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Adaptive undivided wheel opener

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Abstract:*Adaptive undivided wheel opener is a special purpose tool used to tighten and loosen all the nuts of wheel at the same time with less effort. It uses bevel gear assembly for transmitting torque to the nuts and lock – nut arrangement have been used to make the system adjustable to the required pitch length. The most desired advantage is that the total time consumed in the process is very less. It can open and refit the wheel with same tool. Tool is simple in design and easily portable along with vehicle.*

Keywords: Adaptive, Bevel gear assembly, Lock and Nut, Assembling and Dismantling.

1. Introduction

In a day-to-day life there are many problems where there is a need of lot of effort and time to do that specific work. It is always important that our work should be easy and fast. But easy and fast working requires some technical skills to work efficiently and properly .A little but important work that all people would do often is opening a wheel of a vehicle. It is a fact that a huge effort is required to open a single nut of a car wheel and it will become a tedious task to open the wheel in extreme atmospheric conditions. It also creates problem when there is an emergency situation.Here is the solution to the problem mentioned above by "Adaptive Undivided Wheel Opener", it is a special tool designed for opening a wheel with ease. It is so designed that it can open all the four nuts of a wheel in one time. Also it can be used in assembly line of automobiles, garages, workshops and service stations

2. Literature reviews

Car manufacturers specify a proper tightening level, a torque value expressed in foot-pounds, for every fastener on your car. Torque is a rotational force applied around a point or, in this case, a nut. Put a 1-foot-long wrench on a nut and apply 10 pounds of force to the opposite end. You're now twisting that nut with 10 ft-lb (distance times force, or 1 foot times 10 pounds). Use a 2-foot-long wrench and apply 50 pounds of force, and you'll have 100 ft-lb, which, happily, is just about as long as most lug wrenches, and as much force as most elbows are happy cranking on.

fastener fall within a fairly narrow range. Too loose and there's the danger of the nut or bolt spontaneously unscrewing down the road. Or maybe the gasket or O-ring fitting clamped by that bolt will leak. Too tight and there are other risks: The bolted-together part may be compressed, bent or otherwise damaged. The bolt shank could break, or the threads may strip, providing no clamping force at all. The best way to tighten fasteners is with a device called a torque wrench.

Also, the proper torque value takes into account the friction between the threads, which is the single biggest variable that affects the relationship between the torque applied to the bolt head and the clamping force. Friction arises from the threads as well as the rotating bolt face scrubbing along the stationary work piece. Overcoming friction can account for as little as a few percent or as much as 50 percent of the force needed while tightening a nut or bolt. And that means that the clamping force can vary widely—not well when you're installing a cylinder head or an intake manifold.

3. List of Components Used:

3.1 Bevel gears

Bevel gears are used to transmit power between the shafts whose axes are perpendicular to each otherThe structure of bevel gear is similar to an uniformly serrated frustum of a cone In bevel gear, teeth are cut on conical surface in contrast with spur and helical gear for where the teeth are cut on cylindrical surfacesBevel gears are classified in to straight teeth bevel gears and spiral bevel gears based on the structure of teeth. In this method straight teeth bevel gears are used

3.2.Shafts

Shafts are rotating machine element used to transmit power. Drive shaft are used for transmitting torque which is used in this method.Shafts are usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produce power to a machine which absorbs powerHallow shafts are used in A.U.W.O consisting of main shaft and a auxiliary shaft

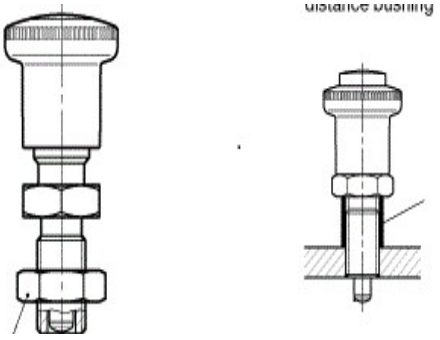
3.3 Bearings

A bearing is a machine element that constraints relative motion to only the desired motion, and reduces friction between moving parts. Ball bearing and roller bearing are two commonly used bearings based on their applications. In this method ballbearings

are used to obtain the desired motion. Bearings hold rotating component such as shafts or axles within mechanical systems

3.4 Lock-Nut

Locknut is a nut that resists loosening under vibration and torque. In A.U.W.O lock nut are used to lock shaft at desired position for various pitch length of wheel.Locknut makes the unified wheel opener system adjustable.



3.5Base plate

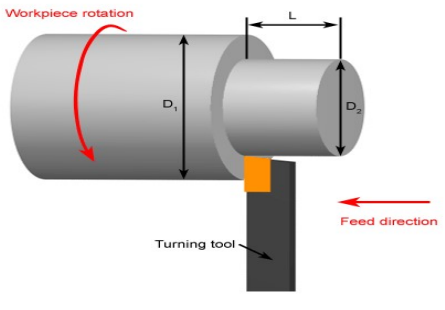
Base plate is made of mild steel.All the components are mounted on the base plate , it act as a support for bevel gear assembly.Base plate of 260mm diameter is used in this method.

3.6L clamp

L clamp is made of mild steel. It is used to hold the bevel gear and pinion in perpendicular position. It slides over the base plate and can be locked to certain pitch length.

3.7SOCKET SPANNERS

The Socket head of spanner covers the nut/bolt of required size completely. The other end consist of a sized cavity through which torque can be applied. Socket spanner differs from box spanner that it doesn't contains Tommy bar for applying force. M12 socket spanner is used in this method



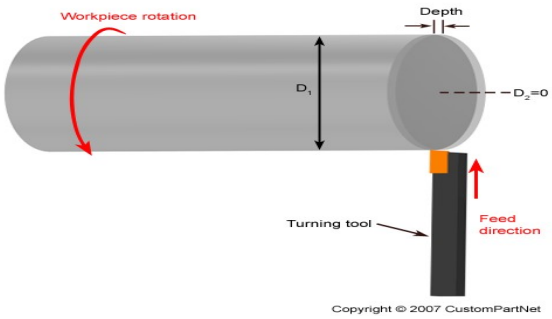
3.8BOLTS AND NUTS

Nuts and bolts are used to connect various component as per the requirements. Nuts and Bolts are fixed in a manner in which it won't disturb or constrain the motion.In this tool, nuts and bolts act as a wheel nuts of car of required dimensions mounted on a separate base plate.

4.Fabrication Process

4.1 Facing

An operation performed on a lathe that feeds a single- point tool into the end of a cylindrical work piece to reduce the length of the work piece. Shaft which is of length 220mm is cut into four equal pieces and so each shaft would be of length 55mm. Further each of this shaft, 5mm is reduced and is done through facing operations



4.2 Turning

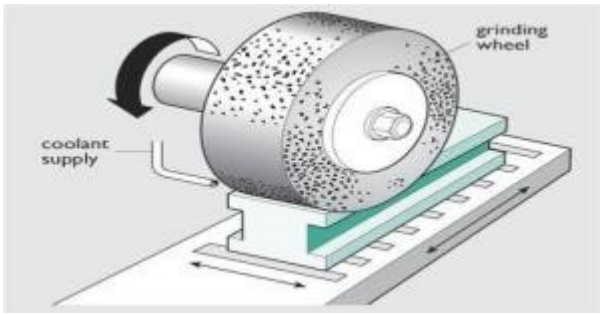
Turning is a machining process in which a cutting tool, typically a non- rotary tool bit, describes a helical tool pathway by moving more or less linearly while the work piece rotates. The auxiliary shaft has been turned from 12mm diameter to 9mm diameter for a length of 150mm.The main shaft has been turned from 12mm diameter to 11mm diameter for a length of 30mm.

4.3 Cutting

Cutting is the separation of a physical object, into two or more portions, through the application of an acutely directed force.Cutting process is carried out using a hacksaw cutting tool for cutting steel plate and shaft as per the requirement.

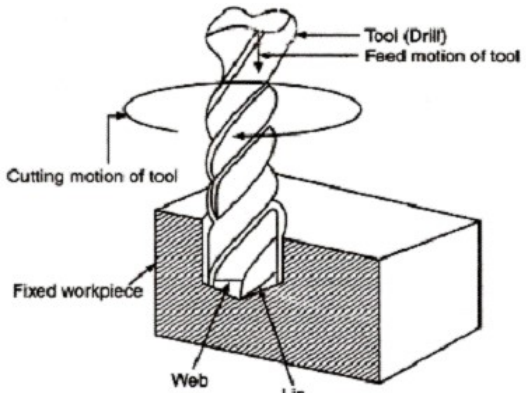
4.4 Grinding

Grinding is an abrasive machining process that uses a grinding wheel asthe cutting tool for good surface finishSolid shaft of required length has been cut using power hacksaw, and the Rough surfaces of this solid shaft has been grinded to get smooth surface. This is done using bench grinder.



4.5 Drilling

Drilling is the process of making holes in a work piece. Either the work piece or drill is stationary or vice-versa. When drilling on the lathe is being done, generally the work piece rotates in the chuck and the drill held in the tail stock. The bit pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute.



4.6 Assembling

Bearing seats are assembled on base plate by welding. Bearings are fitted in their respective shafts**.** The gears are mounted on the output shafts with the help of keys**.** The auxiliary shaft are inserted in the output shaft and the nut is tightened**.** L clamp is mounted on the base plate which slides over the base plate**.** Finally pinion is assembled on the handle and the base plate of bearing of handle is welded

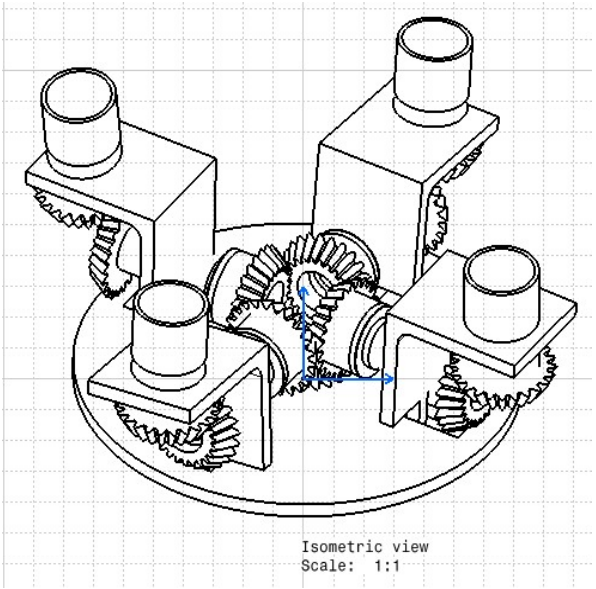
5.Working:

Generally bevel gears are used for transmitting power between nonparallel intersecting shafts. So bevel gear arrangement is used for Actuating the four socket spanners at a time.Twelve driven gears and one pinion gear are used. The pinion gear is meshing with four auxiliary gears which are in turn connected to a gear whose axle containing the socket spanners at its end.

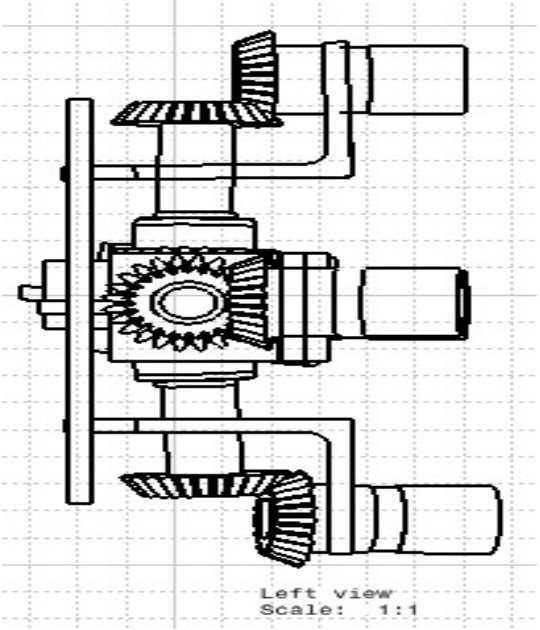
The auxiliary gear connected to a hollow shaft (main shaft). A lock nut arrangement is provided for connecting the main shaft to auxiliary at any desired position. When the pinion is rotated the auxiliary gears are also rotates which in turn gives a rotary motion to the socket spanner. This helps to tighten or loosen the bolts. The adjustment for removing the bolts which are having different pitch circle diameter is achieved by adjusting locknut. After reaching a desired position the locknut is locked with the hollow shaft to make them to rotate as a single shaft.Hence when the handle is rotated, the pinion which is connected to the handle rotates which further rotates meshing bevel gears and transmit the required distributed torque to the socket spanners

6.DRAWING

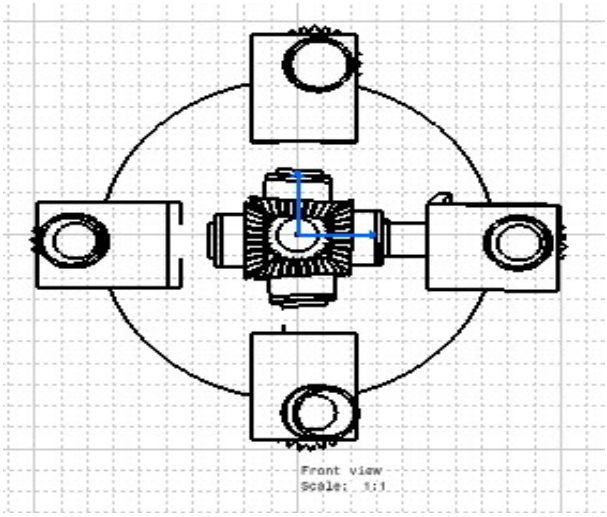
6.1 ISOMETRIC VIEW



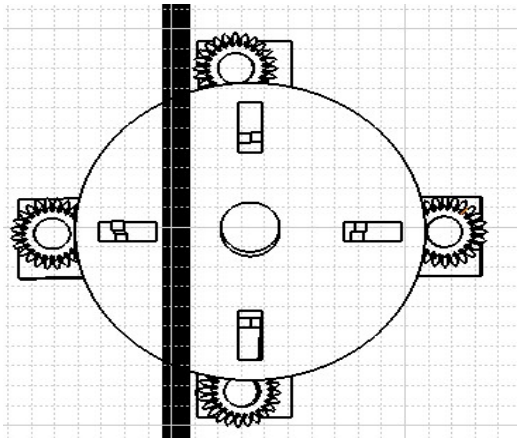
6.2 LEFT VIEW



6.3 FRONT VIEW



6.4 REAR VIEW



7.DESIGN CALCULATION

7.1 Basic principles and Theory

The basic fundamentals of law of gearing have to be followed in designing the bevel gears. The Fundamental law of gearing states that, "For a pair of gear to transmit constant angular velocity ratio, the tooth profiles of these mating gears must be designed in such a way that the common normal (line n-n) or the line of action passes through a fixed point, or also known as the pitch point, on the line of centers."

7.2 Design Parameters:

PCD (Pitch Circle Diameter) = 100 mm to 114.3 mm.
Common nut sizes = M12, M16, M18
Torque required, T = 320 Nm (4 nuts).
Gear material = mild steel.

7.3 Design procedure for bevel gears and pinion

MATERIAL SELECTION: Both gear and pinion are made up of mild steel

NUMBER OF TEETH:

GEAR (Z1) =22

PINION (Z2) =34

CALCULATE PITCH ANGLE:Speed ratio i = Z2/Z1 = 1.54

PITCH ANGLE = tan-1(1.540) =57degree

YOUNG MODULUS = 2E5 N/mm2

PRESSURE ANGLE = 20^0

Cone distance, R = $\psi(i2+1)\{[0.72/(\psi-0.5)(\sigma)]2E\times t/i\}1/3$ (assume ψ=3)

= 30.206 mm.

Module, m_t = R/{0.5 (Z12+Z22)1/2}

= 1.83 mm

≈ 2 mm

DESIGN BENDING STRESS:

$[\sigma b] = k_{bl} * [\sigma o] / (n*k\sigma)$

Where k_{bl}= life factor for bending =0.7

Kσ=fillet stress concentration factor=1.2

n=factor of safety=2

σo=endurance limit stress =302.5N/mm^2

$[_{\sigma b}]$=88.23N/mm^2

DESIGN CONTACT STRESS:

$[\sigma c]=C_R H_{RC} K_{CL}$ N/cm^2

Where C_R=230 (coefficient)

H_{RC}=50 (rockwell hardness)

K_{CL} =0.585 (life factor)

$[\sigma c]$=672.7N/mm^2

DESIGN TORQUE:

$[M_t]=k*k_d*M_t$

Assume $k*k_d$=1.3

M_t= P*60/(2*3.14*N)=143.24N-m

$[M_t]$= 186.30N-m

BASIC PARAMETERS:

b= R/3 = 10.06mm

$m_{av}= m_t-(b\sin\delta/z1)$ = 1.564mm

$d_{1av}=m_{av}*z1$ = 32.5mm

$v=3.14*d_{av}*N/60$ = 3.4m/s

QUALITY OF GEARS:

For velocity 5m/s , under straight bevel gears

IS QUALITY-4 gears are selected

REVISED DESIGN TORQUE:

$[M_t]=k*k_d*M_t$

Load correction factor, k=1.6

Dynamic load factor, k_d=1.4

$[M_t]$= 195.30N-m

BENDING STRESS:

$\sigma_b= (R*(i^2+2)[m_t])/((R-0.5*b)^2*b*m_t y_v*\cos 20)$ = 76N/mm^2

since $[\sigma_b]>\sigma_b$design is safe

7.4. Shaft 1

Torque, T =320 Nm

Maximum shear stress, ţmax = 115 N/mm2

(16Tdo)/(π(do4-di4)) = 115N/mm2

on substitution,

Inner diameter, di = 9.43 mm

≈ 9.5 mm.

Therefore,

Outer diameter, do = 1.5 di

= 15 mm.

Length of shaft required Lo = 30 mm

7.5.Shaft-2 (Auxiliary shaft)

Length of the shaft required, La = 56.75 mm.

Outer diameter, Do = 9.5 mm.

Inner diameter, Di = 0.75DO

Di= 7.5 mm

7.6 BASE PLATE

DIAMETER – 260mm

THICKNESS- 6mm

8. Merits and Demerits:

8.1 Merits:

- It can tighten and loosen all the nuts of wheel at the same time.
- System is adjustable for various pitch length.
- Easily portable along with vehicle.
- Initial investment is less and low maintenance cost.

8.2 Demerits:

- Nuts and bolts may get loosen when operated in high speed.
- Loose fixing of bevel gears and bearings in base plate causes vibrations.

9.Factors determining the choice of materials

9.1 Properties:

- Physical
- Mechanical
- From manufacturing point of view
- Chemical

9.2 Manufacturing case:

Sometimes the demand for lowest possible manufacturing cost or surface qualities obtainable by the application of suitable coating substances may demand the use of special materials.

9.3 Quality Required:

This generally affects the manufacturing process and ultimately the material. For example, it would never be desirable to go casting of a less number of components which can be fabricated much more economically by welding or hand forging the steel.

9.4 Availability of Material:

Some materials may be scarce or in short supply. It then becomes obligatory for the designer to use some other material which though may not be a perfect substitute for the material designed. The delivery of materials and the delivery date of product should also be kept in mind.

9.5 Space consideration:

Sometimes high strength materials have to be selected because the forces involved are high and space limitations are there.

10.COST ESTIMATION

10.1 Comparative cost estimation:

Now-a-days for loosening and tightening nuts in the car, a commonly used tool
is four way car wheel nut wrench brace ,but it suffers with the disadvantage that only one nut can be removed at a time. And so it is a time consuming process. But with A.U.W.O tool all four nuts in a car wheel can be simultaneously removed. The total cost involved for the fabrication of A.U.W.O is around Rs.4000. Costs have been estimated based on the cost of the materials that are being purchased, machining costs and other parameters that are involved in the fabrication of the project. Approximate cost estimation has been done and it has been listed as a Table.

10.2 Component cost:

1. MAIN GEAR (Bevel) = 1500
2. PINION (Bevel) = 700
3. SOCKET SPANNER (Box) = 150
4. SHAFTS (Guide) = 100
5. LOCK NUT = 50
6. HANDLE = 50
7. BEARING = 400
8. TOTAL=3000

10.3 Labour cost:

Turning, facing, drilling, grinding = 800

10.4 Overhead charges:

The overhead charges are arrived by “manufacturing cost”
Manufacturing Cost = Material Cost +Labour Cost=3500
Overhead Charges = 20%of the manufacturing cost=700

10.5 Total cost:

Total cost = Material Cost +Labour Cost +Overhead charges
=3000+500+700
= 4200.

11. Conclusion:

Thus the fabrication of Adjustable Unified Wheel Opener is successfully done. This project is practically implemented in a four wheeler and it is found that the results are positive. The project is working as what it is expected. Thus theproject is economical, and it sustains all the required feasibilities. It has been found that adjustable wheel opener is a perfect tool for assembling and dismantling a wheel in a four wheeler.

12.Future Enhancements:

The project has been fabricated which is purely mechanical. All the operations are done manually. To further extend our project as a useful tool, a motor has to be attached to its drive. Such that by providing a motor, it reduces all the human effort in tightening and loosening the wheel’s nut. Thus the project can be made an indispensable tool in assembling and dismantling wheels in cars.

13. Working model:

14. References:

1. Design data book -P.S.G.Tech.
2. Design of machine elements- R.S .KURMI.
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