A Review on Experimental Investigation on Contact stresses of Spur Gear Used in Automated Lathe Machine

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Abstract- *Lathe is considered as one of the oldest machine tools and is widely used in industries. The spindle which holds the workpiece is located in the headstock and it receives the driving power from the motor. The spindle speed should be changed to suit different machining conditions like type of material to be cut, the diameter and the length of the work etc. In order to change the spindle speeds, back gear arrangement is employed. It has been observed that most of the failures in back gears are due to contact stresses and hence there is a increased in performance requirement such as high load carrying capacity, high speed, high reliability and long life. So as to fulfill above demand here we used a concept of asymmetric gear profile in which two different pressure angles are assign to two faces of gear tooth. To get optimum result using asymmetry four different pressure angles are used. All the gear pair are design in Creo parametric 2.0 and the analysis is carried out in ANSYS workbench 16.0 to calculate contact stress at point of contact. Apart from numerical analysis, contact stresses are also calculated using Hertzian contact stress theory (Analytical Approach).*

Keywords- Asymmetric tooth profile, back gear ,contact stresses, . spindle mechanism, spur gear.

I. INTRODUCTION

Gear is most critical components in a mechanical power transmission system. The power is transmitting by successfully meshing of teeth of pinion with teeth of gear. The tooth of driving pinion exerted a force on the tooth of driven gear and power is to be transmitted between driving & driven shaft. This force is always acts along the pressure line at pitch point called as a normal force or resultant force. This normal force is resolve in tangential & radial component of gear in horizontal & vertical plane respectively. The torque & power of spur gear train is calculating by using tangential component of force. The contact stress and bending stress are inducing on the gear due to the tangential load acts on the gear. If contact stress on the gear is higher than the wear strengths of the gear material gear failure is take place called as wear or pitting failure of the gear.

Wear is progressive removal of metal from the surface. The main causes of wear are misalignment in the shaft, wrong viscosity oil selection & contact stress exceeding the surface fatigue strength of the material. The stress concentration increases & crack is developed over the tooth surface. The size of crack is very high up to gear tooth is insufficient to absorb the load acts on it & finally it get beak. The life of the gear drive is reducing due to the wear failure. To increase life of the gear analysis is very important against the wear failure. The contact stress of the gear is reducing up to the limiting value by increasing the module of the gear. The contact stress of the gear is calculated analytically by using hertz's contact stress theory& Experimental method by using Strain gauge. The results obtain by all these methods are comparing and find the deviation in between them.

II. LITERATURE REVIEW

Alexander Kapelevinch[1] first man who gives geometry and design of involute spur gears with asymmetric teeth. Bending stress plays a significant role in gear design wherein its magnitude is control by the nominal bending stress and the stress concentration due to the geometrical shape. The bending stress is indirectly related to shape changes made to cutting tool. The bending stress can be reduced significantly by using asymmetric gear teeth and by shape optimizing the gear through changes made to the tool geometry is showed by Neils Pedersen [2]. This work is further followed by Sankar Shamugasundaram by giving a case study 'effect of pressure angle and tip relief on the life of speed increasing gearbox' in which KISS soft gear calculation software was used to determine the gear specification and analysis is carried out in ANSYS software version 11.0 for the existing and proposed gear to evaluate the performance of bending stress tooth deflection and stiffness .The study by FatihKarpat & others[3] offers preliminary results to designers for understanding dynamic behavior of spur gears with asymmetric teeth. Fast Fourier transform was used for the frequency analysis of the static transmission errors. It is shown that generally, the dynamic factor, for spur gears with asymmetric teeth, increases with increasing pressure angles on the drive side.

Praveen Silori & other.[4] gives study of mechanical behaviour of a traction spur gear assembly for different materials and also the main focus is to estimate the fatigue life along with the understanding of stress behaviour at root radii of the gear.

Ram Krishna Rathore and Abhishek Tiwari[5] proposed the process of optimization of spur gear bending stress and related fatigue life. The methods of choosing the size and location of the hole were also proposed. This led to unique results where the bending stress had been reduced to 21% approximately. The bending stress was calculated with FEA analysis and comparison of FEA stress was done with the stress calculated from AGMA standard, both the results was in good agreement. Finite element analysis is performed Prateek Kumar&other [6] to optimize the dedendum for the chosen module of 3, 18 teeth, 20-34o asymmetric spur gears. Finite element analysis of asymmetric gear was carried out to design the optimum dedendum. For the chosen 20-34 asymmetric gear pair, 1.1 module is identified as optimum dedendum.

In a study by W. J. Qin and C. Y. Guan,[7] the surface and subsurface stresses of gear teeth are investigated using Hertzian theory and the finite element method. The effects of friction and speed on stress cycles and fatigue life are studied. The stresses near the engagement and recess areas are also found to be greater than the static contact conditions and thus result in low fatigue life, particularly at high speeds. Santosh S. Patil &other. [8] has made an attempt to study the contact stresses among the helical gear pairs, under static conditions, by using a 3D finite element method. The Lagrange multiplier algorithm has been used between the contacting pairs to determine the stresses. The variation of contact stresses with helix angle and also with friction coefficients has been discussed. The commercial finite element software used was ANSYS and the results were compared with analytical calculations.

Santosh S. Patil &other[9] again presented one another paper in which Gear Dynamic Stress Test Rig (GDSTR). GDSTR is a newly designed test rig to compute the contact stresses on the gear pair contact, under real gear conditions. The experimental analysis showed promising results which have been verified by the finite element frictional contact analysis. P. Marimuthu and G. Muthuveerappan[10]Gives Modal analysis which is used to determine the inherent dynamic characteristics of a system in forms of natural frequencies, damping factors and mode shapes. These parameters are important in the design of a system for dynamic loading conditions. In this research paper the modal analysis of involute helical gear pair is carried out using finite element analysis tool ANSYS16. YumeiHua, Yimin Shao&other [11] research on Isometric modification which is proposed as a new method of axial modification of spur bevel gear. The simulation results show that the stress distribution of gear surface is controlled by tooth modification. The load concentration, agglutination and pitting of the gear can be avoided effectively. Miryam B. Sánchez&other [12] they calculate bending stress analysis by using LEWIS FORMULA as Gears is one of the most important component in mechanical power transmission systems. The bending stress of the gear tooth is regarded as one of the key contributors for the failure of the gear in the gear set. Thus, analysis of stresses has become popular as an area of study on gears to minimize the chances of failures and also for the optimal design of gears. The analytical study is based on Modified Lewis formula.

III. OBJECTIVE

Study of back gear arrangement and its failure phenomenon

Backgear is a gear mounted at the back of the headstock (although in practice it is often located in other positions) that allows the chuck to rotate slowly with greatly-increased turning power.

Study of effect of asymmetric gear profile over symmetric gear profile

The object of gear design is to minimize the stresses. The main advantage of asymmetric gears is contact stress reduction on the drive flanks, resulting in higher torque density (load capacity per gear size). These benefits of the gears with asymmetric tooth profiles for unidirectional torque transmission are well known.

Study of effect of height of addendum and drive side pressure angle on contact ratio and contact stresses

The effects of addendum height, teeth number and module determined considering load sharing between the teeth pair wll be studied.

Study of increase in load carrying capacity of lathe gear

There are different ways to improve strength of gears such as, by using asymmetric gear tooth profile, different materials i.e. composites material,Heat treatments, improving surface quality.

IV. DISCUSSION

This literature review presents various researchers' work for minimizing contact stresses in spur. Various analyses are done to study effect of back gear arrangement and its failure phenomenon,, asymmetric gear profile over symmetric gear profile, height of addendum and drive side pressure angle on contact ratio and contact stresses in spur gear. The literature found related to modeling and optimization of gear is mainly based on statistical design of experiments (DOE) such as MATLAB, FEA analysis, ANSYS.

V. CONCLUSION

From study it is concluded that most of the failures in back gears are due to contact stresses and hence there is a increased in performance requirement such as high load carrying capacity, high speed, high reliability and long life. Various researchers have done remarkable investigation in order to improve load carrying capacity of lathe gear. From literature, it shows that numerical results get validated with experimental as well as analytical results In the long run, further study should be done to find the solution on the wear and pitting of gear.

REFERENCES

[1] Alexander Kapelevich,"Geometry and design of involute spur gears with asymmetric teeth", Mechanism and Machine Theory, vol. 35, p.p. 117-130, 2000.

[2] Neils Pedersen, N. L., Improving bending stress in spur gears using asymmetric gears and shape optimization, Mechanism and Machine Theory, 2010, 45 (1), p.p. 1707–1720.

[3] FatihKarpat, Stephen Ekwaro-Osire and EsinKarpat, A Computer Program for Dynamic Load Simulation of Spur Gears with Asymmetric and Symmetric Teeth, World Journal of Mechanics, 2012, 2, p.p. 239-245.

[4] Praveen Silori,AmirShaikh,Nithin Kumar KC and TusharTandon, Finite Element Analysis of Traction gear using ANSYS, Materials Today: Proceedings 2 , (2015) , p.p. 2236 – 2245.

[5] Ram Krishna Rathore and Abhishek Tiwari. Bending stress analysis and optimization of spur gear, International Journal of Engineering Research & Technology; 2014, 3: 2044- 2049.

[6] Prateek Kumar, Saroj Mandal and S.Senthilvelan, 15th National Conference on Machines and Mechanisms, 2011, NaCoMM2011-156.

[7] W. J. Qin and C. Y. Guan, An investigation of contact stresses and crack initiation in spur gears based on finite element dynamics analysis, International Journal of Mechanical Sciences, 2014, vol. 83, p.p. 96–103.

[8] Santosh S. Patil ,Saravanan Karuppanan , Ivana Atanasovska and Azmi Abdul Wahab, Frictional tooth contact analysis along line of action of a spur gear using finite element method, Procedia Materials Science, 2014, vol. 5, p.p. 1801 – 1809.

[9] Santosh S. Patil ,Saravanan Karuppanan and Ivana Atanasovska, Experimental measurement of strain and stress state at the contacting helical gear pairs, Measurement, 2016, vol. 82, p.p. 313–322.

[10] P. Marimuthu and G. Muthuveerappan, Design of asymmetric normal contact ratio spur gear drive through direct design to enhance the load carrying capacity, Mechanism and Machine Theory, (2016), 96, p.p. 22–34.

[11] YumeiHua, Yimin Shao , Zaigang Chen and Ming J. Zuo, Transient meshing performance of gears with different modification coefficients and helical angles using explicit dynamic FEA, Mechanical Systems and Signal Processing, (2011), 25, p.p. 1786–1802.

[12] Miryam B. Sánchez, José I. Pedrero and Miguel Pleguezuelos, Contact stress calculation of high transverse contact ratio spur and helical gear teeth, Mechanism and Machine Theory, 2013, vol. 64, p.p. 93–110.

[13] Shuting Li, Effects of centrifugal load on tooth contact stresses and bending stresses of thin-rimmed spur gears with inclined webs, Mechanism and Machine Theory, 2013, vol. 59, p.p. 34–47.