A Comprehensive Report on Lathe Transmission System

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Abstract— In lathe's in order to acquire adequate machining operation effective transmission system is required with proper wide range of speed option (step or step down). Generally, in lathe transmission system, a combination of gear trains is there which increases or decreases the of spindle shaft which is been coupled with the transmission system. To increase the life of the lathe transmission system against fatigue failure, which occurs because of repetitive tensile stresses at the root of the gear tooth of transmission system is a quite challenging task. The inability of gears is very sudden against fatigue loading without giving any indications of failure. Many researchers gave practical ways for improving the gear design of transmission system like, the use of advanced material, harden the gear surface by heat treatment and carburization, improve the surface finish by shot penning method, changing the pressure angle, use asymmetric gear tooth, modify the shape of root fillet curve, etc. In this paper a comprehensive report has been presented which reveals the significant contribution of various researchers in improving the technology of Lathe transmission system or gear train.

Keywords: Lathe Transmission System, Gear, Failure, FEA

I. INTRODUCTION

Lathe machines are conventionally used for machining operations with gradual material removal from the workpiece to finish the materials with desired surface finish and dimensional accuracy. This surface finish and dimensional accuracy is achieved by effective power trains. Other parameters are also their which significantly affect the surface finish and dimensional accuracy, but there we are discussing the role of transmission system in lathe machines. In lathe machines transmission system generally spur gears are used. These spur gears are frequently used to provide speed and torque conversions from a rotating power source to connected mechanical devices. There are internal and external sources of excitations for the gear set. The internal one is induced by the time varying mesh stiffness. Many authors [1], [2] considered this fluctuation as the main source of excitation of the system and at the origin of the observed noise and vibrations. Bartelmus [3], [4] and Chaari et al. [5], [6], [7] introduced this varying mesh stiffness in a dynamic model of a spur gear system in order to study its response in presence of defects. Amplitude modulations were observed with added frequency components in response spectra. Bartelmus [3], [4] and Walha et al. [8] studied the effect of backlash on the dynamic response of a two stage gearbox. He concluded that tooth separation occurs at the transient regime with increase in the vibration level.

The external sources of excitation are mainly induced by the fluctuation of the input velocity and torque caused by the motor at its transient regime. The load condition variation can also be considered a significant external source of excitation. But, it seems that the effects of input rotational velocity on the linear dynamic behavior of gears were investigated only on few occasions. Sika [9] and Sika and Velex [10] proposed a model to study in transient regime the backlash and backstrike effect and the influence of gear tooth geometry as well as shaft and gear-shaft-bearing casing positioning on the dynamic behavior of a gear system. The starting of gear system powered by an electric motor was also investigated by Hugues [11].

Barsoum et al. 2014 presents a finite element modeling framework to determine the torsion strength of hardened splined shafts by taking into account the detailed geometry of the involute spline and the material gradation due to the hardness profile.

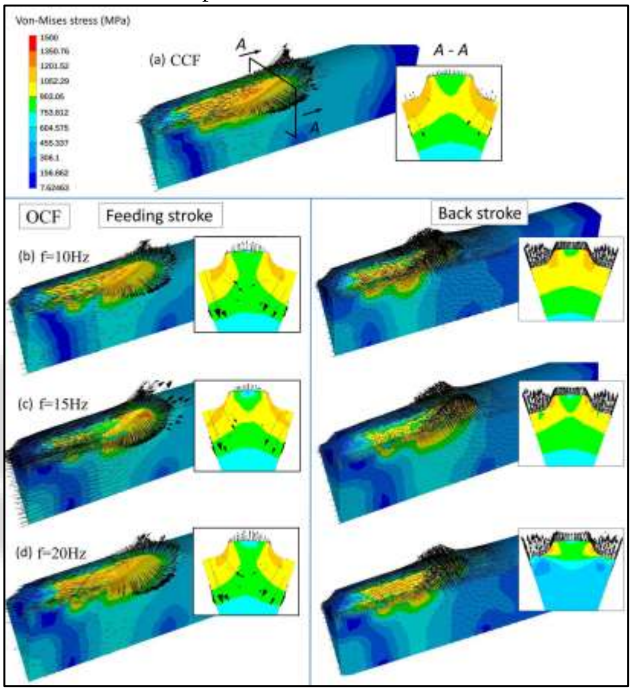

Fig. 1: Von-Mises stress and velocity distribution of the workpiece in different condition [12]

The aim is to select a spline geometry and hardness depth that optimizes the static torsion strength. Six different spline geometries and seven different hardness profiles including non-hardened and through-hardened shafts have been considered. The results reveal that the torque causing yielding of induction hardened splined shafts is strongly dependent on the hardness depth and the geometry of the spline teeth. The results from the model agree well with experimental results found in the literature and reveal that an optimum hardness depth maximizing the torsional strength can be achieved if shafts are hardened to half their radius.

Min-Chao et al. 2016 a novel axial-infeed incremental rolling process of spline shaft with 42CrMo steel is proposed to solve the problems of present manufacture process. The principle of the axial-infeed incremental rolling process is introduced firstly, and then the deformation mechanism is analyzed by finite element method (FEM). The numerical results show that the deformation and material flow during the novel process only occurs in the surface layer of the blank, and the metal flow

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velocity component along the radial direction is significantly higher than that along the axial direction. Next, the experimental research is carried out on axial-infeed incremental rolling equipment, and the microstructure and hardness of the products are evaluated. The experimental results show that the microstructure in the surface of tooth profile, and root is fibrous tissue which is continuous, dense, and streamlined, and the hardness of the tooth profile and root area obviously increases.

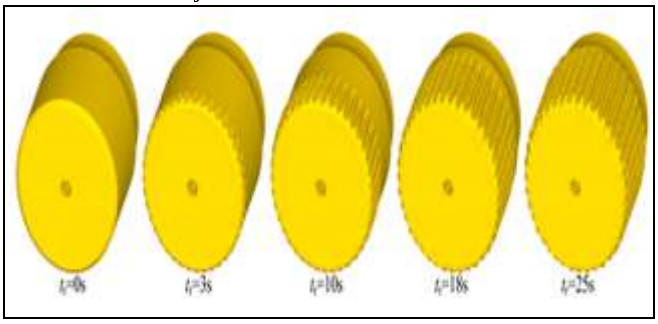

Fig. 2: 5 Diagram of formation process of the spline shaft by FEM [13]

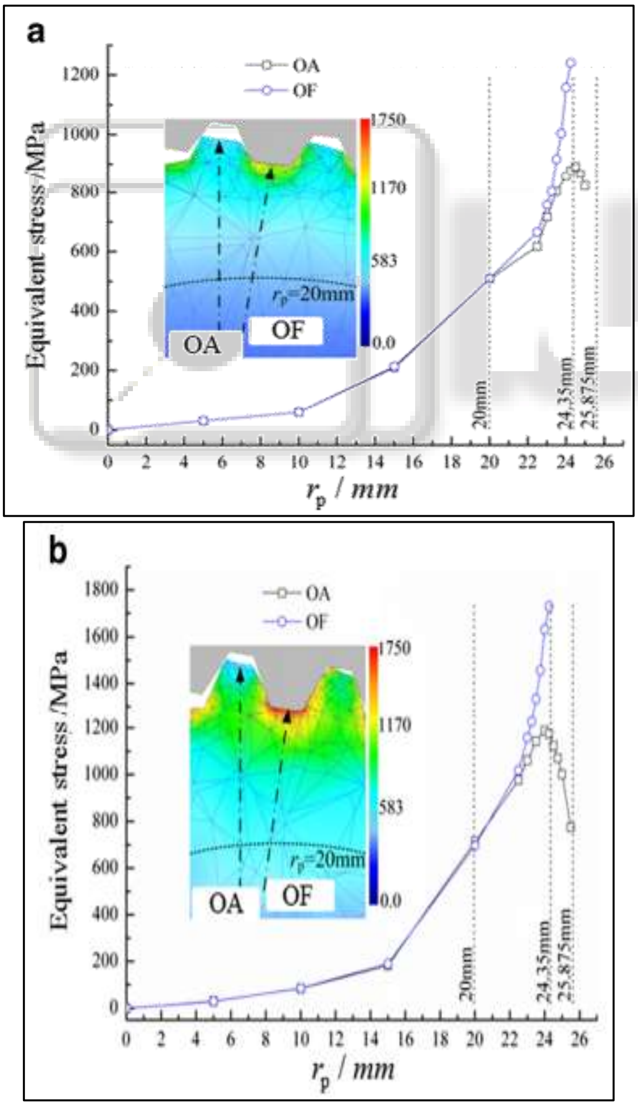

Fig. 3: The equivalent stress distribution of the spline shaft: a preformation area and b correction formation area [13]

Zhang et al. 2017 investigate the differences between the OCF and CCF, forming experiment, hardness test and micro observation were performed. In consideration of the different friction condition and variational velocity, a friction modal considering sliding and velocity was used in simulation. The force-stroke curve got from the horizontal oscillating extrusion machine shows that OCF can reduce the load about 25% than CCF and that oscillating frequency affects the friction as well as the forming force. Moreover, the results of experiment and simulation indicate the surface quality of OCF is better than CCF because lower friction leads to less metal pileup.

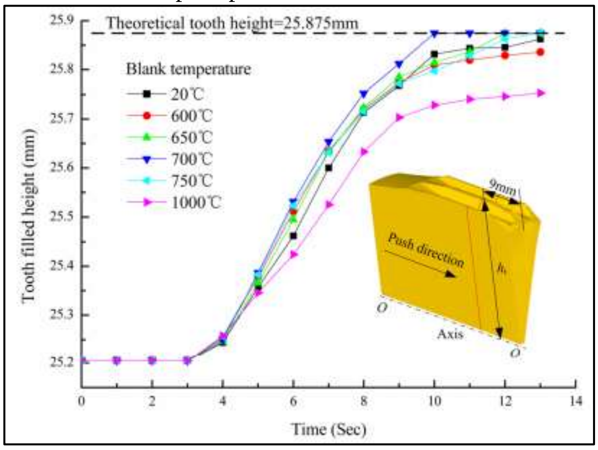

Fig. 4: Comparison on tooth-filled height under different deformation temperatures [14]

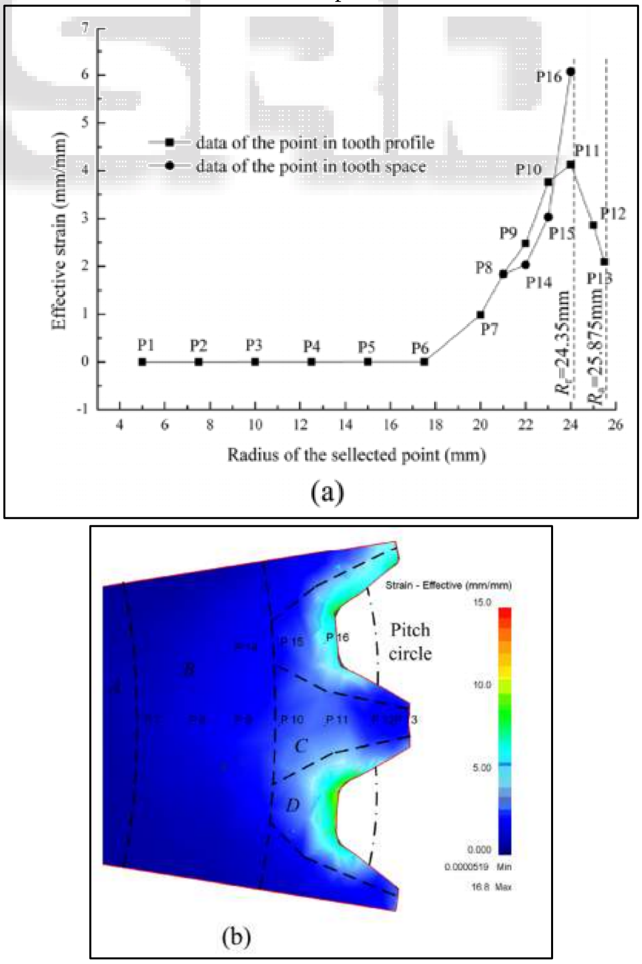

Fig. 5: Effective strain of the selected point under different radius, a the values of the effective strain and b schematic diagram of the selected points and four different deformation regions [14]

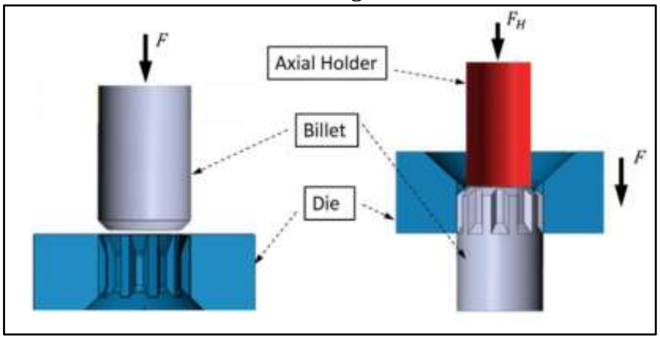

Fig. 6: Spline-forming process [15]

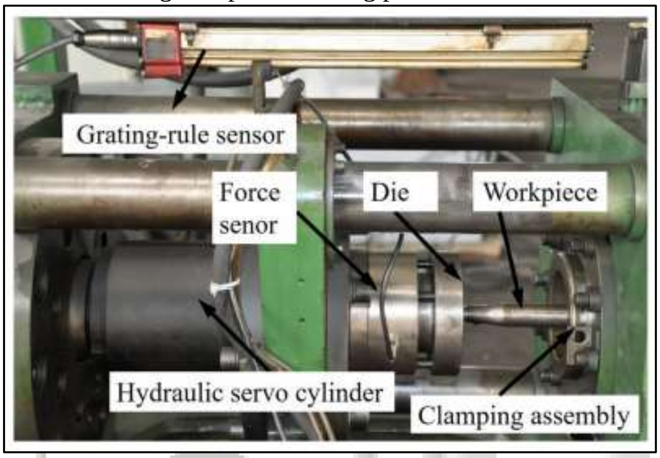

Fig. 7: Forging equipment [15]

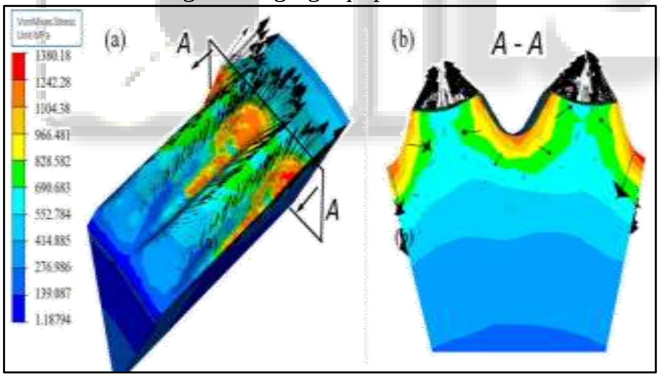

Fig. 8: Metal flow and distribution of von Mises stress (a) and section at the maximum stress (b) [15]

Zhang et al. 2014 [8] With the advantages of minimized stress concentration and allowing a combination of rotation and axial motion, internal helical splines have been widely used in automotive and aeronautic industries. However, this type of splines can only be manufactured using machining or extrusion method. This paper studied the recess swaging method, a net-shape forming process, for manufacturing the internal helical splines. In order to investigate the deformation tendency of workpiece along the thickness direction, Finite Element (FE) simulations and experiments were firstly performed on the recess swaging of tube without mandrel. Results show that the stress state in the forging zone is triaxial compressive except for the tensile axial stress at the inner surface of the tube. Moreover, during the recess swaging process material mainly flows along the axial and thickness direction, but the axial flow dominates. With increasing the reduction in outer radius and the wall thickness, metal flow along the axial direction increases but along the thickness direction decreases. Furthermore, based on the fundamental research on recess swaging experiments and FE simulations on the recess swaging method for manufacturing the internal helical splines were conducted. After the recess swaging, the hardness at the bottom of the tooth improved approximately 56.9%, while that at other zones increased 41%. The strength and the wear resistance of tooth were also improved. In summary, the recess swaging process provides an effective method for manufacturing the internal helical splines.

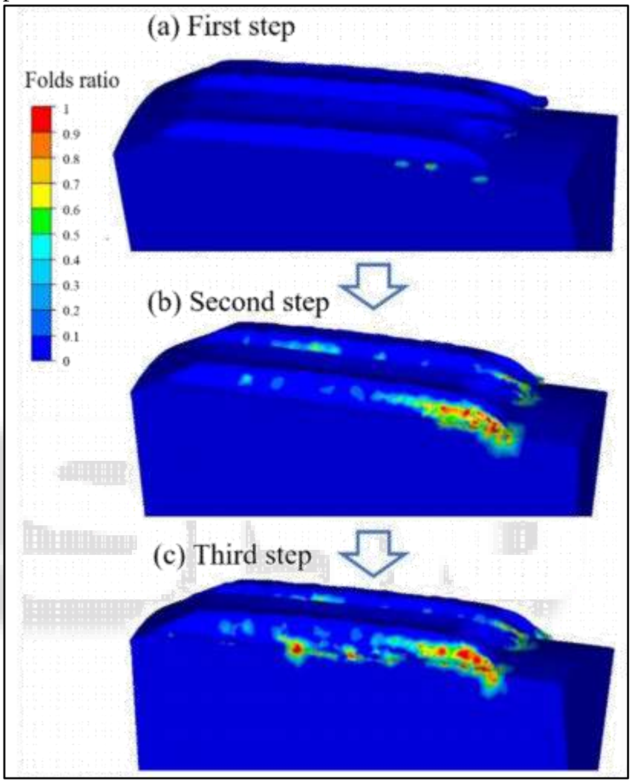

Fig. 9: Distribution of folds at the first step (a), second step (b) and third step (c) in the forming method of assembling dies [16]

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

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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.

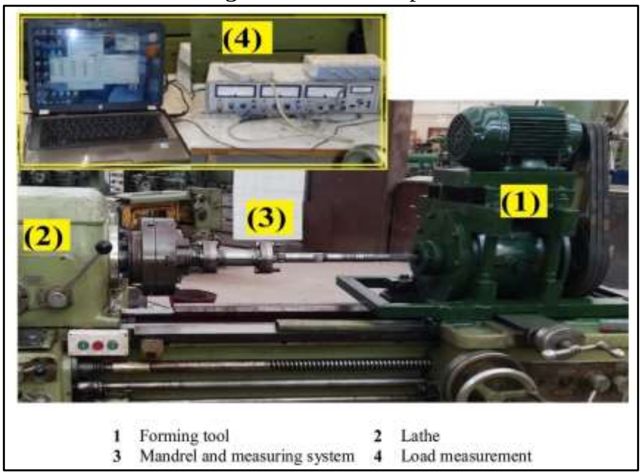

Fig. 10: Test rig components of forming process. [16]

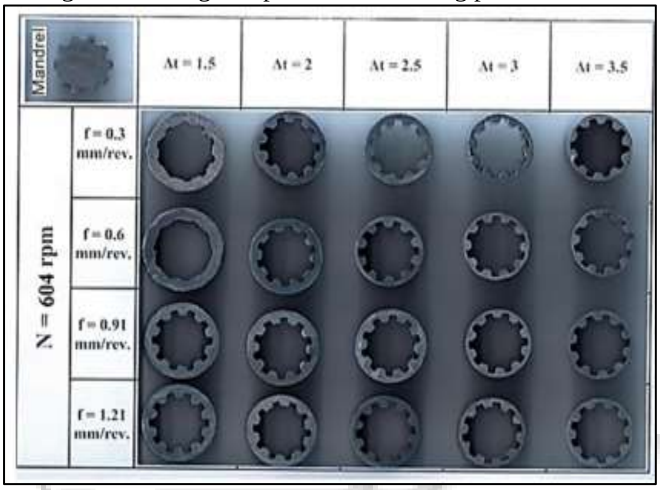

Fig. 11: (a) The cross section of internally- spline sleeves at various axial feed and cross in-feed. (b) The internally-spline sleeves at various cross in-feed [16]

II. CONCLUSION

Lathe designers should choose adequate couplings to reduce the effect of fluctuating torques and speed of the driving motor to reduce excessive vibrations in transient regimes.

On the other hand, the vibrations induce by lathe transmission system are due to high dynamic loads on the teeth in contact; a supplementary safety factor should be correctly chosen to take into account such overloads.

The particle damping can be installed on the machine tool through the thread. Particle damper can be used to improve the accuracy of machine tool when the vibration of machine tool becomes larger and the accuracy becomes lower due to aging and other reasons.

In comparison with lumped parameter method, the finite element method is simple and intuitive in computing the DTE of gear systems for the reason that there is no need to externally specify the excitation in the form of time-varying mesh stiffness, static transmission error and time-varying backlash which are determined directly by gear geometry in the finite element model.

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