Computational analysis of Lathe Transmission system

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Abstract - *In lathe machining process, particular for harder material, the speed of chuck where work piece is mounted plays a significant role in machining. This speed is achieved by several combinations of gear systems within gear box. Even though so many compound gear boxes with standard gear ratios are readily available in the market, due to the need of increase or decrease the finalspeed output, a specific compound gearbox is designed with areduction gear ratio of 10:1 for the application to be used in lathe machining. In this work a CAD model of gear box system for lathe has been developed by using Solid works and FEA analysis has performed by using ANSYS. Moreover,analytic analysis has also been carried to study the impact of other parameters such as transmission ratio, number of teeth. The analytic analysis has been carried out by using MATLAB.*

Key Words: Lathe, Gear, Transmission ratio, Stress.

1. INTRODUCTION

Gear is one of the most widely used rotating machinery parts. Its performance directly determines the performance of the rotating machine [1 , 2] . Mesh stiffness has a great influence on the dynamic characteristics of gear systems [3 , 4] . How to analyze accurately mesh stiffness has become a hot topic in gear researches. There are analytical method, finite element (FE) method and analytical-FE method in calculating time-varying mesh stiff- ness (TVMS) of gear pairs. FE method could simulate automatically the actual tooth profile, such as tooth profile modifica- tion, manufacturing errors and mounting errors. It has a high accuracy in analyzing the TVMS of gear pairs. Nevertheless, FE method requires repeated modeling for different gears and more computing resources [5 , 6] . Analytical-FE method is pro- posed combined with analytical method and FE method, which can quickly calculate TVMS under various gears, such as tooth profile modification, thin-web foundation, foundation with holes, crack and so on [7–9] . But the method could not suitable to the new conditions, such as manufacturing error, et al. It needs to further study to expand the application scope. Analytical method is widely used in calculating TVMS of gear pairs because of the high computational efficiency and convenient use. The potential energy method is one of the most popular analytical method, which has been investigated by many researchers.

Ayma et al. 2017 Internally-spline sleeves have an increased attention since these parts serve as power transmission means in many industrial applications. This research presents using ball spinning process for producing internally-spline sleeves. The process was investigated experimentally and theoretically. The experimentally investigated variables were: the rotational speed of the mandrel 86, 604, 1146 and 1747 rpm; the axial feed, 0.3, 0.6, 0.91 and 1.21 mm/ rev; the cross in- feed 1.5, 2, 2.5, 3 and 3.5 mm. An analytical expression was derived to predict the deformation loads. The theoretically investigated variables were: the mentioned axial feed and cross in-feed at 604 mandrel rotational speed; the initial tube thickness of 3.5 to 8 mm with step 0.5 mm; the ball diameters of 16 to 32 mm with step 4 mm; the number of ribs was 4, 5, 6, 8, and 10. The effects of these variables on the forming load and the quality of formed sleeves were investigated. The results showed that, these variables affecting the forming load and product quality. The optimum values of these variables were determined. The theoretical results have been found to be in close agreement with experiment.[11]

Xiaodong et al. 2020 proposes an approach for tooth faults detection of planetary gearboxes based on the tooth root strain signal of ring gear. Firstly, the tooth fault mechanism is analyzed with two steps. A lumped-parameter model is adopted to investigate the influence of the tooth fault on the ring-planet mesh force, and a 2-D finite element model is built to figure out the fault features in the time domain of the ring gear strain signal caused by such abnormal mesh force. Secondly, the monitoring strategy of sun gear and planet gear is proposed. In the strategy, the averaged strain matrix, whose elements correspond to the teeth of the interesting gear, is obtained by using the extracting and averaging operation. The faulty tooth can be identified by comparing the elements in the matrix. The efficiency of the monitoring strategy and the requirement for complete monitoring are also discussed. Finally, experiments are carried out. In the experiments, the monitoring strategy is applied to different faults of planet gear and sun gear in low speed condition and high speed condition. The theoretical fault features can be obviously seen in the time domain of the measured strain signals, which shows the effectiveness of the proposed approach.[12]

Getachew and Hirpa 2020 presented Gear tooth profile can deviate from its initial design shape and size as a result of increasing service time under time-varying load, introducing external agents like debris, overheating due to friction, wear, and in generally due to other nonlinear factors such as backlash. As a result, the dynamics of the gear will also vary depending on the resulting gear tooth profile. In this study, the worn-out gear tooth is modelled as a backlash by assuming a uniformly distributed worn out surface and the effect on the dynamic performance is investigated. By changing the amount of backlash of the gear tooth from 0 mm to 1 mm by 0.2 mm increment, the gear is modelled and analysed for three loading cases using MSC ADAMS software. This paper discusses the effect of backlash or uniformly worn out spur gear tooth faces on the dynamics specifically the contact and angular accelerations of the gear.

2. Methodology

In this work a CAD model of gear box system for lathe has been developed by using Solid works and FEA analysis has performed by using ANSYS. Moreover, parametric analysis has also been carried to study the impact of another parameter.

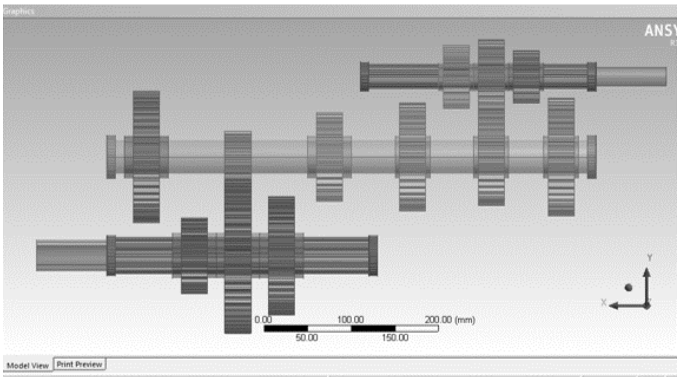

Figure 1 CAD model of Lathe transmission system

$$\sigma_b = \frac{F_t k_v k_m k_o}{bmj}$$

Where;

F_t = Transmitted Tangential Load,

k_m= Load distribution factor,

K_v = Dynamic Factor,

k_o=overload factor,

b = Face Width and

j= Geometry Factor.

$$p_p = y_m y_p \sqrt{\frac{F_t}{bd_1}\frac{u+1}{u}}$$

$$y_m = \sqrt{0.35E}$$

$$y_p = \sqrt{\frac{1}{\cos\alpha \sin\alpha}}$$

Where,

P_p = contact stress,

E = Modulus of elasticity,

F_t = transmitted tangential load,

b=face width,

d = operating pitch diameter of pinion, in (mm),

α= pressure angle,

u= transmission ratio.

3. RESULTS AND DISCUSSION

In this section, effect of lathe transmission system and gear face width has been examined.

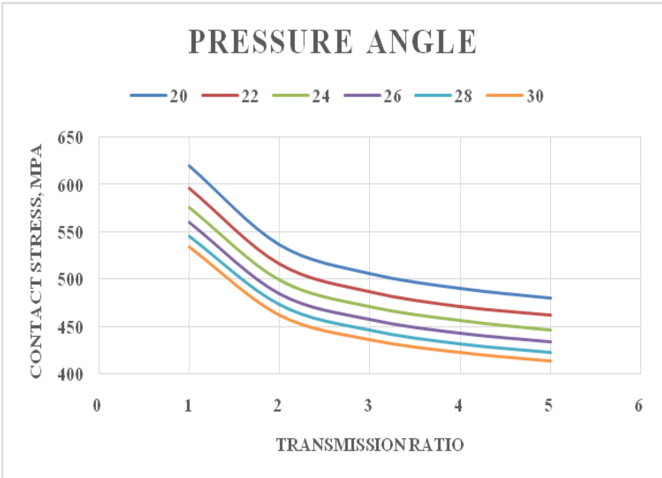

Figure 2 Effect of Transmission ratio on contact stress

Fig 2 show Effect of Transmission ratio on contact stress. It can be concluded that on increasing pressure angle corresponding with transmission ratio the contact stress linearly decreases. Therefore, transmission ratio and pressure angle can be increases to the maximumlimit as per the requirement in order to overcome from contact stress.

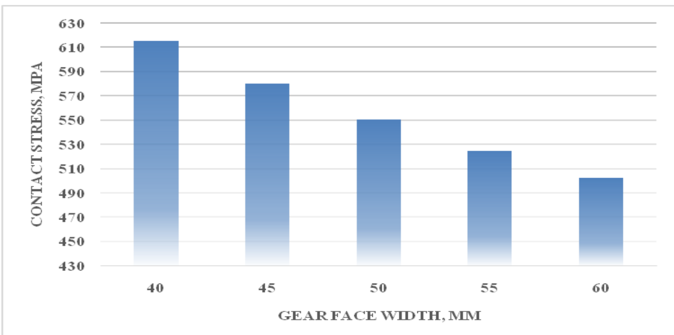

Figure 3 Effect of gear face width on contact stress

Figure 3 shows the Effect of gear face width on contact stress. From this it is seems that on increasing pressure angle along with Face width the contact stress significantly decreases. It can also be revealed that pressure angle and face width are inversely proportional to contact stress. And the load carrying capacity becomes more

4. CONCLUSION

The face width and transmission ratio are an important geometrical parameter during the design of gear and gear box system. As it is expected, in this work the maximum bending stress decreases with increasing face width and it will be higher on gear of lower face width with higher transmission ratio. As a result, based on this finding if the material strength value is criterion then a gear with any desired transmission ratio with relatively larger face width is preferred.

REFERENCES

[1] Y. Lei , N. Li , L. Guo, N. Li , T. Yan , J. Lin , Machinery health prognostics: a systematic review from data acquisition to RUL prediction, Mech. Syst. Sig. Process. 104 (2018) 799–834.

[2] Y. Lei, J. Lin, M.J. Zuo, Z. He, Condition monitoring and fault diagnosis of planetary gearboxes: a review, Measurement 48 (2014) 292–305.

[3] H. Ma , J. Zeng, R. Feng, X. Pang, Q. Wang, B. Wen , Review on dynamics of cracked gear systems, Eng. Fail. Anal. 55 (2015) 224–245.

[4] X. Liang, M.J. Zuo, Z. Feng, Dynamic modeling of gearbox faults: a review, Mech. Syst. Sig. Process. 98 (2018) 852–876.

[5] S. Li, Effects of misalignment error, tooth modifications and transmitted torque on tooth engagements of a pair of spur gears, Mech. Mach. Theory 83 (2015) 125–136.

[6] X. Liang, H. Zhang, M.J. Zuo, Y. Qin, Three new models for evaluation of standard involute spur gear mesh stiffness, Mech. Syst. Sig. Process. 101 (2018) 424–434.

[7] Q. Wang , K. Chen , B. Zhao , H. Ma , X. Kong , An analytical-finite-element method for calculating mesh stiffness of spur gear pairs with complicated foundation and crack, Eng. Fail. Anal. 94 (2018) 339–353.

[8] K. Chen , H. Ma , L. Che, Z. Li, B. Wen , Comparison of meshing characteristics of helical gears with spalling fault using analytical and finite-element methods, Mech. Syst. Sig. Process. 121 (2019) 279–298.

[9] K. Chen, Y. Huangfu, H. Ma, Z. Xu, X. Li, B. Wen, Calculation of mesh stiffness of spur gears considering complex foundation types and crack propagation paths, Mech. Syst. Sig. Process. 130 (2019) 273–292.

[10] D. Yang, J. Lin, Hertzian damping, tooth friction and bending

[11] Ayman A. Abd-Eltwab, S. Z. El-Abden, Khaled I. E. Ahmed, M. N. El-Sheikh, Ragab K. Abdel-Magied, "An investigation into forming internally-spline sleeves by ball spinning", International Journal of Mechanical Sciences, Volume 134, December 2017, Pages 399-410

[12] Xiaodong Zhang, Hang Niu, Fagui Di, An Approach for Tooth Faults Detection of Planetary Gearboxes Based on Tooth Root Strain Signal of Ring Gear, Measurement In press, journal pre-proof Available online 7 November 2020...

[13] Getachew A. Ambaye, Hirpa G. Lemu, Dynamic analysis of spur gear with backlash using ADAMS, Materials Today: Proceedings In press, corrected proof Available online 27 October 2020