DESIGN AND FABRICATION OF ADJUSTABLE UNIFIED WHEEL OPENER

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ABSTRACT: Adjustable Unified wheel opener is a special purpose tool made to open/close all the nuts of a wheel in one time with less effort. Although various methods are used for opening nuts, they require a lot of effort to open a single nut. The main objective of work is to develop a single tool with multiple mechanisms, which can be made use during assembling and dismantling of wheels in automobiles. It can be successfully used as a standard tool irrespective of the model of the vehicle. Also it can be used in assembly line of automobiles, garages, workshops and service stations.

KEYWORDS: multiple mechanisms, irrespective of model of vehicle, assembling, adjustable, dismantling,

I. INTRODUCTION

Engineering in general, and Mechanical engineering in particular, deals with a wide spectrum of products, ranging from large and complex systems comprising of numerous elements down to a single component. Apart from being a physical object, a product can also be a service that requires the application of engineering knowledge, skills and devices to be useful to society. A service falls under the category of a system in that it is carried out with the help of personnel, facilities and procedures. The service offered by an automobile maintenance and repair garage would be a typical example from mechanical engineering. Even computer software could be treated as an engineering product. It is also created using engineer ing knowledge and skills. In the following, the term product when used alone denotes the object to be designed and made with the help of engineering knowledge and skills, irrespective of whether it is a large system, a simple machine, a component or a service. A general understanding of the nature of product is a prerequisite for designing it. A complex product can be sub divided into sub-assemblies or sub system, component etc. Frequently the planning, layout and design of a complex multi element product is an interdisciplinary effort, requiring the expertise and skills not only of several engineering specialization but even non engineering ones. It is always preferable that our work should be easy and fast. But easy and fast working requires some technical skills to work efficiency and properly. 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. A little but important work that all people would do ofte n 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 Adjustable Unified 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 car wheel in one time. And the most desired achievement is that, the total effort and time needed in the process is very less. It can open and also refit the wheel with the same tool easily. Tool is simple in design, easy to use and easily portable along with the vehicle.

II. SYSTEM MODEL

A. Proposed system

Hence in order to overcome all the above disadvantages a design should be proposed which should be more convenient, cheaper and easy access. In the previous versions of unified wheel opener spur gear arrangement have been used for the uniform rotation of all the box spanners, in A.U.W.O system, bevel gear arrangement have been used, coupled with the shaft arrangement to transmit the power applied uniformly to all the four box spanners. And in further spring and lock - nut arrangement have been used to make the system adjustable to the required pitch length.

B. Working Principle

Generally bevel gears are used for transmitting power between non parallel 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 cam and follower mechanism is used for making the project adjustable. For this purpose radial cam is used because the follower moves in the direction perpendicular to the cam axis. And spherical face follower is used because the side thrust and wear is considerably low. 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) which is acting as a guide for follower. The other end of the follower is connected to a bevel gear. A lock nut arrangement is provided for connecting the main shaft to follower at any desired position. When the pinion is rotated the auxiliary gears are also rotated 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 rotating the cam. The followers are in contact with cam when the cam is rotated the follower will move linearly. After reaching a desired position the follower is locked with the hollow shaft to make them to rotate as a single shaft. Then the cam is brought back into its initial position to prevent the cam from severe wear while the follower is rotating. The pro-e model of our project is shown in Fig .1
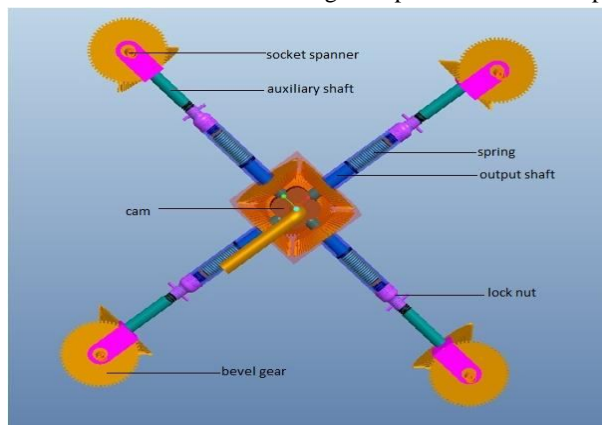

Fig. 1 Front View of A.U.W.O

III. FABRICATION PROCESS

In the manufacturing of the axles following operations are used:-

A. Sawing

Initially the cast iron shaft dimensions are its diameter is 12.5 mm and length is 220 mm. This solid shaft is used as a follower. The total length of 220 mm is cut into four equal pieces, which is done using power hacksaw.

B. Grinding

Solid 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 which is done using bench grinder, which is available in the college.

C. Facing

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

D. Turning

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool path by moving more or less linearly while the work piece rotates. The auxiliary shaft has been turned from 12mm diameter to 9mm for a length of 150mm, then for a length of 30mm, 12mm diameter is turned to 11mm. Then further the 12mm shaft is turned to 10mm for remaining length of the shaft.

E. Drilling

Drilling is the process of making holes in a work piece. Either the work piece rotate 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 is fed into the work piece by means of the hand wheel on the outer end of the tail-stock assembly. Since drill feed is by hand, care must be taken, particularly in drilling small holes. Coolant should be withdrawn occasionally to clear chips from the hole and to aid in getting coolant to cutting edges of the drill. A 10mm drill bit is used for drilling 8 holes. This holes helps in assembling the component through nuts and bolts.

F. Cam

A square plate is taken, and the required dimensions for the cam are marked using scriber, and finally the marked portion is cut using hacksaw. For finishing, the end surfaces are grinded using the bench grinder.

G. Springs and Bearings

Open coil spring is chosen for better compression, and is purchased from the market after a detailed survey. Bearings are also bought from the market. Bearings are easily available in the market, since a standard size has been chosen.

H. Assembly

Bearing seats are assembled on base plates by welding. The gears are mounted on the output shafts with the help of key. The spring and auxiliary shaft are inserted in the output shaft and the nut is tightened. The Bearings are fitted in their respective shafts. The lock nuts are welded on the base plates. The gears are welded on the auxiliary shafts. The cam is welded on its shaft. Finally the pinion is assembled on the handle and the base plate of bearing of handle is welded with the base plates of other output shaft bearings. The Assembled View of the project is shown in Fig. 2

Fig. 2 Assembled View of the projec

A. *Basic principles and Theory*

IV. DESIGN CALCULATIONS
A. *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."

B. *Design Parameters*

PCD (Pitch Circle Diameter)	= 105 mm to 114.3 mm.
Common nut sizes	= M16, M17, M18.
Torque required, T	= 320 Nm (4 nuts).
Average force by human, F	= 500N.
Length of handle, Lh	= 600 mm.
Gear material	= Mild steel.
Module, m	= 2 mm.
Pressure angle ,	= 20˚

C. *Design procedure for bevel gears and pinion*
 Bevel gear

Power to be transmitted, P	= 1.5 kW.
Torque, T	= 320 Nm.
Speed ratio i	= 1.
Z1 (gear)	= 25 teeth, Z2
(pinion)	= 25 teeth. Young's
modulus, E	= 2×10³ N/mm².
Cone distance, R	= $\psi(i2+1)\{[0.72/(\psi-0.5)(\sigma)]2E \times t/i\}1/3$
	= 30.206 mm.
Module, m	= R/{0.5 (Z12+Z22)1/2}
	= 1.83 mm
	$\approx$ 2 mm.

D. *The dimensions for pinion &gear are as:*

Addendum, ha	= 0.943×m
	= 1.886 mm.
Dedendum, hf	= 1.257×m
	= 2.514 mm.
Outside diameter of pinion, dp	= (Tp+2)×m
	= 44 mm.
Outside diameter of gear, dg	= (Tg+2) ×m
	= 44 mm.

E. *Spring parameters*
 Open coiled, ground ends.
 Circular cross section.

F. *Design procedure for output shaft*
 Shaft dimensions
 Shaft-1 (Output shaft)

Outer diameter, do	= 1.5 di (inner diameter).

Torque, T	$=300$ Nm
Maximum shear stress, t_{max}	$= 115$ N/mm2
	$= (16Tdo)/(\pi(do4-di4))$
on substitution,	
Inner diameter, di	$= 16.23$ mm
	≈ 16 mm.
Therefore, Outer diameter, do	$= 1.5$ di
	$= 25$ mm.
Length of shaft required, Lo	$= 15$ mm

G. *Design procedure for auxiliary shaft*
    Shaft-2 (Auxiliary shaft)

Length of the shaft required, La	$= 46.75$ mm.
Outer diameter, Do	$= 15.5$ mm.
Inner diameter, Di	$= 0.75$ Do
	$= 11.625$ mm.

H. *Time consumption*

Time taken to remove a nut, t	$= 15$ seconds
Setup time, s	$= 10$ seconds
Total time, T_t	$=4t$
	$= 60$ seconds (conventional)
Total time, T	$= t+s$
	$= 10+15$
	$= 25$ seconds (our project)

I. *Design of Cam*

Maximum displacement required, x	$= 10$mm.
Maximum space available for cam, d	$= 30$mm.
Width of the cam, w	$= 21$mm
Length of the diagonal, l	$= 30$ mm

V. RESULTS AND DISCUSSIONS

A. Practical Implementation

After checking the feasibility conditions, (i.e. economic feasibility, operational feasibility and technical feasibility) adjustable unified wheel opener is designed and it is implemented in real world problems. It worked successfully and finally the output is obtained as such as what is desired.

B. 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 spanner which costs about Rs.700. It has four different size box spanners (17mm, 19mm, 21mm, 23mm) for removing different nuts, 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.2330. 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. 1

S.No.	DESCRIPTION	COST (in Rs.)
1	MAIN GEARS(Bevel)	100
2	PINIONS(Bevel)	960
3	CAM	50
4	FOLLOWER	100
5	SOCKET SPANNER(Box)	320
6	SHAFTS(Guide)	50
7	LOCK NUT	50
8	HELICAL SPRING(Open coil)	50
9	HANDLE	50
10	BEARING	400
11	WELDING	200
	Total	2330

Table. 1 Cost Estimation

VI. 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 the project 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.

A. **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.

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