Drive Adaptor Failure Analysis of Hydraulic Torque Wrench Tool – A Review

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Abstract— This paper explains the failure analysis of drive adaptor of hydraulic torque wrench tool used in Minar Hydro System Pvt. Ltd. situated to nearby MIDC. This project work states how the failure taken place and what are the preventive actions to be taken to avoid failure .In this work the CAD model is prepared using Creo software. And the failure analysis is conducted using Ansys software and further preventive action carried out by proper heat treatment process. In this paper the essential factors required for failure analysis of drive adaptor of hydraulic torque wrench are taken into consideration and discussed in brief. This failure of drive adaptor is taken place due to twisting force acting on the end area of drive adaptor during testing of this tool. The Hydraulic torque wrench tools are designed in such a way that it can handle the strong and toughest bolting jobs and machine structure accurately, precisely and quickly as per requirement. Drive adaptor assembled with hydraulic torque wrench tool enabling the operator to quickly switch and operate from tightening to loosening applications using hydraulic power pack system which supplies pressure of about 700 bars.

Key words: Chemical Composition of Steel, Failure Cause, Design, Failure Analysis

I. INTRODUCTION

The ultimate purpose of the failure analysis is entirely positive in order to prevent further failures occurs when some system fails to perform the work up to the expectations for which it was created or developed. Drive adaptor is one of the component part of hydraulic torque wrench which get failed during calibration or testing of tool in in testing machine [1].

This type of failure occurs as because of the twisting force or moment acted on drive adaptor end area and it failed to sustain twisting force or moment supplied by the hydraulic fluid from the hydraulic power pack system through proper medium. Failure of shaft or drive adaptor itself is a human concept where materials do not fail in and of themselves, it follows the laws of nature perfectly as defined. A drive adaptor is loaded beyond its tensile strength and it gets breaks as the maximum stress level is reached at weak concentration point. When any part fails in service, it may under-designed, poorly manufactured or wrongly treated after manufacturing for the circumstances in which it was used.

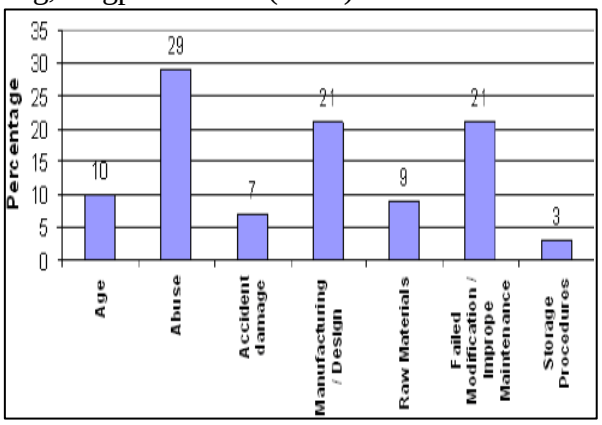

Fig. 1: The Common Causes of Service Failure

Analysing failures for drive adaptor is a process in determining the physical root causes of problems. The failure analysing process is complex, draws upon many different technical disciplines, and this process uses a variety of laboratory techniques, observations and inspections. One of the key factors in properly performing a failure analysis of drive adaptor is keeping an open mind while examining and analysing the evidence to foster a clear, unbiased perspective of the failure of adaptor. Collaboration with experts in other disciplines is required in certain circumstances to integrate the analysis of the evidence with a quantitative understanding of the background information and stressors on the design, manufacture, and service history of the failed drive adaptor or complete system. Well performed, failure product analysis and root cause analysis are critical steps in the overall problem-solving process and are key ingredients and key constituents for correcting and preventing failures of product, achieving higher levels of quality and reliability, and ultimately enhancing customer satisfaction for better service.

A. Material Composition and Comparison:

In this paper the sample of material is tested by ASTM E 415 method for the chemical composition test.

Table I: Comparison of Chemical Composition

Sample Identity		**DMR-1700**	
C %	0.349	C %	0.359
Si %	2.013	Si %	2.00
Mn %	0.467	Mn %	0.512
P %	0.015	P %	0.019
S %	0.007	S %	0.009
Cr %	1.097	Cr %	1.00
Ni %	3.409	Ni %	3.00
Mo %	0.429	Mo %	< 1
Al %	0.015	Al %	0.016
Cu %	0.009	Cu %	0.009

V %	<0.001	V %	<0.002
Nb %	<0.001	Nb %	<0.007
Ti %	<0.006	Ti %	<0.006

Table 1: Comparison of Chemical Composition between Sample Tested and Standard Material [3].

B. Materials Testing and Analysis:

SN	Material Property	Laboratory Values	Industrial Values
1	Yeild Stress	$1530*10^6$ N/m^2	$1560*10^6$ N/m^2
2	Ultimate Stress	$1890*10^6$ N/m^2	$1920*10^6$ N/m^2
3	Elongations	12.6mm	13.4mm
4	Young modulus	200GPa	-
5	Poisons ratio	0.3	-

Table 2: Material Behaviour and Property

C. Static Structural Analysis by ANSYS Software:

Providing turning moment to end of the drive adaptor of an about 9000 Nm gives the result of maximum stress concentration that is up to 835.34*106 N/m2 at the hole area of the drive adaptor.

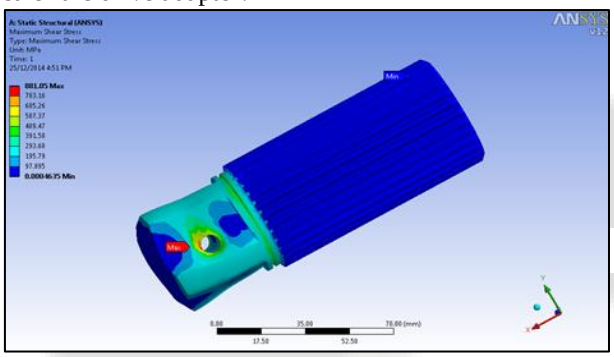

Fig. 2: Static Srtuctural Analysis by Providing Turning Moment to Left End of Adaptor in the ANSYS Software. [2]

D. The Heat Treatment Process for Failure Prevention:

Heat treatment is an operation or combination of operations which involving heating and cooling of metal or alloy in solid state to obtain desirable conditions and properties so that it achieves high physical strength and relieves internal stresses.

Following is the stepwise heat treatment process for the drive adaptor alloyed steel material.

1) Material is placed in the furnace- Drive adaptor which is to be heat treated is placed in the furnace, other than drive adapter material is not acceptable in the furnace.
2) Pre heated at 760°C and Hold for 30 min- As material is placed in the furnace, it is allowed to pre heat at 750 °C and then held at this pre heated temperature before it is being cooled at a controlled rate, considering all parameters of heating the drive adapter as per specification. This pre heated temperature is allowed for an about half hour then after it is allowed to cool at controlled rate. This process is associates with it only partial recrystallization of steel and there is no any phase change occurs with material and the constituents of ferrite and cementite are remains there in structure throughout the process.
3) Hardening at 925°C and hold for 2.5min/mm wall thickness- Hardening is the process of heat treatment of the steel which increases its hardness by quenching or tempering. The drive adaptor material is allowed to heat at 925°C and it is allowed to hold for 2.5 min/mm of wall thickness of drive adaptor.
4) Oil quenching till it gets cooled in the oil tank (Meta-quench 32 oil) until room temperature- Quenching is the process of hardening the steel, in which it is heated at hardening temperature and then allowed to cool at oil or water bath. Here drive adapter after heated at 925°C it is allowed to oil quenched in the oil tank until it achieves room temperature. This process makes steel wear resistant and improves strength toughness and ductility.
5) Tempering at 295°C and holding 5min/mm wall thickness- Tempering is nothing but the process of reheating the material or steel below its critical temperature in order to achieve the final properties of steel. Drive adapter is reheated at 295°C indicating the lower critical temperature and it is hold at this temperature for 5 min/mm of wall thickness.
6) After tempering process is completed drive adaptor is allowed to cool at atmospheric room temperature. This tempering process is applied in order to relieve residual stresses, improve ductility, improve toughness, reduce hardness, and increase percentage elongation.
7) Before checking of resultant hardness of drive adaptor it is required to grind surface of material, it will found that the required hardness of 50-55 HRC is obtained.

E. Furnace for Heat Treatment:

Above heat treatment process is carried out in the furnace shown below. Company person developed their own furnace for heat treatment which has temperature indicator for adjusting temperature.

Fig. 3: Furnace for Heat Treatment of Drive Adaptor [7]

F. Testing Result for Drive Adaptor:

The stepwise heat treated drive adaptor is allowed to test at testing machine in order to check the prescribed capacity of the hydraulic torque wrench that is given as pressure of 700bar and torque of 15000Nm.

Fig. 4: Drive Adaptor Testing Result Showing It Is Tested at 700 bar Pressure

After testing of drive adaptor assembled with the whole hydraulic torque wench tool in the testing machine, the result was found that the drive adaptor abled to work at 700bar and there is no failure found at this pressure.

II. Result and Discussion

The observations taken are concluded that there is no large variation in the chemical composition and the material of drive adaptor is meeting the standard chemical values. Considering the data about yield strength, ultimate strength and elastic limit, the static structural analysis has been made in the ANSYS software. And by correcting heat treatment process for drive adaptor material it is found that the required hardness value of 50-55 HRC is obtained by which material able to sustain maximum stress and torque value and able to work at 700 bar pressure and provide maximum torque of about 14000Nm which is the desired condition for hydraulic torque wrench tool.

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