Design and Development of Compound Lever Handle for Hand Pump

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Abstract

Conventionally, class I type lever is used to operate the hand pump. The operator has to bow for operating the hand pump and more force is required, resulting more fatigue and stress.

Author has designed and developed a compound lever handle for hand pump and same has been presented in this paper. By using this compound lever handle force required to operate the pump reduces and posture of the operator also changed, resulting less fatigue and stress.

***Keywords*: Compound Lever, Class I Lever, Hand Pump, Simple Machines.**

INTRODUCTION

Lever is a simple machine which is used to lift heavy load with least effort. Basically there are three types of levers namely class I, class II and class III and each type has fulcrum, load and effort which together can lift the load. In ancient Egypt, constructors used the lever to move and uplift obelisks weighing more than 100 tons [1]. In class I lever fulcrum is located between the load and effort. The class I lever is being used in many machines/such as in bicycle brakes, scissors, etc. In class II lever, the load is situated between the fulcrum and effort, such as wheel barrow to lift tool such and garden waste having load in the centre of the barrow.

In class III lever, effort is applied between the fulcrum and load. For example, fisherman catching the fish. The fish becomes the load at the end of the lever.

A compound lever is a simple machine which operates on the principle that the resistance from one lever in the system of levers acts as effort for the next, resulting amplification of applied force from one lever to next one. Fig. 1 shows a compound lever formed two class I levers.

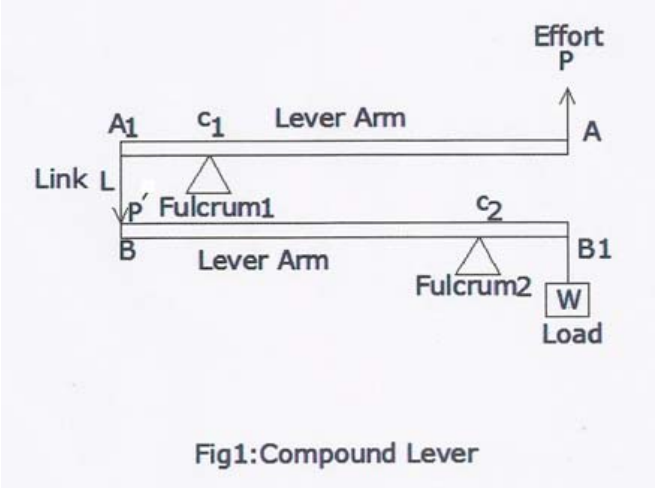

Fig1:Compound Lever

The distance of effort from fulcrum 1 (AC_1) is called lever arm, similarly distance of P′ from fulcrum 2 (BC_2) is also called lever arm. The ends A_1 and B of levers are connected by link L. The length AC_1 is greater than length A_1C_1 and similarly length BC_2 is greater than B_1C_2. The effort is applied on end A and lever end B_1 is connected to load W to lift it. For equilibrium $PxAC_1 = P'xA_1C_1$ and $P'xBC_2 = WxB_1C_2$.On multiplying first relationship by second and then dividing by common term P′ and rearranging the terms, yields $AC_1xBC_2/A_1C_1xB_1C_2=W/P$. As the values of AC_1 and BC_2 are greater than the values of A_1C_1 and B1C2 respectively, so more load can be lifted by applying less effort.

A Micro Biomass Briquette Press is reported on website www.homefuse.net/Engineering, in which a compound lever system has been used for pressing the biomass to make the Briquettes [2]. US Patent 2382307 disclosed the multiple lever tools in which compound lever system has been used in hand tools to reduce the effort [3]. US Patent 3636954 disclosed a compound lever mechanism having common fulcra each compound lever comprising two or more simple first order levers articulated in series, the common fulcra and joints between the simple levers being provided by localized zones of the construction adopted to flex preferentially when sufficient force is applied to the levers. This mechanism is suited for incorporation in a compound lever forceps or like devices, thus enabling devices having a scissors action to be formed in one piece for example as one shot polypropylene injection mouldings [4].

US Patent 7346991 discloses a hand tool providing double compound leverage to the jaws in which double leverage of the force is exerted on the handles to the jaws [5]. There are many manufacturers of India Mark II and III hand pump in India and supplying the same all over the world. In which the simple lever type handle is being used.

The hand pumps are being used from 1930s. A simple lever was used as handle to operate these hand pumps. The operator has to bow when he operates the hand pump and more force is required to operate it.

Author has designed and developed a compound Lever Handle for Hand Pumps in which operator does not droop to operate the hand pump and less force is required to operate the pump. Beside this the stresses on all structures of spine can be reduced by using this innovative compound lever handle.

OBJECTIVES OF THE PRESENT INVENTION

(1) To provide a compound lever handle to operate a water hand pump to reduce human effort.
(2) To provide a compound lever handle to keep the natural body posture of the operator when he operate a hand pump.
(3) To provide a compound lever handle, which is simple in design.
(4) To provide a compound lever handle to reduce human fatigue.
(5) To provide a compound lever handle to operate the hand pump easily and conveniently.
(6) To provide a compound lever handle to maintain it easily.
(7) To provide a compound lever handle to manufacture easily.
(8) To provide a compound lever handle to reduce risk of stresses and injuries.

WORKING PRINCIPLE

Compound lever handle comprises with a base plate 10, side plates 17, 17′, handle 1, crank 18, connecting rod 5, link 7, studs 13, 14, 15 and 16, pins 4 & 6 as shown in Fig. 2, the handle 1 is mounted on shaft 19.

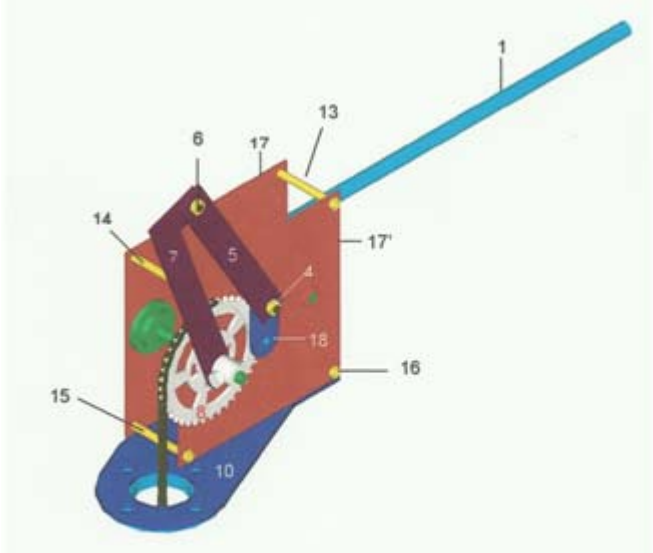

Fig. 3: Isometric view of compound lever handle.

This shaft is supported on ball bearings 25 and 26. The bearing 25 and 26 are mounted on side plates 17 and 17′ respectively. A gear 2 is mounted on the shaft 19 and meshed with gear 12. The gear 12 is mounted on shaft 21,

which is supported on bushed bearing 28 and 29. These bearings are fixed with side plates 17 and 17′. The gear 12 is meshed with gear 3 as shown in Fig. 3.

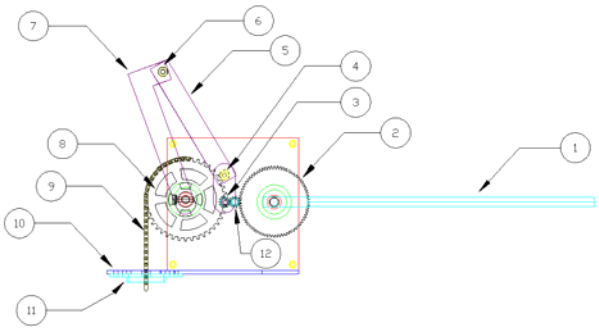

Fig. 3: Front view of compound lever handle.

The gear 3 is mounted on shaft 22, which is supported on bushed bearing 30 and 31 as shown in Fig. 4. These bearings 30 & 31 are fixed with side plates 17 and 17′. A crank 18 is mounted on one end of shaft 22. One end of this crank 18 is connected to the connecting rod 5 with the help of a pin 4. The other end of this connecting rod is connected to the one end of a link 7 with the help of a pin 6. The other end of this link 7 is fixed with sprocket 8 as shown in Fig. 2. This sprocket is mounted on shaft 20, which is supported on bearings 23 and 24. These bearings 23, 24 are fixed with side plates 17 and 17′ respectively as shown in Fig. 4.

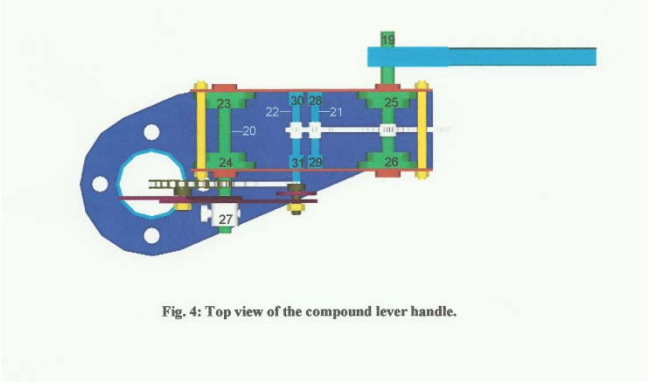

Fig. 4: Top view of the compound lever handle.

A chain 9 is passed over the sprocket 8. The one end of this chain 9 is fixed with sprocket 9 and other end is free to be connected to the piston rod of the hand pump as shown in Fig. 2 & Fig. 3. Flange 11 is fixed with base plate 10 as shown in Fig. 3. This flange is used to mount the compound lever handle on hand pump.

When handle 1 is pushed in downward direction, it rotates the shaft 19, resulting the rotation of gear 2. The gear 02 is meshed with gear 12, thus gear 12 also rotates. The gear 12 is meshed with gear 3, which also rotates in direction of rotation of the gear 2. The gear 3 and crank 18 are mounted on the same shaft 22, so crank 18 also rotates in same direction as that of gear 3 (i.e. clockwise direction). The other end of the crank 18 is connected to the one end of link 7. The other end of this link 7 is fixed with sprocket 8 which is mounted shaft 20, resulting in rotation of sprocket in clockwise direction. The free end of chain will lift when the sprocket rotates in clockwise direction. The free end of chain is connected to the piston rod of the pump, which lifts the piston in upward direction thus water is lifted by hand pump using this compound lever handle.

DISCUSSION

A Micro Briquette Press reported on web site [2]. In this press compound lever handle has been used to reduce the manual effort for making the Briquettes. A compound lever system disclosed in US Patent 2382307 is used in hand tools to reduce manual effort. A compound lever mechanism reported in US Patent 3636954 is used for compound lever forceps or like devices, thus enabling devices having a scissors action to be formed in one piece. The compound lever system disclosed in US Patent 7346991 is used for hand tools, in which double leverage of force is exerted on the handles to the jaws.

In conventional hand pump handle requires more force to operate the hand pump because a class first lever type handle is used to operate the pump. In conventional handles the ball bearing are not used at the pivot, therefore more friction acts between the surfaces having relative motion, resulting more effort requirement to operate the pump.

Besides this the operator has to keep himself in back bent posture to operate the pump. As the posture deviates from natural body position, there is an extra tension placed on all the structure of the spine. The bent postures in particular means increased stress and risk of injury.

Hand pumps are being used all over the world for drawing the water. Majority of the rural population use hand pump for drawing drinking water.

To operate the hand pump having conventional simple lever type handle is more risky for pregnant women as they have to bent to operate the pump. The handle of India Mark II & III type hand pumps is long and heavy. The operator has to push the handle in downward direction and pull in upward direction for drawing the water by hand pump. When it is pushed in downward direction by the operator the effort requirement is less, but operator has to droop to operate the pump and the spine will be used as a lever although it is not suitable to use like a crane. The spine becomes a very long lever arm, with a load being handled at the end. The muscles of the back have to support not only the weight of the trunk as it is bent over, but also the load being handled. The force exerted by the spinal muscles can be up to ten times more than the load to be handled [6]. As the weight of the handle of India Mark II is more, so there will be more stress on spine when operator pulls the handle in upward direction, resulting increased risk of injury and more fatigue occurs to the operator.

The innovative compound lever handle, developed by the author is suitable to operate the hand pump with reduced effort as well as to maintain the natural posture of the operator. The effort is reduced by using ball bearings to support the shafts and using compound lever system as shown in Fig. 2. The effort from the handle 1 is transferred to the sprocket through simple gear train comprising gear 2, 12 and 3. The number of teeth on driven gear 12 are four times of the number teeth on gear 2 and 3, so that for a particular movement of the handle 1, four times movement on sprocket can be achieved. In this way operator also does not bend to operate the hand pump, resulting reduced risk of spinal injuries and stress.

CONCLUSION

(1) The hand pump can be operated with less effort by using this innovative compound lever handle.
(2) The stresses on all structures of spine can be reduced by using this compound lever handle.
(3) The risk of injuries can be reduced by using this handle.
(4) The risk of injuries may be reduced in pregnant women if they operate the hand pump by using this innovative handle.
(5) As the force requirement is less to operate the pump by using this handle, so operator can operate the pump for a long period without fatigue.
(6) This compound lever is simple in design.
(7) This compound lever is easy to manufacture.
(8) This compound lever is easy in maintenance resulting low maintenance cost.
(9) This compound lever handle is suitable for drawing water from deep tube wells as well shallow wells.

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