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STUDY OF THE OPEN GEAROF HYDRAULIC POWER TONG OPERATED UNDER ABNORMAL CONDITIONS

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ABSTRACT

Open gear is key driving device of hydraulic power tongs, and bearing the rotating loads from two idlers. When unscrewing and screwing, there is only a single idler meshes with open gear and the stress focuses in the contact areas which having a bad influence on the quality of makeup and breakout and the operating life of the hydraulic power tongs. In order to learn the effect of the gear pair of single idler - open gear on high torque. Building the three-dimensional model of the gear pair by the software Pro/E, then simulated the condition of single idler meshes with open gear and double idlers mesh with open gear. The results show that the multiple stress of the condition of single idler working is higher than double and the multiple stress increment of single idler and open gear are 17.7% and 87.8%.The gear pair of single idler - open gear on high torque will reducing stiffness and working life of the open gear easily. It is necessary to avoid to working in such condition. And measures should be taken to decrease the stress concentrative, such as: increase the radius of gear root arc and make the tooth surface load sharing homogeneous along the axis.

Key Words: Hydraulic power tong ; Open gear ; ANSYS Workbench; Anormaly working ; The numerical simulation.

Introduction

Hydraulic power tong is the special mechanical equipment in oilfield operations, it is mainly used to rapidly and discharge tubing thread. It is simple structure, convenient operation, reliable performance, long service life, wide applicable scope, large output torque, and so on, therefore, the use of hydraulic power tongs when he worked in workover can improve the work efficiency of workers, and reduce their Labour intensity[1]. But there are some defects and problems when power tongs in use process, when working in high torque, gear speak deformation easily, cause a skid and bitten drilling tools, short service life and different specifications of the drilling tools need to change jaw, bring inconvenience to operate and so on[2].

Open gear is the main stress components of the head of open type power tongs, as power transmission and pliers bite tight organization, open gear directly influences the mechanical properties of power tongs, shackle on work performance. Hydraulic power tongs abnormal work

seriously affect the quality of work life and shackle. In the actual production process, the small make-up torque on the string always cause the string slippage[3]. And in abnormal operating conditions, open gear has low stiffness, big mouth parts deformation under overload, easy cause skid and bitten drilling tools, short service life, seriously affect the reliability of open type hydraulic power tongs[4]. In order to ensure the quality of the hydraulic power tongs buckled, study of the strength of open gear and idlers under abnormal working conditions has a certain significance.

Jun Mao studied the open gear cover of shear stress, bending stress and tensile stress, the stress analysis and calculation, and is verified by the method of finite element results[5].H Cheng used the method of determine the structure of the dangerous section is deduced the theory calculation formula of main jaw mechanical strength[6]. Power tongs gear transmission system is as the research object, based on Hertz contact theory application in gear meshing contact force of computation, the study on the dynamic characteristics of gear transmission system. The gear meshing force in different stages of change rule[7]. Wu Changlin compared with the international organization for standardization (ISO) and the American gear manufacturers association (AGMA) calculation method about involute cylindrical gear. The results show that the AMGA of bending strength calculation results more sensitive to the change of the geometric parameters of gear[8]. M.Pimsran and K.Kazerounian analyzed the contact pressure distribution of cylindrical contact process, by using virtual contact interface stiffness (PISE) method to simulate elastomer stiffness distribution of contact area[9]. After geometric modeling theory research, Litvin used the finite element method (fem) contact analysis of spiral bevel gear, get contact region shape and stress distribution[10]. Orthogonal face gear is studied by TANG Jinyuan under the loading condition of gear meshing transmission performance parameters, tooth surface gear contact stress and bending stress change rule of the finite element analysis of key technology, analytical formula calculation results by Hertzian contact stress contrast, put forward the contact stress and bending stress calculation of finite element mesh density determination method[11].

At present, scholars at home and abroad are important parts of hydraulic power tongs and a lot of research on gear meshing transmission characteristics. But for the band gap of the gear, study in power tongs abnormal working conditions is less reported. In this paper, based on the structural feature of the hydraulic power tongs opening gear and stress distribution, by the method of finite element analysis, validation if the hydraulic open gear under abnormal conditions have sufficient mechanical strength under the load generated by maximum buckled torque.

2 Introduction of Open gear working under abnormal condition

Hydraulic power tongs work by the hydraulic motor to drive torque of the synchronous idlers and driving open gear to realize shackle Circular motion; Open gear drives the string at the same time holding mechanism clamping or loosening of the string. there are two kinds of working condition, as shown in figure 1, figure 2. As shown in figure 1, for the gear meshing condition of idler and open gear. As shown in figure 2, is open gear and idler gear meshing condition.

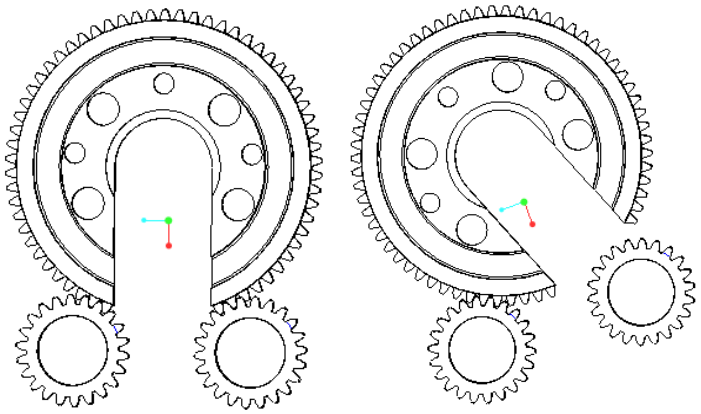

Fig.1 Double Idlers engage with Open GearFig.2 Single Idler engages with Open Gear

3 finite element analysis of Open gear

In order to improve the calculation efficiency, simplify the gear model. simplify the model and imported it into the Workbench, a complete model of gear pair as shown in figure 3, figure 4 is the final simplified model.

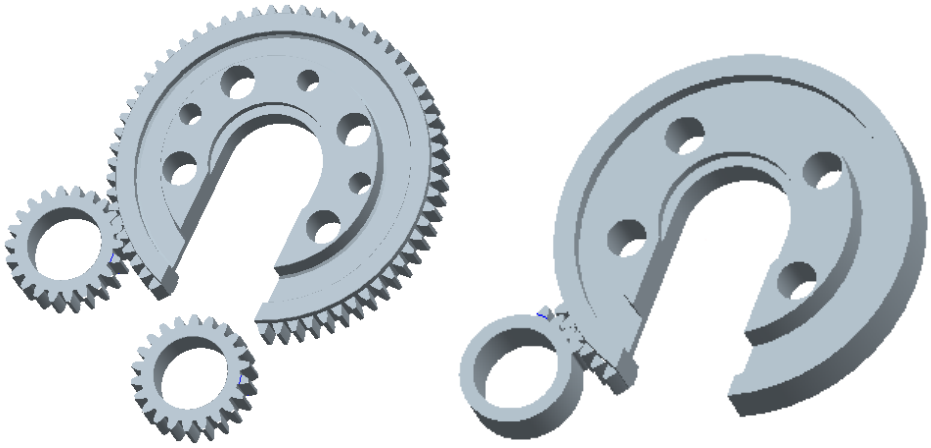

Fig.3 Three-dimensional Model of the Gear pairFig.4 Simplified Model of Gear pair

Open gear and idlers are both spur gears, the parameters as shown in table 1. material of Open gear: 40Cr, σ_s=785MPa, σ_b=980MPa, material of idler: 20CrMnTi、σ_s=835MPa、σ_b=1080MPa[6].

3.1 meshing

Tab.1 Parameterof the Gear

	open gera	idler
module（mm）	10	10
tooth number	66	22
pressure angle（°）	20	20

meshing the gear pair, the overall grid model, a total of 139008 units, 816728 nodes. Finite element mesh model of gear pair as shown in figure 5, figure 6.

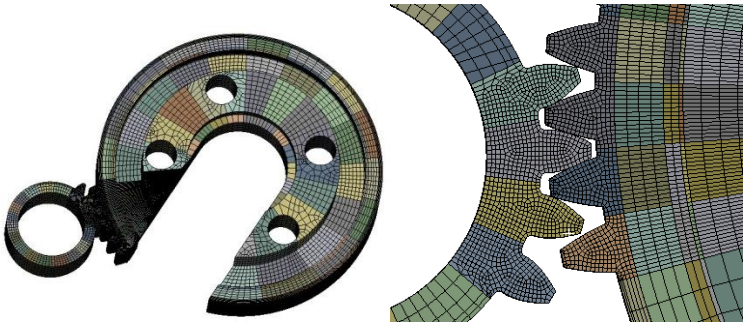

Fig.5 Meshing of the whole modelFig.6Local Mesh Refined

3.2 load and boundary conditions

Hydraulic power tongs in the process of working parameters are shown in table 2. Screw on assignments include four steps: Clamping - fast spinner - closely – string. The torque Hydraulic power tongs in low bit is 75000N.m, Transmission ratio is 3. Therefore, torque applied in the idler is 25000N.m. In the process of analysis, four inner hole of open gear set to full constraints, idler inner hole release ring to the degrees of freedom, and the applied torque.

Tab.2 Parameter of the Hydraulic power tong

Working conditions	parameter
maximum torque in higher gear	5000 N.m
maximum torque in lower gear	75000 N.m
maximum speed in higher gear	40 r/min
maximum speed in lower gear	2.7 r/min

3.3

Solve the gear pair model. Gear pair Mises stress nephogram as shown in figure 7. Maximum stress is 1011MPa. Idler’s Mises stress distribution as shown in figure 8, A larger stress

concentration on tooth root and meetting the requirements. As shown in figure 9, the maximum Mises stress of the open gear is 894.51 MPa, at the tooth root of open gear and meetting the requirements. But, mises stress of open gear and idler in the abnormal conditions are close to the ultimate strength. If workingin abnormal condition for a long time, it will greatly reduce the service life of gears.

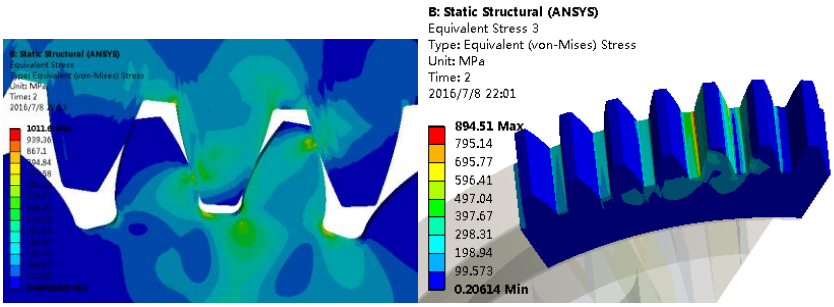

Fig.7 Stress Nephogram of Gear pairFig.8Stress Nephogram of Idler under unusual condition

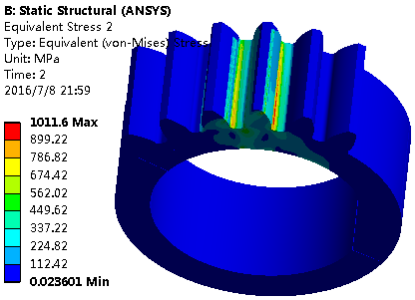

Fig.9 Stress Nephogram of Open Gearunder unusual condition

3.4 the finite element analysis of dual idler

The analysis process as same as open gear working in abnormal condition. The gear stress nephogram is shown in figure 10, The maximum stress is 760 mpa. As shown in figure 11, Stress concentration at the root of idler, and the maximum stress is 538MPa. As shown in figure 12, stress nephogram of open gear, and the maximum stress is 760MPa.

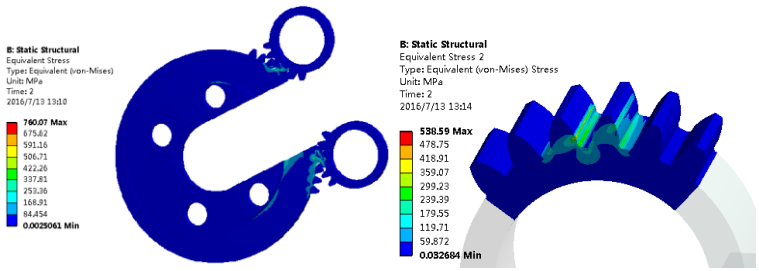

Fig.10 Stress Nephogram of Normal Operating ConditionFig.11Stress Nephogram of Idler under Normal Operating Condition

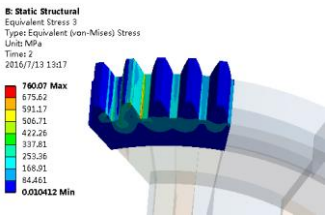

Fig.12 Stress Nephogram of Open Gear under Normal Operating Condition

3.5 the analysis results of two kinds of working conditions is compared

As shown in table 3, is the compared of the analysis results of two kinds of working conditions.

Tab.3 Analyze of the maximum stress of normal and unusual condition

	maximum stress in normal working condition	maximum stress in abnormal condition	stress increment
open gear	760.07MPa	894.51MPa	17.7%
idler	538.59MPa	1011.6MPa	87.8%

Analysis the data in the table, open gear under normal condition and abnormal conditions stress increment is 17.7%. Idler's stress significantly increased, increased by 87.8%.

4 conclusion

Analyzed the hydraulic power tongs in low speed high torque, single idler and double idlermesh to the open gear. The conclusion is as follows:

(1) in Abnormal condition, there is stress concentration in idler tooth root, the maximum stress is 1011.6 MPa. the maximum stress of the open gear is 894.5 MPa, appeared in the root. stress is large in idler and gear.
(2) Open gear under normal condition and abnormal conditions stress increment is 17.7%. the idler's stress significantly increased, increment is 87.8%.
(3) a large stress concentration in open gear root in both kinds of working conditions. increase dedendum arc transition radius should be taken to reduce stress concentration.

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