur Gear b)Spur Gear with Sinus Func (T=2π) c)Spur Gear with Sinus Func (T=4π)*

Table 2 *Comparison of Analyze Results*

	Spur Gear	Spur Gear with Sinus Function Profile (T=2π)	Spur Gear with Sinus Function Profile (T=4π)
Max Stress (MPa)	45.30	30.60	38.80
Mesh Distribution Stretch (%)	100.00	99.77	99.88
Aspect Ratio (%)	92.68	92.78	93.45

It plays a significant role in optimization studies. Modern CAD systems reduce the operational time of complicated mechanical structures and manufacturing necessities. Optimization process is the most important factor among these.

Design parameters for three different gears can be seen in Table-1 and the profile is given in Fig. 1 in schematical view.

Relation between the contact surfaces of gear couple was provided in CATIA (see Fig. (2)). When the main gear was stabilized, 200Nm moment was applied to only pinion gear. Same mesh distribution for three gear couple were used in modeling. Mesh distribution percentage was obtained as 99% and can be seen in Table-2.

Stress distribution in spur gear contact surface was shown homogenous characteristics as an expecting result. When the spur gear profile was changed to sinusoidal function(T=2π), stress distribution has local homogenous characteristics. Increasing period of the sinus function(T=4π) causes to stress concentration on sharp edges on tooth root and gear profile end.

Stress distribution of straight spur gear was given in Fig. (3). Max stress value was calculated as 45.3 MPa on the tooth root of contact surface. Spur gear with sinusoidal profile function (T=2π) drops max stress to 30 MPa due to increasing contact surface area (See Fig. (4)). In the (T=4π) case, stress distribution has local accumulation areas (see Fig. (5)). These results can be interpreted detaily from Fig. (6).

CONCLUSION

In the present work, sinusoidal gear profile function have been used to improve the transmission performance for spur gears. Gear couples were modeled and stress analysis has been carried out with CATIA software. Concluding remarks are given below:

- Gear profile with sinusoidal function gives better moment transfer capability comparing to spur gear with straight profile.
- Period of the sinusoidal function decreases the max stress of the gear due to stress accumulation at the end edge of gear.
- If the sharp edges of gear was smoothed, moment transfer in gear couple increases.
- With the sinusoidal gear profile, gear couple becomes shape dependent and this prevents the axial misalignment of gears.

This investigation could be useful on improvement of strength of gears.

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