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The Test System Design and Actual Test of Motor Axis Torque During Seamless Steel Tube Rolling

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Abstract: The gear break fault of reduction box was arisen often because of the motor axis torque amplification during seamless steel tube rolling. So, the motor axis of certain seamless steel tube factory was regarded as research object. The test system of motor axis torque during seamless steel tube rolling was designed. Test position was confirmed. Strain foils, torque track 9000 digital telemetry system and vision digital record device were adopted on the actual test of motor axis torque during seamless steel tube rolling. The strain oscillograms and relative compute results during rolling from the first steel tube to the ninth steel tube were obtained. The full range torque compute formula during actual test was obtained. The actual output torque compute formula was obtained. The relative actual output of mean torque and maximum torque was obtained. The research provides important references base for real time motor axis torque test and effective gear break fault prevention of reduction box during seamless steel tube rolling. *Copyright © 2013 IFSA.*

Keywords: Seamless steel tube rolling, Motor axis torque, Test system design, Digital telemetry system, Actual test.

1. Introduction

Torsional deformation of machine part will be brought under the torque action. Different torque test methods were adopted under different torque conditions. Torque test methods mainly contain equilibrant method, energy conversion method and transmission method. The application of transmission method is the most extensive. Telemetry strain torque test method is one kind of transmission method. Output voltage was sent by radio emission in the method. Because the method is noncontact, slither clutter can not been brought. The method can adapt to various complicated and odious test circumstances.

In recent years, many research works were made by researchers all over the world on motor output axis torque test. A novel indirect measurement method for load torque of asynchronous motor was proposed by Bai Xutao, Wu Fengjiang and Sun Li in Harbin Institute of Technology in 2007 [1]. A measuring system of motor's torque and rotor speed based on virtual instrument was designed by Yu Jiaming and He Ligao in Nanjing University of Aeronautics and Astronautics in 2008 [2]. The testing system of step motors torque based on LabVIEW was researched by Long Huawei, Zhai Chao and Hu Dongqing in University of Science and Technology of China in 2008 [3]. The torque measuring system of hot roller motor was researched by Chen Dong

and Shu Xuesui in Beijing China Textile Electromechanical Equipment Limited Company in 2008 [4]. Indirect detection method for motor torque under consideration of variation of stator resistance was researched by Bu Shupo in Heilongjiang Institute of Science and Technology in 2009 [5]. The study of non-contact torque measurement of rotating shaft was analyzed by Wang Dengquan, Yang Ming and Ye Lin in Shanghai Jiao Tong University in 2010 [6]. Development and application of on-line detector for motor torque was researched by Xiong Jianhua, Wang Mingcai and Feng Enshan in China University of Petroleum in 2010 [7]. The torque measurement research of rolling motor output axis was made by Liu Xuefeng and Xie Fuchun in North China University of Technology in 2012 [8]. Research on on-line torque test system for large motor in active oilfield service was made by Liu Jian, Xiao Wensheng and Chen Ke in China University of Petroleum in 2012 [9]. The motor axis of certain seamless steel tube factory was regarded as research object. The test system of motor axis torque during seamless steel tube rolling was designed. Actual test of motor axis torque during seamless steel tube rolling was made.

2. The Design of Motor Axis Torque Test System during Seamless Steel Tube Rolling

The actual situations of torque test are complicated circumstance, odious circumstance and high speed running equipment. The test system of motor axis torque during seamless steel tube rolling was designed by adopting telemetry strain torque test method. It was shown as Fig. 1. The system mainly contains strain foil, torque track 9000 digital telemetry system and vision digital record device.

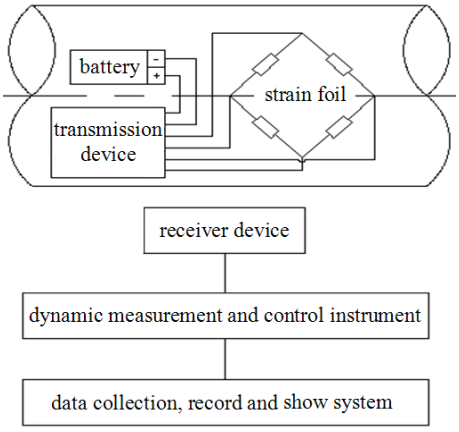

Fig. 1. The test system of motor axis torque during seamless steel tube rolling.

Torque track 9000 digital telemetry system is advanced torque test equipment produced by Binsfeld Engineering Company. The system mainly contains 9 volt battery, transmission, receiver device, dynamic measurement and control instrument and cable. It was shown as Fig. 2. Dynamic measurement and control instrument is the core of torque track 9000 digital telemetry system. It was shown as Fig. 3. Signals can been adjusted, restored, disposed and outputted. The output form is voltage. The output range is 0 Voltage to 10 Voltage. Torque can be tested accurately and conveniently by dynamic measurement and control instrument.

Fig. 2. Torque track 9000 digital telemetry system.

Fig. 3. Dynamic measurement and control instrument.

Vision digital record device is duration and carry convenience data memorizer. The most advanced personal computer technology was adopted. It can provide good data collection, storage and show. It possesses the ability of long time and high speed data storage. Its distinctive two disk structure design can insulate data storage from system disk. Relative fault hazardous of Windows operating system can be eliminated. The best integrity of key user test data can be maintained by its distinctive storage structure. Vision digital record device has two allocations. They are 8 channels and 16 channels. The important parameters such as digital filtering, real time count, working cycle and standard deviations can be provided by digital signal processing chip on every channel. Input adapter can adapt to most normal sensors. Data can be transferred out quickly by vision digital record device for browse, analysis and printing.

3. The Actual Test of Motor Axis Torque during Seamless Steel Tube Rolling

3.1. Test Position Confirmation

Safety coupling was regarded as observation point. The direction faced to reduction box was regarded as forward direction. The measure point positions during actual torque test that is strain foil positions are on the two sides' levels of safety coupling axis respectively. It was shown as Fig. 4.

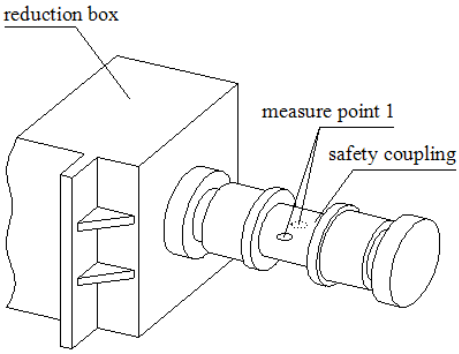

Fig. 4. The measure point positions during actual torque test.

3.2. The Actual Test of Motor Axis Torque during Seamless Steel Tube Rolling

Test equipments must be connected correctly according to test system design before test so as to ensure accurate test. After accomplishing the strain foil bridge construction and the installation and debugging of torque track 9000 digital telemetry system, actual test can be made. Spot strain foil bridge construction and torque telemetry instrument transmission device was shown as Fig. 5.

Fig. 5. Spot strain foil bridge construction and torque telemetry instrument transmission device.

Section channel steel was placed and fixed on ground near torque telemetry instrument transmission device during actual test. Receiver device base was adsorbed on channel steel by magnet to ensure strong wireless signals can be received by receiver device. Wires were connected on receiver device, dynamic measurement and control instrument and vision digital record device respectively. It was shown as Fig. 6.

Fig. 6. Spot connections of receiver device, dynamic measurement and control instrument and vision digital record device.

The record routes and record folders were appointed on record device. Then, seamless steel tube rolling equipment begins work without seamless steel tube rolling. Test was begun meanwhile. So, whether the tested equipment is in normal work condition or not can be observed. It was shown as Fig. 7.

Fig. 7. The test condition of seamless steel tube rolling equipment without seamless steel tube rolling.

It can be judged from the test condition of seamless steel tube rolling equipment without seamless steel tube rolling that strain foil, torque track 9000 digital telemetry system and vision digital record device are all in normal work condition. So, normal torque test can begin. The maximum, minimum and mean of actual output strain shown as

voltages form can be obtained by the data processing function of vision digital record device. Then, relative torques can be calculated according to the torque calculation formulae of dynamic measurement and control instrument. The strain data shown as voltages tested during nine seamless steel tubes rolling were obtained. The strain oscillograms and relative compute results during rolling from the first steel tube to the ninth steel tube were shown as Fig. 8 to Fig. 16 respectively. Channel number that is channel 2, duration, sample quantity, mean, standard deviation, effective value, maximum, minimum and relative time are all listed in compute results.

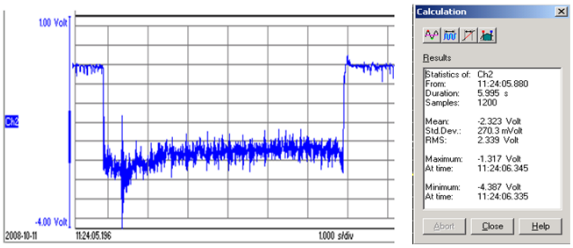

Fig. 8. The strain oscillogram and relative compute results during rolling the 1st steel tube.

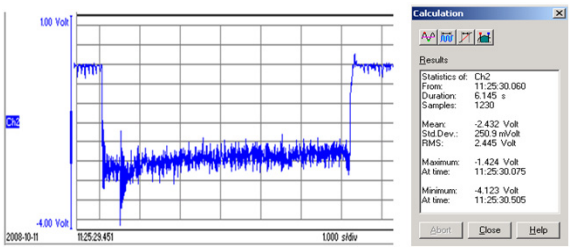

Fig. 9. The strain oscillogram and relative compute results during rolling the 2nd steel tube.

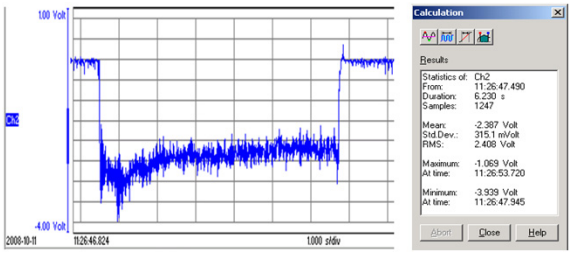

Fig. 10. The strain oscillogram and relative compute results during rolling the 3rd steel tube.

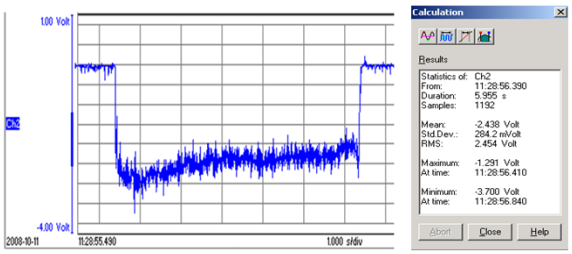

Fig. 11. The strain oscillogram and relative compute results during rolling the 4th steel tube.

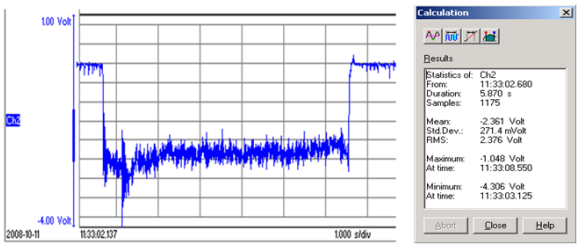

Fig. 12. The strain oscillogram and relative compute results during rolling the 5th steel tube.

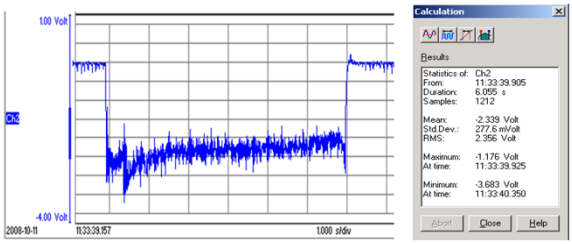

Fig. 13. The strain oscillogram and relative compute results during rolling the 6th steel tube.

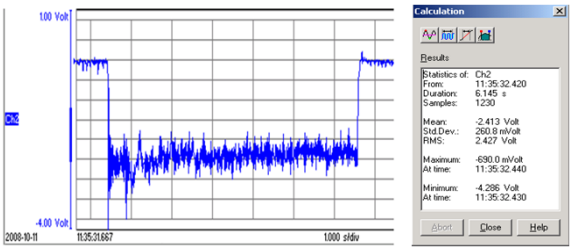

Fig. 14. The strain oscillogram and relative compute results during rolling the 7th steel tube.

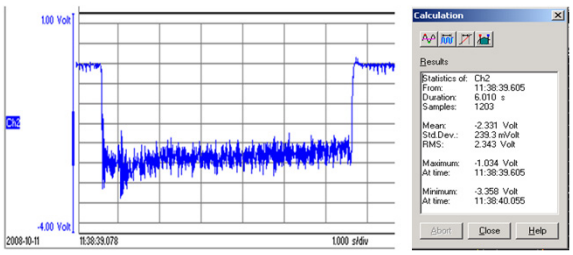

Fig. 15. The strain oscillogram and relative compute results during rolling the 8th steel tube.

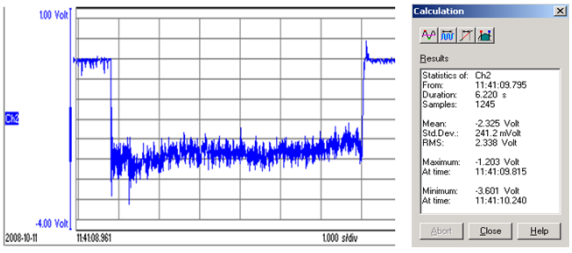

Fig. 16. The strain oscillogram and relative compute results during rolling the 9th steel tube.

The full range torque compute formula during actual test was shown in formula (1):

$$T_{FS} = \frac{4V_{FS}\pi E(D_0^4 - D_i^4)}{V_{EXC} \cdot GF \cdot N \cdot 16000\,(1+\upsilon) \cdot G_{XMT} \cdot D_0}, \quad (1)$$

where T_{FS} is the full range torque; V_{FS} is the maximum system output; E is the material elastic modulus; D_0 is the internal axle diameter; D_i is the external axle diameter; V_{EXC} is the electric bridge voltage; GF is the strain foil sensitivity coefficient; N is the strain foil quantity; υ is the poisson ratio; G_{XMT} is the torque telemetry instrument gain. The actual output torque compute formula during actual test is shown in formula (2).

$$T_e = \frac{V_{output}}{10} \cdot T_{FS}, \quad (2)$$

where T_e is the actual output torque. The actual output torque can be calculated by substituting relative data tested by channel 2 into equation (1) and equation (2). Relative mean torques and maximum torques was shown in Table 1.

Table 1. The actual output of mean torques and maximum torques.

Steel pipe rolling process	Mean torque (kN·m)	Maximum torque (kN·m)
Rolling No. 1 steel pipe	22.5058	42.5052
Rolling No. 2 steel pipe	23.5618	39.9474
Rolling No. 3 steel pipe	23.1258	38.1590
Rolling No. 4 steel pipe	23.6199	35.8494
Rolling No. 5 steel pipe	22.8739	41.7175
Rolling No. 6 steel pipe	22.6608	35.6788
Rolling No. 7 steel pipe	23.5521	35.6788
Rolling No. 8 steel pipe	22.5833	32.5330
Rolling No. 9 steel pipe	22.5251	34.8873

It can be seen from Table 1 that the torque tested during the first steel pipe rolling was maximum. Its value is 42.5052 kN·m.

4. Conclusions

The motor axis of certain seamless steel tube factory was regarded as research object. The test system of motor axis torque during seamless steel tube rolling was designed according to spot actual condition. The constitution and function of torque track 9000 digital telemetry system were elaborated. The features of vision digital record device were elaborated. Test position was confirmed. The actual test of motor axis torque during seamless steel tube rolling was made. The strain oscillograms and relative compute results during rolling from the first steel tube to the ninth steel tube were obtained. The full range torque compute formula during actual test was obtained. The actual output torque compute formula was obtained. The relative actual output of mean torque and maximum torque was obtained. It can be seen from torque compute results that the torque tested during the first steel pipe rolling was maximum. Relative reasons were analyzed. After the first steel tube blank was put out from heating furnace, it was placed for a while. Its temperature reduces. So, the rolling torque becomes bigger during subsequent rolling. The phenomenon will cause serious concussion on relative steel tube rolling equipment. So, steel tube rolling should be made at congruous temperature range so as to reduce rolling torque during rolling.

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