The Extension Hydraulic Wheel Wrench

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Abstract

Flat tire damage problems on heavy vehicles require a long time and use a lot of labor. This is caused by loosening nut job requires heavy vehicle tires high torque value. The Extension Hydraulic Wheel Wrench is designed to reduce the time and labor in the process of converting heavy vehicle tires. This tool is used in conjunction with a hydraulic jack and tire wrench. This project uses modern approach of analysis and simulation software CATIA V5R20, to estimate the force exerted on the body and acting projects will be built. CATIA V5R20 software used to achieve the study objectives. The results obtained from the simulation are compared with the calculated data collectively. In addition, all solid body constructed usingCATIAV5R20asa pre-requisite before the simulation is made & finally the project is built with high quality material sand tested mild steel usage. The project is in accordance with various environment, climate & fulfill safety features as well as smoothing the heavy transport-industry.

Keywords: *CATIA V5R20, Wheel Rench.*

1.0 Introduction

Malaysia's vibrant economy and fast-moving lifestyle have resulted in an increase in the demand for transportation. The transportation industry includes the transportation of people and goods. Thrust Four of the Ninth Malaysian Plan states the Government's intentions to improve the standard and quality of life. The government undertakes to increase the efficiency and reliability of infrastructure facilities and services to support trade and business activities. Heavy vehicle is an important transportation industries especially light truck and heavy truck or cargo truck for transmit. Normally the tires were a vital component of a vehicle. Each vehicle requires the tire no matter heavy vehicle and light vehicle. Function tire for vehicles is changing and maintenance direction of travel, absorbing road shocks, supporting vehicle weight and transferring traction and braking forces to the road surface. Commercial tires are used on thousands of heavy trucks that travel the nation's highways and road. Tire wear is influenced by factors such as tire pressure, heat, mechanical issues and road conditions.

Furthermore breakdown cases, flat tire problems outside the area the workshop and require the changing the wheel. Changing a large truck wheel is more difficult than changing out a car wheel due to the size and weight of the wheel. For changing the wheel require loosening and remove the lug nut. Therefore to loosen the lug nut with lug wrench or wheel wrench requires more than manpower and take a long time. With such awareness to the necessity hydraulic extension lug wrench for reduce the problems encountered for the loosening lug nut in commonly with lug wrench

1.1 Statement of the Problem

From the point of applied sciences there is friction between the tires and surface of the road generally, it will wear the surface of the tire and causes damage to the tire. Tire wear is influenced by factors such as tire pressure, heat, mechanical issues and road conditions. Though any vehicle can experience tire problems and especially flat tire cases. Of this problem causing it should changing the wheel and a heavy vehicle typically have spare wheel. In the process of changing a heavy vehicle wheel will typically employing more than one man's power and time consuming.

To remove the flat tire should remove or loosening the lug nut and are generally harder to loosen. Most threaded fastener should be tightened to specific torque value. For the specification torque lug wheel heavy vehicle is an around 650Nm and require much force to loosening and tightening the lug nut.

1.2 Objectives

The objectives of the design are:

i. To facilitate the process loosening and tightening of heavy vehicle wheel flat tire breakdown case.
ii. To reducing man power and time.
iii. Identifying design with CAD and CAE with CATIA V5R20.
iv. Applications the Right Hand Ruler theory to loosening and tightening with the extension hydraulic wheel wrench, hydraulic jack bottle and breaker bar.

1.3 Literature Review

Relationship the extension hydraulic wheel wrench with modern or common using in loosening and tightening is very close. Usually force and torque require for loosening and tightening the nut and screw. For lug nut many wrench can doing the loosening and tightening using man power to produce the force or power tool be related fluid power. Fluid power as air and fluid or electrical energy to produce torque energy. Lug wrenchor a socket wrench used to turn lug nuts on automobile wheels.

For lug wrench or wheel wrench heavy vehicle different light vehicle as strength, material and size socket. Furthermore the lug nut for heavy vehicle extremely built tough because “torque value” (torque is the twisting force applied to a threaded component such a bolt or nut) for lug nut around 450Nm to 600Nm. Generally, human power cannot produce against the torque value lug nut heavy vehicle. Excluding lug wrench connection with long hollow pipe and more than one human power. These process harm or weary to human and taken a time.

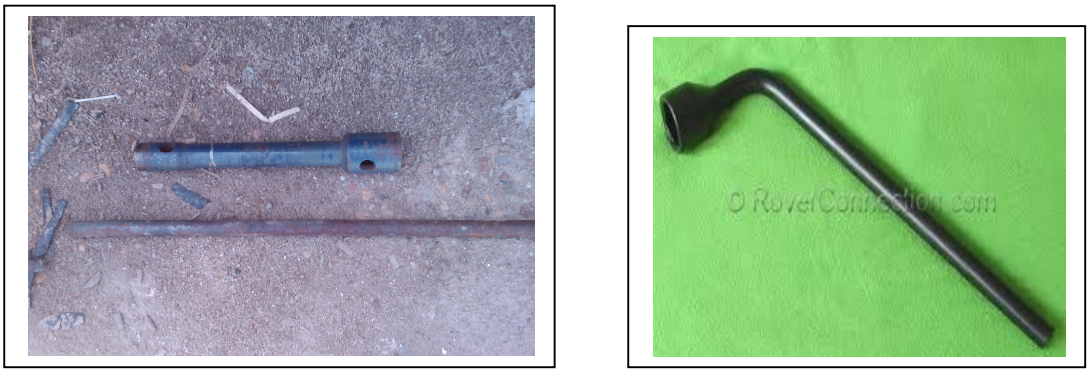


Figure 1.1 : Lug wrench heavy vehicle& light vehicle (left right)

Using a fully man power for produce a force and use hollow pipe to give more torque for loosening and tightening the nut. Usually this principle is complicated and harm. This is traditional skill to loosening and tightening the nut.

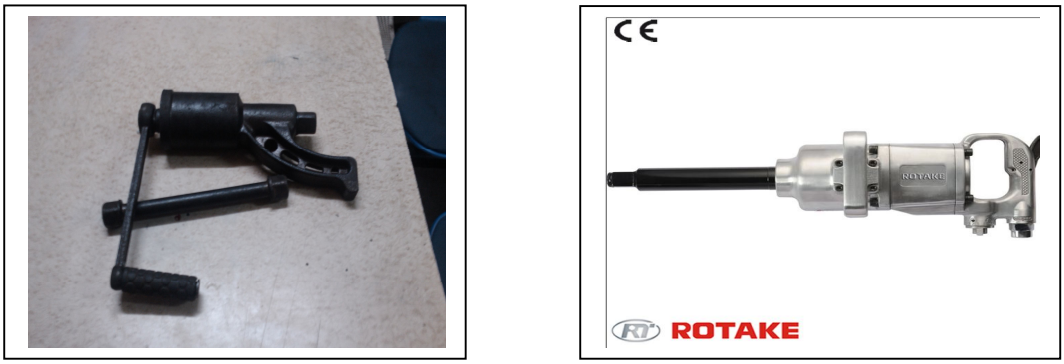


Figure 1.2: Rotary Wrench & Pneumatic Toque Air Wrench (left right)

Rotary wrench designed with its own internal gear. Purpose of this tool is to do the work loosen the nuts by turning the crank tool. The gear is easy to failure and using human power. A spindle rotate given the force and external gear produce more torque to rotating the socket wrench or nut. The spurs gear built in rotary wrench own ratio for more force and torque. Furthermore the rotary wrench own debility because require man power to rotate a spindle. Sometimes is difficulty for to turn the spindle.

The pneumatic torque wrench is sometimes confused with a standard impact wrench, because it looks similar, but is actually a totally different tool. A pneumatic torque wrench is driven by continuous gearing, and not by the Hammers of an impacting wrench. This is why a pneumatic torque wrench has very little vibration, and excellent repeatability and accuracy. Torque capabilities of pneumatic torque wrenches range from 118Nm, up to a maximum of 47,600Nm.Using pneumatic torque wrench is a limited power in the workshop alone in doing work to loosen and tighten the nut. Air compression for this operation is on 10 Bar and built in jack hammer. Require two stage air compression for operation because air compression for pneumatic require high air pressure. The pneumatic torque wrench cannot using for breakdown case because require air compressed as power source.

2.0 Methodology

As mentioned before, this project will only manufacturing the design and focus on 2D rather than 3D simulation. The 3D simulation all necessary requirements for design the extension hydraulic wrench. Thus, for this proposal, there will be simulation on modeling the extension hydraulic wrench. In fact, this project barely took out the 3D and run the simulation to analysis the extension hydraulic wheel wrench. Hence, in this chapter, the proposal will guide and show for various applications on how power tool, lathe machine ,hand tool, SMAW, Oxy Acetylene Cutter, measuring tool and CATIA V5R20 work to solve flow over a body step by step. This is very significant for a beginner to develop their understanding about CATIA V5R20, power tool, lathe machine ,hand tool, SMAW, Oxy Acetylene Cutter and measuring tool since this problem will requires a basic concept regarding using the tool for manufacturing. In fact, the problems also will provide principal information on using the tool for design and manufacturing an extension hydraulic wheel wrench.

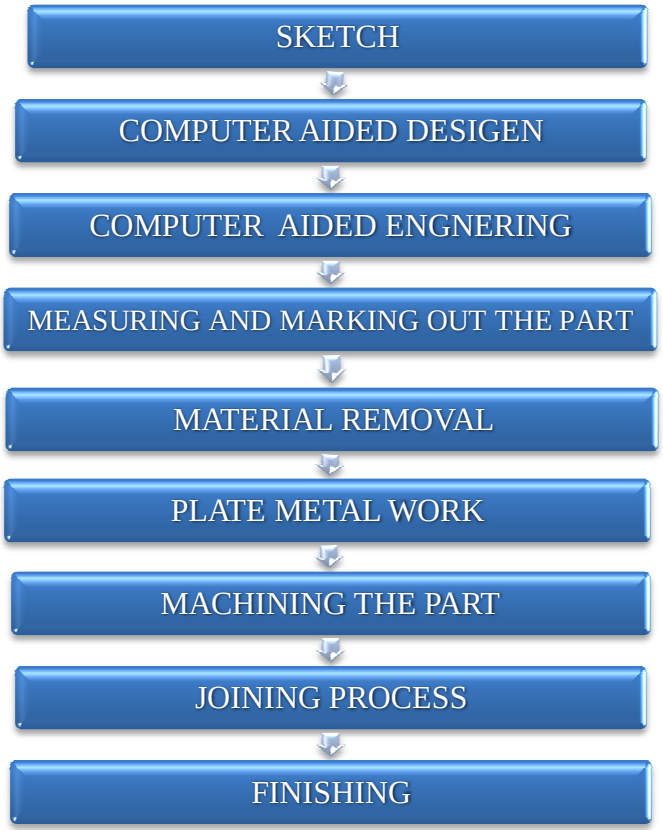


Figure 2.1: The methodology flowchart for method design and manufacturing

In this project, development the extension hydraulic wheel wrench must conscientious from mechanical engineering science and ergonomic for consumer. The source for design these project must approve and relevant.

Furthermore these project, development and research require from time to time for become better function. For these project, knowledge and development base from. In the manner, for design and manufacturing the extension hydraulic wheel wrench is base on engineering knowledge and using assistant computer programming. Many assistant computer programming for design and simulation something related engineering design because to more accurate and planning for design the product to effective.

Generally the method for design and manufacturing the extension hydraulic wheel wrench need a planning for reduction of leads time.

2.1 Procedures

Computer-aided engineering (CAE) is the broad usage of computer software to aid in engineering tasks. In general, there are three phases in any computer-aided engineering task:

- Pre-processing – defining the model and environmental factors to be applied to it. (typically a finite element model, and thin sheet methods are also used)
- Analysis solver (usually performed on high powered computers)
- Post-processing of results (using visualization tools)

CAE areas covered include:

- Stress analysis on components and assemblies using FEA (Finite Element Analysis);
- Thermal and fluid flow analysis Computational fluid dynamics (CFD);
- Multibody dynamics (MBD) & Kinematics;
- Analysis tools for process simulation for operations such as casting, molding, and die press forming.
- Optimization of the product or process.
- Safety analysis of postulate

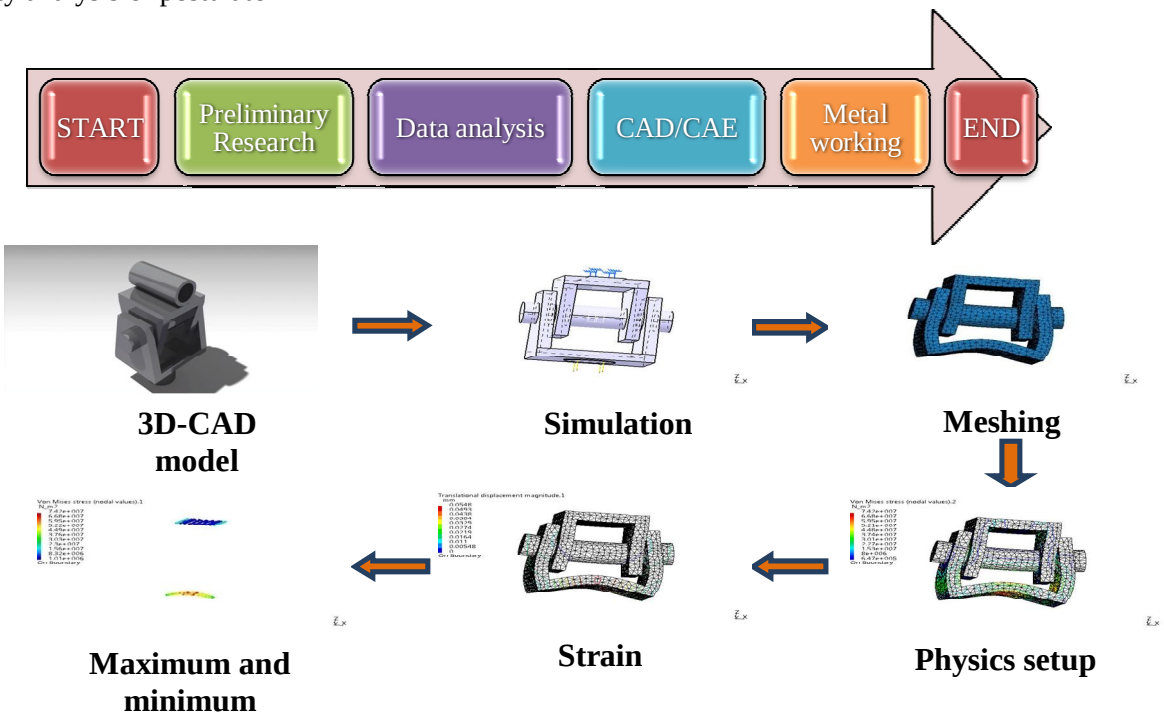


Figure 2.2: Project Analysis Procedure

3.0 Findings and Discussion

3.1 Findings

Most thread fastener such as wheel nut, screw or bolt and nut should be tightened specific torque value. For heavy vehicle wheel nut the torque value and specific to show schedule below.

For M 22 size data:

Pitch, P(mm)	Pitch diameterd2(mm)	Effective area As(mm²)	Minor area d1 (mm)	Lead angle Tanβ
2.5	20.376	303	19.294	0.0391

3.1.1 Relation formula between nut and torque value.

$F = T / (d2/2 (\mu/ \cos \alpha + \tan\beta) + \mu n * dn/2)$

a. F: Force (N)
b. T: Torque (Nm)
c. d2: Pitch diameter (mm)
d. μ :Friction coefficient of threaded portion
e. cos α : Half angle of screw threaded (ISO screw 30 degree)
f. β : Lead angle (degree)
g. μn : Friction coefficient of bearing portion
h. dn :Pitch diameter of bearing surface(mm)

Formula torque value M22 to gain force *F.*

$F = T / (d2/2 (\mu/ \cos \alpha + \tan\beta) + \mu n * dn/2)$

$\{ [20.376/2\{ (0.15/ \cos 30) + 0.0391\}] + [0.15 (31.22/2)] \}/1000$

$= 4.5045e -3$ m

$= 450Nm / 4.5045e -3$ m

= **100,000 N**

Summary the calculation torque value M22 nut resulting require more force 100,000N to loosening the nut and tightening. The torque value is a 450Nm only and for maximum torque value for M22 normally around 500Nm.

Process design the extension with computer software such as CATIAV5R20 is more effective to planning manufacturing the extension hydraulic wheel wrench. Therefore for analysis and simulation CAE analysis application and including conceptualization design CAD to visualization solutions to create, modify, and validate complex innovative shapes, from subdivision. Usually analysis and simulation with CATIA V5R20 have report or summary. Below this report:

Analysis

Mesh:

Entity	Size
Nodes	6807
Elements	26287

Element Type:

Connectivity	Statistics
TE4	26287 (100.00%)

Element Quality:

Criterion	Good	Poor	Bad	Worst	Average
Stretch	26287 (100.00%)	0 (0.00%)	0 (0.00%)	0.428	0.672
Aspect Ratio	25981 (98.84%)	306 (1.16%)	0 (0.00%)	3.359	1.758

Materials.1

Material	mild Steel
Young's modulus	2e+011N_m2
Poisson's ratio	0.303
Density	7860kg_m3
Coefficient of thermal expansion	1.17e-005_Kdeg
Yield strength	2.48e+008N_m2

Static Case

Boundary Conditions

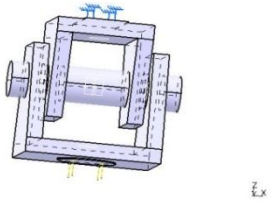


Figure 3.1: Boundary Conditions

STRUCTURE Computation

Number of nodes	:	6807
Number of elements	:	26287
Number of D.O.F.	:	20421
Number of Contact relations	:	0
Number of Kinematic relations	:	0
Linear tetrahedron	:	26287

RESTRAINT Computation

Name: Restraints.1
Number of S.P.C : 453

LOAD Computation

Name: Loads.1

Applied load resultant:

Fx = 9 . 519e-013 N
Fy = 2 . 632e-012 N
Fz = 2 . 000e+004 N
Mx = -2 . 332e-007 Nxm
My = 2 . 178e-007 Nxm
Mz = 5 . 004e-016 Nxm

STIFFNESS Computation

Number of lines	:	20421
Number of coefficients	:	373491
Number of blocks	:	1
Maximum number of coefficients per bloc	:	373491
Total matrix size	:	4 . 35 Mb

SINGULARITY Computation

Restraint: Restraints.1

Number of local singularities : 0
Number of singularities in translation : 0
Number of singularities in rotation : 0
Generated constraint type : MPC

CONSTRAINT Computation

Restraint: Restraints.1

Number of constraints : 453
Number of coefficients : 0
Number of factorized constraints : 453
Number of coefficients : 0
Number of deferred constraints : 0

FACTORIZED Computation

Method : SPARSE
Number of factorized degrees : 19968
Number of super nodes : 2233
Number of overhead indices : 120582
Number of coefficients : 3255108
Maximum front width : 780
Maximum front size : 304590
Size of the factorized matrix (Mb) : 24 . 8345
Number of blocks : 4
Number of Mflops for factorization : 1 . 204e+003
Number of Mflops for solve : 1 . 312e+001
Minimum relative pivot : 4 . 312e-002

Minimum and maximum pivot

Value	Dof	Node	x (mm)	y (mm)	z (mm)
1.7254e+008	Ty	235	-5.2000e+001	3.5659e+001	-2.6849e+001
5.4895e+009	Tx	3944	3.3423e+001	-5.0030e+000	3.9017e+001

Minimum pivot

Value	Dof	Node	x (mm)	y (mm)	z (mm)
1.8532e+008	Ty	4559	3.5000e+001	1.5000e+001	1.0000e+001
1.8880e+008	Ty	2452	4.0000e+001	1.9761e+001	-4.5394e+001
2.0104e+008	Tz	235	-5.2000e+001	3.5659e+001	-2.6849e+001
2.0203e+008	Ty	4389	-4.4568e+001	2.3286e+001	1.9920e+001
2.1113e+008	Tz	2452	4.0000e+001	1.9761e+001	-4.5394e+001
2.1206e+008	Tz	4389	-4.4568e+001	2.3286e+001	1.9920e+001
2.1378e+008	Tz	4559	3.5000e+001	1.5000e+001	1.0000e+001
2.1472e+008	Ty	2729	-3.7000e+001	1.1036e+001	4.0877e+001
2.1922e+008	Ty	855	2.5000e+001	-1.4635e+001	4.0000e+001

Translational pivot distribution

Value	Percentage
10.E8 --> 10.E9	1.0797e+001
10.E9 --> 10.E10	8.9203e+001

DIRECT METHOD Computation

Name: Static Case Solution.1
Restraint: Restraints.1
Load: Loads.1
Strain Energy : 4.953e-001 J

Equilibrium

Components	Applied Forces	Reactions	Residual	Relative Magnitude Error
Fx (N)	9.5192e-013	7.9915e-011	8.0867e-011	1.1403e-013
Fy (N)	2.6320e-012	2.7655e-010	2.7918e-010	3.9367e-013
Fz (N)	2.0000e+004	-2.0000e+004	-1.0077e-009	1.4210e-012
Mx (Nxm)	-2.3325e-007	2.3327e-007	2.2261e-011	4.8292e-013
My (Nxm)	2.1781e-007	-2.1782e-007	-1.0566e-011	2.2922e-013
Mz (Nxm)	5.0042e-016	-3.3408e-012	-3.3403e-012	7.2465e-014

Static Case Solution.1 - Deformed mesh.2

Figure 3.2: On deformed mesh ---- On boundary ---- Over all the model

Static Case Solution.1 - Von Mises stress (nodal values).2

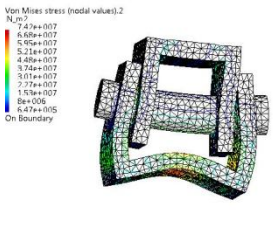


Figure 3.3: 3D elements: Components: : AllOn deformed mesh ---- On boundary ---- Over all the model

Static Case Solution.1 - Deformed mesh.1

Figure 3.4: On deformed mesh ---- On boundary ---- Over all the model

Static Case Solution.1 - Translational displacement magnitude.1

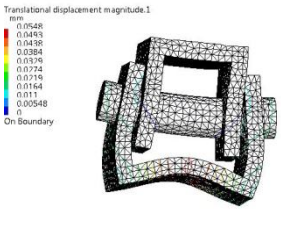


Figure 3.5: 3D elements: : Components: : AllOn deformed mesh ---- On boundary ---- Over all the model

Static Case Solution.1 - Von Mises stress (nodal values).1

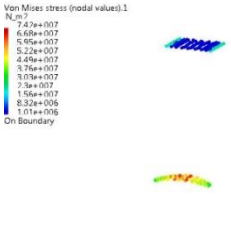


Figure 3.6: 3D elements: : Components: : AllOn deformed mesh ---- On boundary ---- Over local selections:---- Clamp.1---- Distributed Force.1

Static Case Solution.1 - Stress principal tensor component (nodal values).1

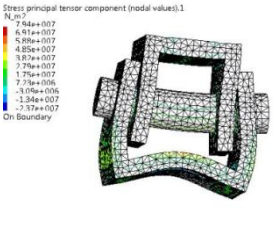


Figure 3.7: 3D elements: : Components: : C11On deformed mesh ---- On boundary ---- Over all the model

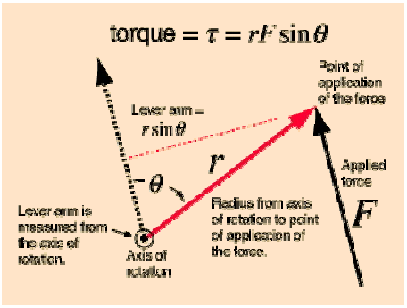
Global Sensors

Sensor Name	Sensor Value
Energy	0.495J

3.3 Discussions

3.3.1 Torque value and Right Hand Ruler

Standard torque to M22 1.8 T Series is 500Nm, for axial tension arrange 113600 N. Maximum axial tension 162500N and minimum axial tension 87400N. Axial stress means a stress that tends to change the length of a body. Generally the wheel nut the heavy vehicle is around 500Nm equal to axial tension **111000N**. For these loosening wheel nut using the extension hydraulic wheel wrench with hydraulic jack bottle and with breaker bar related formula Torque calculation:



In the diagram, the angle is the angle <= 180 degrees between the r and F vectors when they are drawn from the same origin. The direction of the torque is given be the right hand rule, which gives a vector out toward the reader in this case. Note that the torque is maximum when the angle is 90 degrees. A practical way to calculate the magnitude of the torque is to first determine the lever arm and then multiply it times the applied force. The lever arm is the perpendicular distance from the axis of rotation to the line of action of the force. If a force of magnitude F =N is applied at a distance r = m from the axis of rotation. In an orientation where r makes the angle θ = degrees, with respect to the line of action of the force. Then the lever arm = m. The magnitude of the torque is τ = N m.

Force applied that means jack bottle and lever arm that means breaker bar. The lever arm is defined as the perpendicular distance from the axis of rotation to the line of action of the force. Below calculation for torque value related Force applied x lever arm. A torque is an influence which tends to change the rotational motion of an object.

(Torque)N m= Force applied x lever arm
=9810 x 0.3048(sin10 degree)
=520Nm

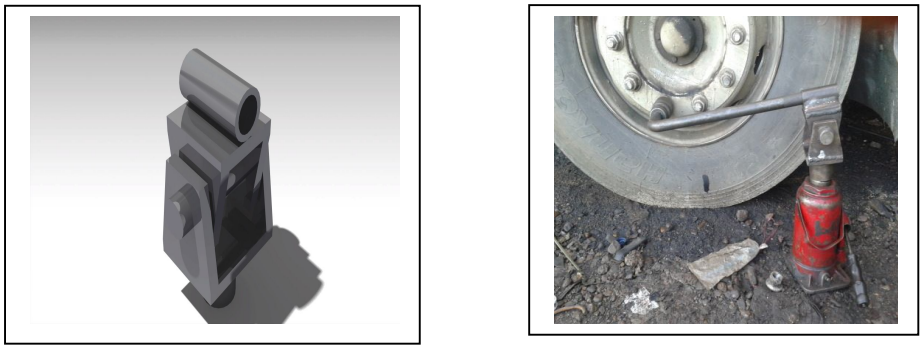


Figure 3.8: Extension Hydraulic Wheel Wrench

4.0 Conclusion

The possibility of a theory right hand ruler on app in the extension hydraulic wheel wrench has been proved too. With the nowadays technology computer software as CAD/CAE for geometry the 3D body, analysis and simulation the design to saving the time, cost and planning with the accurate. The extensions hydraulic wheel wrench to reduce manpower and saving time to loosening wheel nut heavy vehicle with hydraulic jack bottle and breaker bar when the heavy vehicle breakdown case because flat tire problem. FEA or finite element analysis method rapidly grew as the most useful numerical analysis tool for designer. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

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6.0 References

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