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Application Analysis on Force Multiplication Drawing Device

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Abstract. In the field of mechanical installation and repairing, drawing devices are often used to disassemble or push up components of various types of axie and set. Nowadays it is widely used in areas such as mechanical installation, machinery manufacturing, machinery repair, but still have problems to be used well with an appropriate force. The article presents a new kind of drawing device named force multiplication drawing device. It is designed by using the lever principle and can acquire much stronger drawing force. After theoretical calculations, it is proved to be very valuable.

Introduction

Common mechanical drawing device achieves the purpose of saving effort according to the thread principle. In short, it is a set of bolts and nuts system, connecting one or more pairs of tensile claws on nuts symmetrically. One end of the bolt is tapered. At the other end, rotating the bolt with a wrench to make sure the nut is fixed. In this way, through rotating the bolt, tensile claws are made do the straight-line motion.

Bolts and nuts system is analyzed from the mechanical point of view. The smaller the pitch, the greater the tension obtained. But the thread tooth structure will be smaller and shear resistance will be poorer. While in the course of use, buckle injury will be easily but repair will be difficult. In the case subjected to the same torque, the larger pitch, the smaller obtained tensile. Increasing the length of the rotating wrench is need, but the operation requires two or more people to cooperate. So according to the drawing tonnage, the bolt diameter, pitch, pulling claw length and other sizes of common Puller is determined. But limitations of each product are great.

Force multiplication drawing device has the same function with common Puller and a unique reinforcement structure. Reinforcement means saving effort. The product achieves the purpose of saving effort with two approaches which include the lever principle and differential thread. By combining both sides, manual mechanical puller possesses characteristics that small form factor, wide range of uses and operating easily.

Product Description

Further illustration of force multiplication drawing device combined with figures:
1-internal nut; 2-screw; 3-outer nut; 4-lower nut; 5-rod; 6-triangular lever; 7-hinge; 8-tensile claw (refer with: Fig. 1).

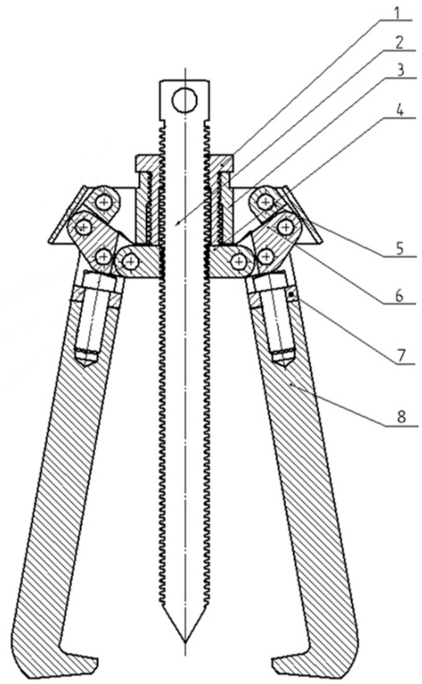

Fig. 1. Design chart of the force multiplication drawing device

As shown in Figure 1, for the tie is not tight, you can just use the ordinary drawing functions. According to size of parts, 2-screw puller is rotated to fit the position so that its apex is up against the parts center or positioning holes. Tensile claws symmetrically hang over the suitable location of the workpiece which need to pull. Rotating the screw manually, excluding the gap of retractor and workpiece. At the same time, the bottom of the 1-internal nut and the top of the 4- lower nut are in contact. Wrench is fixed on the 3-outer nut. The screw clockwise is rotated by another wrench or lever. So the screw goes forward until pulling up the workpiece to finish drawing work.

Due to a tight fit or damage and corrosion of mating surface of parts, common puller will not properly drawn, or extremely laborious. So on the basis of the above operation, removing the wrench fixed on the 3-outer nut. At the same time, the puller remains intact because of the pre-tightening force between tensile claws and the workpiece. The wrench is fixed on the 1-internal nut so that the wrench and lever of the 2-screw can be intact. Counterclockwise rotation of the nut with a wrench makes the 1-internal buckles inside and cooperates with 2-screw. The pitch is four millimeters. Also making it buckles outside and cooperating with the 3-outer nut. At the time, the pitch is three millimeters.

In the case of no friction, rotating a circle, the 3-outer nut driven the 8-tensile claw forward one millimeter relative to the 2-screw. But common puller goes forward four millimeters per rotation. So this tension is the four times as large as the ordinary drawing tension. When the wrench rotates the nut counterclockwise, the outer screw has the trend of upward movement. Pulling the connecting 5-rod and 6-triangular lever go upward. Triangular lever does the upward movement through the 8-tensile claw which connected with the 7-hinge. Through analyzing the lever principle, this process can save several times the force. By combining the two kinds of labor structure, the tension of this puller is the several times or even ten times as large as the ordinary drawing tension.

Theoretical Calculations

Tab. 1. Theoretical calculations' symbols and their meanings

Symbols and their meanings			
F_a	Axial pressure	W	The drawing device's output power
F	Human force	P_1	Pitch of main pipe's internal thread
η	Total mechanical efficiency	P_2	Pitch of main pipe's external thread

According to energy conservation, multiply external force input power by mechanical efficiency equals to drawing device's output power (refer with: Eq. 1).

$$\eta \cdot W_{\text{external work}} = W_{\text{work output}} \tag{1}$$

Multiply torque by rotation angle equals to input power and multiply axial force by screw distance equals to output power (refer with: Eq. 2).

$$\eta \cdot F \cdot L \cdot 2\pi = F_a \cdot (P_2 - P_1) \tag{2}$$

After further finished, the force multiplication drawing device's total axial force generated can be calculated (refer with: Eq. 3).

$$F_a = \eta \frac{2\pi \cdot F \cdot L}{P_2 - P_1} \tag{3}$$

Here are the samples of force multiplication drawing device for an example (refer with: Table. 2).

Tab. 2. The force multiplication drawing device's experimental data

Experimental data	
$F = 294N$（General Date）	$L = 0.4\text{m}$
$P_1 = 4mm$	$P_2 = 3mm$
$d_1 = 30mm$	$d_2 = 45mm$
$T = 392N \cdot m$	$45\#Steel's$ Friction Coefficient f = 0.07

After theoretical calculations by using experimental data, drawing device's output power can be calculated and it has passed the reasonable strength analysis (refer with: Eq. 4).

$$F_a = \eta \frac{2\pi \cdot F \cdot L}{P_2 - P_1} = 1301N \tag{4}$$

However, the general drawing device's output power only achieves 67.98N in the same conditions. As can be seen, the new product can achieve the function of the output power of 19.1 times by using lever principle and differential thread principle. If the friction force is added in the calculation, it can also have a positive result (refer with: Eq. 5).

$$F_a' = F_a \times (1 - \frac{f}{\sqrt{1+f^2}}) = 1210.152N \tag{5}$$

Conclusion

Analyzing principle and calculation, it can be found that force multiplication drawing device can effectively pull and saving effort apparently. Moreover, force multiplication drawing device can save steel material so that the dimensions become small and easy to operate in the same tonnage, especially on the production of large-tonnage drawing device. When requiring less tension, using ordinary drawing device has compatible effect. When requiring larger tension, differential screw and lever system are used but the screw does not rotate, which protect the workpiece and the top of drawing device from damage. Especially through the design of triangular lever, friction among the internal nut, the screw and the outer nut greatly reduced. So useful work increased significantly and reinforcement effect is outstanding.

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