Redesign of Hydraulic Torque Wrench For Cost Optimization(LP SERIES)

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***Abstract*:-This paper contains the study for optimization of hydraulic torque wrench. The hydraulic torque wrenches are designed to handle the toughest bolting jobs accurately and quickly. In this paper solution for reducing the cost of the tool is carried out. The study was done on low profile series of hydraulic torque wrench.First designing of the wrench was carried out and then the analysis. The low profile hydraulic wrench is advantageous because of its ease in use in low clearance space.The material of the tool selected is EN-24 and Aluminium alloy T6-7075 for its strength and low cost. The other remaining parts of the wrench is stainless steel and structural steel.A 3D model is prepared on INVENTOR 2017 and its analysis is done on ANSYS. Considering the results obtained from the analysis various parts of the wrench where the stresses induced are less compared to others, the part is modified and iterated until satisfactory results were achieved. This process helps in finding the optimized design for the hydraulic torque wrench of low profile without any failure and with minimum forces acting on the tool.**

***Key words*:**Aluminium, Ansys, EN-24, Optimization, torque wrench,

I. INTRODUCTION

A hydraulic torque wrench is a power tool designed to exert torque on a fastener to achieve proper ,better tightening or loosening of a connection through the use of hydraulics. A torque wrench is applied to the nut either directly or in conjunction with an impact socket. Hydraulic torque wrenches apply a predetermined, controlled amount of torque to a properly lubricated fastener. The hydraulic torque wrench was invented by George A. Sturdevant in 1968 in Houston, Texas.

The concept of a hydraulic powered torque wrench was first introduced on the market sometime in the early 1960s in a primitive form, and several key advances have been developed by manufacturers since that time which provided major advancements in the technology and usability of the tools far beyond the original concept tool. Today's tools offer benefits such as lighter weights, smaller nose radius dimensions for fitting into tight spaces, use of exotic alloys, actuation triggers on the tool itself, multi-position reaction members, 360° × 360° hose swivels, and the ability to run multiple tools simultaneously from a single power pack. The main characteristics of a hydraulic torque wrench which set it apart from other powered wrenches of similar function are that:

(1) It must generate torque using only hydraulic means.
(2) It must be self-ratcheting
(3) It must include an accurate method of determining the amount of torque applied.

Some manufacturers utilize a holding pawl design to keep the wrench locked in position prior to each power stroke, others use varying designs, which as in all industries have debatable faults or claimed advantages. Hydraulic torque wrenches typically offer accuracy of ±3% and have a high degree of repeatability making them well suited to applications where large bolts are involved and a high degree of accuracy is required. A hydraulic torque wrench is significantly quieter, lighter weight and more accurate than pneumatic impact wrenches capable of similar torque output, making it an appealing alternative for many users to the very loud and cumbersome impact wrenches or torque multipliers which were formerly the only viable option for working with very large nuts and bolts until the hydraulic torque wrench was introduced.But with hydraulic wrenches, the power source is at the pump, so the wrench itself is able to fit into a much tighter space. When you need a tool that is small and versatile, a hydraulic torque wrench is your choice. Square drive wrenches are widely used due to their versatility and durability. When it comes to torque tools, no other products provide as much torque output with such a limited height tool as low profile hydraulic wrenches. These tools do not require sockets, as the integral cassette link is attached to the piston that goes over the nut or bolt head. Again, these are great tools for situations where other torque tools won't fit.

Low Profile series is the hydraulic torque wrench which vigorously extends in international market. Compared with the square drive hydraulic torque wrench,this series work directly on the nuts,and its body suits well in the narrow space. It can fulfill all different working situations, the operator can change the hexagonal cassette or it can add the reducer to make the low profile hydraulic torque wrench workable at wide ranges.

The main advantage of the low profile series over the square drive series is its low weight and it can fit in low space where working with the square drive wrench is much difficult.

II. DESIGN

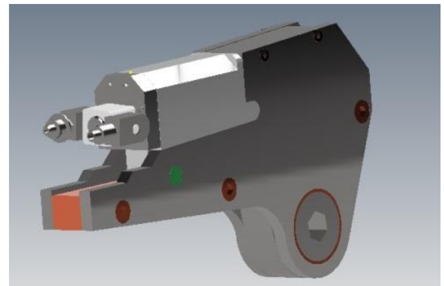


Fig.1

The fig. 1 shows the assembly of the low profile hydraulic torque wrench created in Autodesk Inventor 2017.

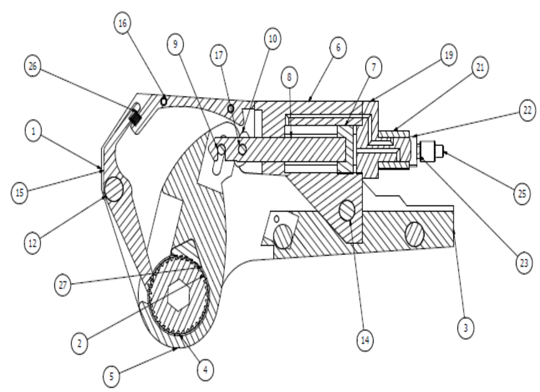
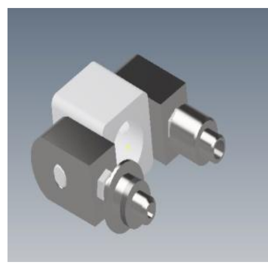


Fig.2 Sectional View of Assembly of Low-Profile Hydraulic Torque Wrench

Fig.2 shows the detailed assembly of a Low Profile Hydraulic Torque Wrench. It consists of a cylinder head(19), a swivel assembly(21,2,23,25) mounted on cylinder head, piston rod(8) and piston head(7) inside the cylinder, a drive plate() connected to the piston via hook, a ratchet(2) with internal hex slot connected to the drive plate(5) via drive pawl(27), bush(4), a stopper(15) to restrict reverse motion of the ratchet, a compression spring (26) attached to the stopper to bring it back to its original position, a compression spring connecting drive pawl to the drive plate, oil rings inside the cylinder sealing it for leak proof. There are two ports in the cylinder, one is inlet for the oil under pressure and other is outlet of oil coming from the pump through the swivel. The swivel is designed so as to provide 360° × 360° rotational hose swivels. The swivel has two different hoses which is mounted on the swivel assembly connecting the two ports of the cylinder. There are two back plates(1) to support the whole assembly and to provide support for reaction. There is a supporter(3) which is placed in between the two plates which provides the necessary rigid support against the hydraulic pressure ranging from 200 bar to 700 bar. The base of cylinder head is also supported by the supporter. There are two bushes inserted in the hole of the two base plates to avoid wear and tear of the ratchet. As shown in the Fig.1, the ratchet is held in between the plates which rotates to give the desired output torque to tight/loose the nut. The central slot of the ratchet is hexagonal in shape which fits on the outer surface of the hexagonal nut which has the same hexagonal shape and size. The hydraulic torque wrench of low-profile series can be used for different sizes of nuts. It can be done by changing the ratchet of the tool. The ratchet comes in different sizes. For LP2 model it comes in sizes from 20mm to 60mm. for larger size of the nut, a higher size tool is preferred. This type of tool offers a great advantage over the manual wrenches which are limited to sizes and the amount of torque achieved by them also varies from person to person.

Fig.3

The working of the tool starts from first resting the tool on the nut or bolt properly, as shown in fig 2. After the tool setup is done, the wrench is started whose swivel is connected to the hydraulic pump which provide the required pressure. The oil under pressure from the pump enters the cylinder through the swivel and the high pressure oil acts on the piston head which pushes it to move forward with high velocity and force. The piston rod is connected to the piston at one end which is inside the cylinder and the other end is connected to the drive plate. The end of the piston has a hook which pushes the drive plate along with itself. The drive plate is connected to the pawl which engages to the ratchet. The forward motion of the piston makes pawl to rotate the ratchet which in turn rotate the nut or bolt. While in reverse motion of the piston which is achieved by pumping of the fluid from the other end on the piston head, the pawl returns back with the drive plate via spring but the reverse motion of the ratchet is restricted by the stopper(15). This prevents the reverse rotation of the nuts and bolts. By giving an exact amount of pressure in the cylinder, an accurate amount of torque is achieved on all nuts and bolts. This accurate torque applied on each nut makes the joint perfect without any gaps in the joint. The drive pawl overcome the possibility of ratchet reversing opposite, enhance the efficiency and precision of torque.



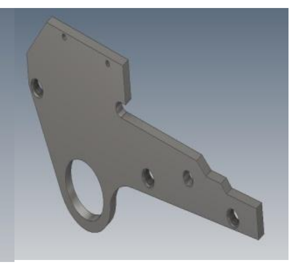
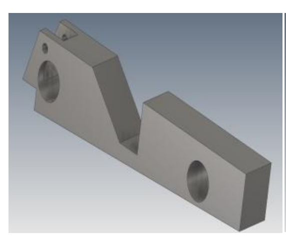


Fig.4 Fig.5

Fig.4 and Fig.5 are the parts designed in Inventor software. The fig.4 is swivel assembly from where oil under pressure is pumped from hydraulic into the cylinder.



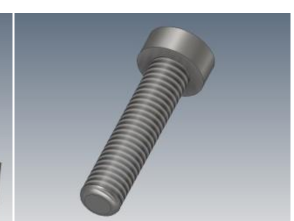


Fig.6 Fig.7

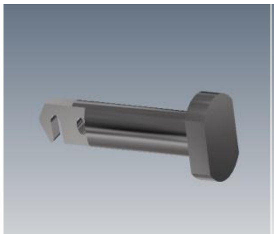


Fig.8

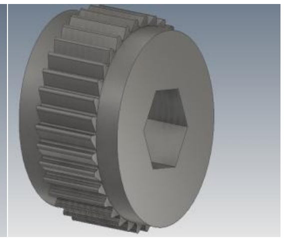


Fig.9

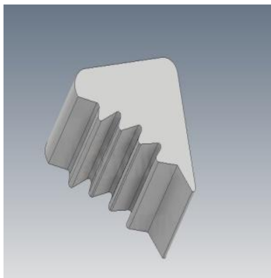


Fig.10

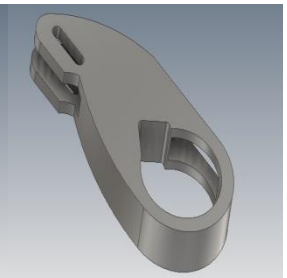


Fig.11

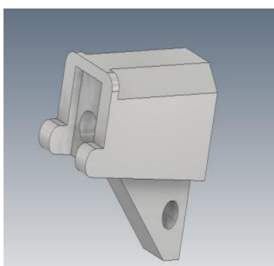


Fig.12

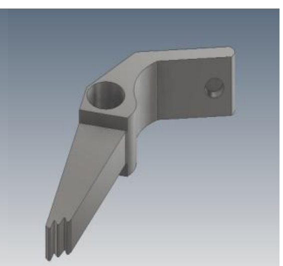


Fig.13

Fig. 4,56.6,7,8,9,10,11,12 and 13 are the parts of a Low Profile Hydraulic Torque Wrench designed on Inventor 2017.Fig.12 is the cylinder head of the tool and fig.13 is the stopper used to prevent reverse rotation of the ratchet.

III. ANALYIS

Table 1 Properties

Part Name	Material	Yield Stress MPa	Young Modulus GPa	Density kg.m^{-3}
SidePlate	SS	207	81	7750
Cylinder	T67075	480	70	2810
Piston	T67075	480	70	2810
Ratchet	EN-24	950	207	7840
Driveplate	EN-24	950	207	7840

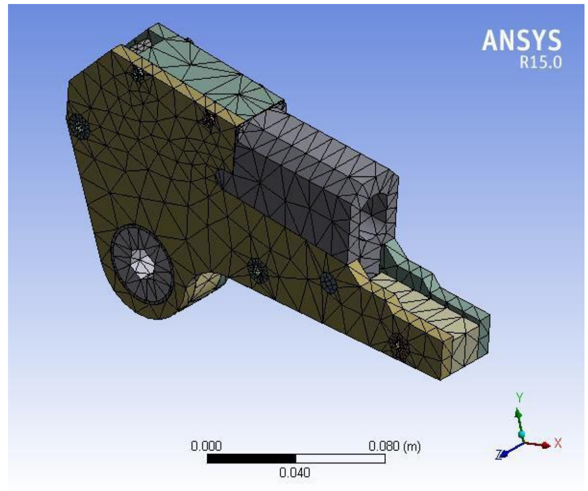


Fig.14 Mesh

The fig.14 shows the meshing of whole model whose analysis is been carried out in ANSYS. Static Analysis is been carried out.

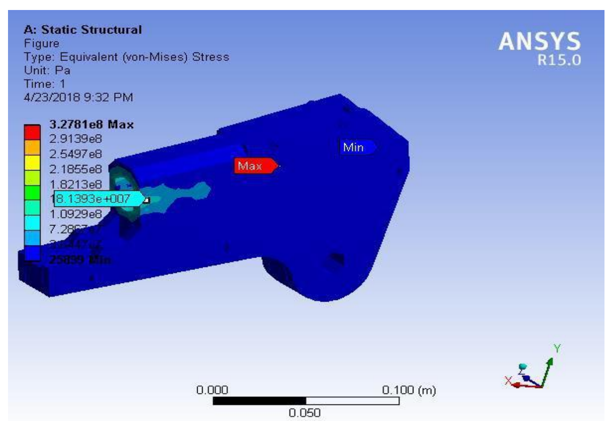


Fig.15 Von-Mises Stress

The results obtained in Von-Mises stress is safe. It show there is only little maximum stress taking place where hydraulic oil pushes the piston forward.

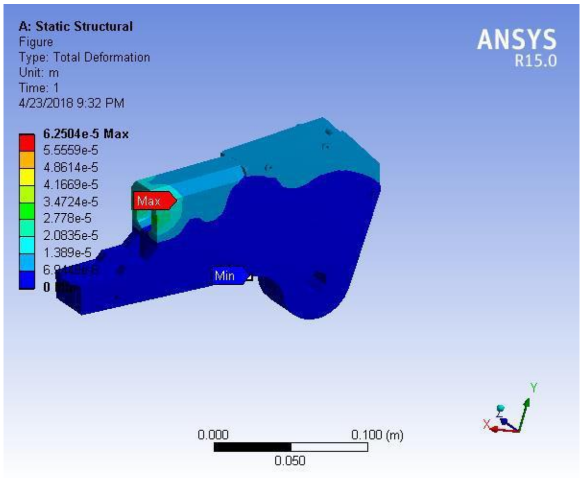


Fig.16 Total Deformation

The above fig.16 shows the total deformation of the tool's body. It shows the maximum deformation is very low which is at the body of cylinder .

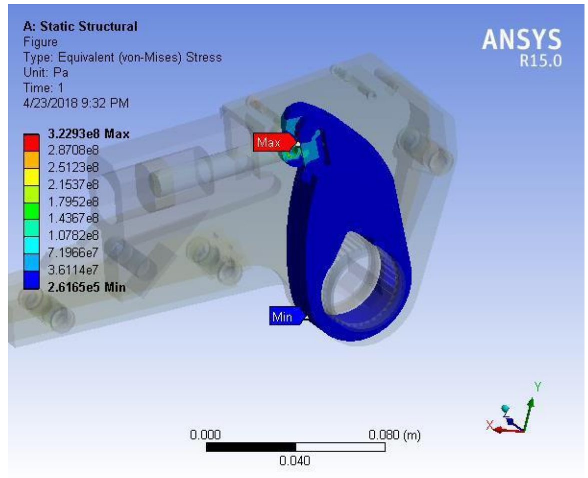


Fig.18

Fog.18 is the stress analysis carried out on the drive plate and also the contacts. It shows the maximum stress at the point where connecting rod is in contact.

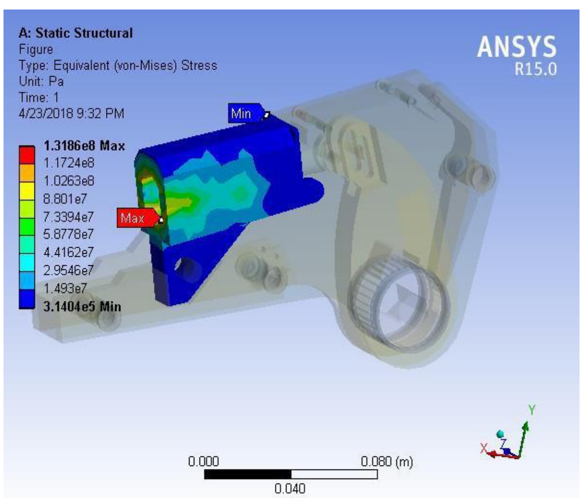


Fig.17

Fig.17 is the result of stress analysis of cylinder head which shows the maximum and minimum stressed region. The maximum occurs where the high pressure is introduced. Thus by maintaining the flow of oil this stress can be minimized.

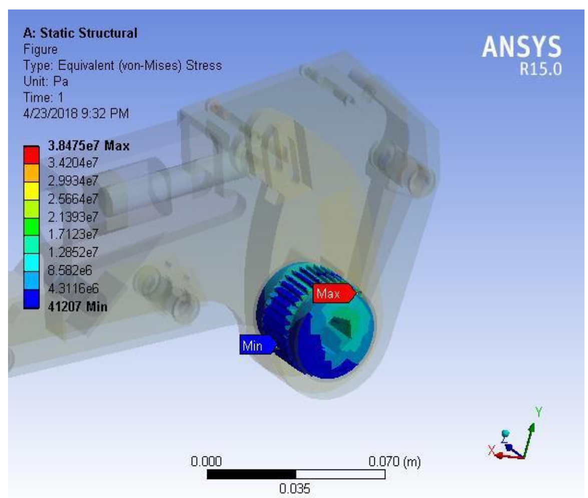


Fig.19

Fig.19 is the stress analysis on the ratchet which is driven by the drive plate. The maximum stress is at point of contact with the stopper. This stress at point of contact can be reduced by providing frictionless contact, thus increasing the life of the part. This helps in optimizing the tool.

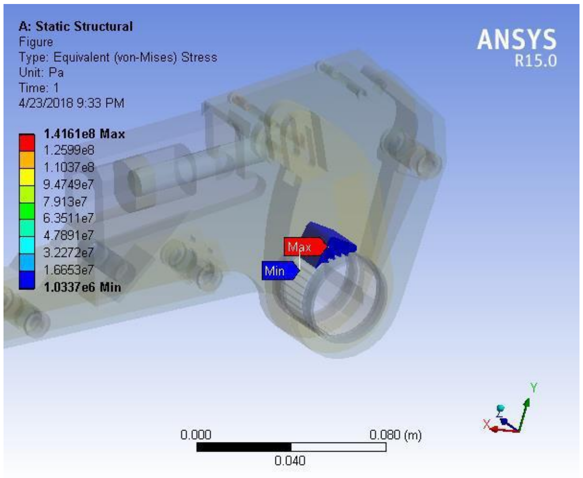


Fig.20

Fig.20 is the Von-Mises Stress analysis on the drive pawl which is the connecting link between drive plate and the ratchet. It receives maximum stress at the point which is in contact with ratchet.

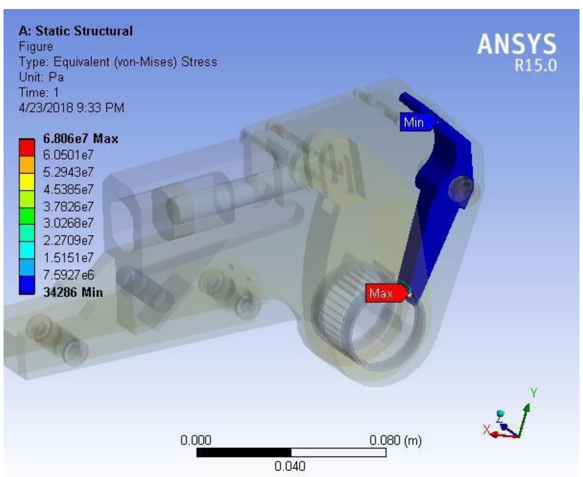


Fig.21

Fig.21 is Von-Mises Stress analysis carried out on the stopper which rests on the ratchet at one point and other point is connected to the spring with the body of the tool. The point which is in contact with the ratchet experiences maximum stress and minimum stress is at the point of spring contact.

IV. CONCLUSION

1. From above results of the analysis from ANSYS it is evident that the proposed design of the tool is safe and can be optimized for cost and performance.
2. The tool cost is reduced by reducing the part material from area where stress concentration is low. As solved above most of the contact region has lower stresses, thus the cost can reduced by reducing the area.
3. The tool can be optimized by reducing the thickness of the side plate since very less forces are acting on it.
4. By introduction of reaction washer, the reaction forces are minimized without using other reaction devices or other additional parts.
5. This helps in optimizing the cost of the tool from its market price.
6. Use of high quality oil rings decreases the chance of any leak and make the tool leak proof.
7. The Low Profile Hydraulic torque wrench is most suitable over a wide range of application because of its low space requirement.
8. Cost optimization of the tool can be carried by taking into consideration the results obtained from the analysis.

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