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Design and Analysis of Foot Operated Water Spout

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The article presents four designs of a foot–operated water tap. These designs were useful for operating a water tap without touch and control the flow of water with the operation of the foot. The designs were suitable for the round in shape cap of the water faucet or an attachment can be fixed on the handle of the existing tap to convert the cap round in shape. The clutch wire and cotton rope were used to convert the rotational motion into linear motion. Among the four designs, two work with the help of the singlepedal operated with clutch wire and the other two work with two pedals and pulleys. These designs were analyzed in detail with operation, advantages, and disadvantages. The proposed novel designs were economical, prevents infection, saves consumption of water, controls water flow and easy to install.

Keywords: Water tap, Faucet, Foot, Clutch wire, Linear motion, Rotational motion

1 Introduction

Hand–free water tap is one of the best solutions to stop and spreading of the corona virus infection with physical contact. In the present Covid–19 situation, the water taps at various locations such as sinks, wash basins and drinking water points, there was a high risk of infection in hands which may cause the spread of virus vary rapidly in our society[1]. To protect from such infection, it was necessary rinse the tap head thoroughly with sanitizers or tissues or any other techniques. It was observed a huge wastage of water with time of ablution[2]. In general, the water tap flow rate can be controlled with sensor based or mechanical based or combination of both systems with touch–free operation[1,2]. Sensor based water tap controller works with the principle of Ultrasonic and Passive interface receiver (PIR) based microprocessor and android based technology etc.. The sensors are costly and operate for a fixed time as programmed for minimum time interval. This leads to the wastage of the water during the usage and also need electricity for operation[3]. Mechanically based system was operated by foot with components such as pedal, pulley, rope, rack and pinion etc.[4]. Very few studies were available in literature on mechanical based foot–operated valves[5–9]. Latch mechanism design is one of the oldest technology which uses a crank, cable wire, foot pedal, specially, water controlling pipes for foot–operated valve design[10]. This design needs changes in existing wash basin. The helical compressive spring was an another alternative solution for holding the plug of the valve and pedal of the actuator in position[8]. This assembly was employed with coupling, stem (formed by casting its blank and finally machined threaded to size), valve, body flange, seal of valve, etc. This design also needs special mechanical expertise for the fabrication due to its complexity. Rack & pinion in pedal–operated water tap mechanism avoids the excess use of water in some basic activities like hand washing, shaving, washing utensils, etc.[4]. This mechanism was less durable and gives low mechanical advantages, more noise, and vibration. A twin half inch lever design modification carried out to modify the original tap design with a ball valve, spring, valve core, valve handle, snap ring etc.[9]. Press tap water design uses, tippy tap, foot lever, wooden flap, water container[11]. Its major limitation was to be used with container only. Combination of mechanical and sensor based water tap controller designs improved with regulating device incorporates, gear mesh, temperature sensor, ultrasonic sensor, microprocessor, stepper motor, user console display penal, automated faucet valve etc.[6]. Automatic tap based on android and arduino board, ethernet shield, android solenoid valve were complex, high cost and applicable to smart homes[3].

The above state of the art reveals mechanical based systems was cheap and economical, however some of

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these designs were complex and also had limitations. The focus of this study was to present an improved water tap design with simple, economical and easy installation at various locations. A total of four novel designs were developed and discussed with their pros and cons in detail. All four designs were fabricated and installed at existing metal sink fitted at Fire Research Laboratory, CSIR–CBRI, Roorkee, India. The operation and performance of all four developed devices were evaluated after their proper installation at existing wash basin without changing faucet and piping system at Fire Research Lab.(CSIR-CBRI).

2 Materials and Methods

The specific purpose of the present study was:

(i) To design and fabricate a foot–operated faucet for services related to touch free and efficient water use and pandemic protection in general.

(ii) To provide a foot–operated faucet for hand washing facility at "Reaction to fire lab"

Fire research laboratory, Central Building Research Institute, Roorkee for office staff and lab. work.

2.1 Design and development process of foot–operated spout

A sound design of touch free water tap should include following facilities:

a) The designs should be easy in operation, safe,
b) low cost and easy to install and dismantle.
c) It must be durable under any circumstances.
d) It should also provide continuous flow of water.
e) Maintenance of mechanisms should be easy and low cost.
f) Spare parts must be easily available at the time of repair in local market.

In the present study all four designs were developed in such a way taking in to consideration their easy operation, cost effective, systems effectiveness etc.

A total of four foot–operated spout designs were developed and analyzed their technical features experimentally. The four proto–type designs with their elements, materials of which they are made in the processes were given in Fig. 1 (a–b).

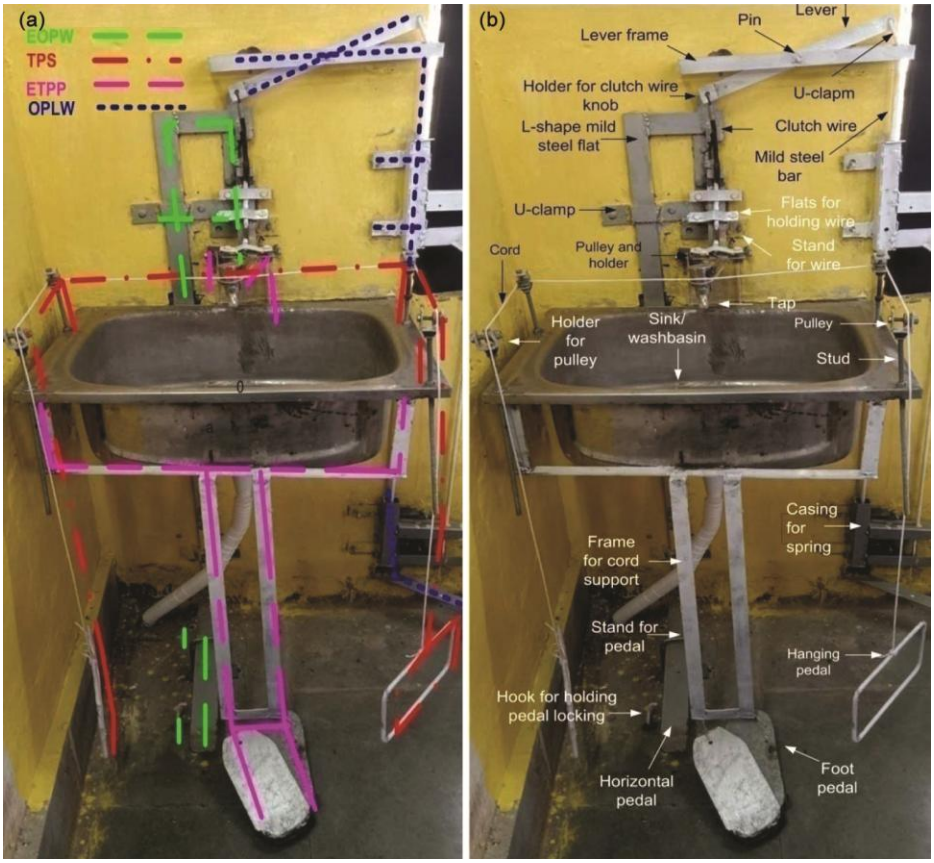

Fig. 1 — Photograph of single and two pedal operated fabrication of hand free water tap designs, a) OPLW, EOPW, TPS and ETPP, and b) materials with their part name.

The foot–operated mechanisms for faucets were basically fabricated of mild steel, bronze and cotton rope. The materials, parts and with their assemblies' dimension details are given in Table 1 and shown in Figs 2, 3, 4 (a-h). The materials used for components may be either metallic or non–metallic i.e. polyvinyl chloride (PVC). With these elements, parts and materials of four deigns namely one pedal, lever and wire (OPLW), efficient one pedal, wire operated (EOPW), Two pedals and stud operated (TPS) and efficient two pedals and pulley operated (ETPP) hand free water tap were developed and studies were carried out on their performance analysis. The fabricated device were painted to enhance the anti–corrosion action of the systems and designed in such a way taking into consideration mechanisms durability, effectiveness, eco–friendliness, economical aspects, and easy installation and safety measures.

Table 1 — Specification of various parts of fabricated foot operated water spout devices

Parts Name	Specifications
Mild steel stand for horizontal pedal	As per dimension given in Fig. 5 (c). mild steel as shown in Fig. 2a
Bar use to join U – Clamp & pedal	1300 mm (L) X 10 mm (d), Plain mild steel bar as shown in Fig. 2b
L– Shape Clamp	50 mm (L) X 10 mm (W), A 6 mm diameter TMT bar was bent in L–Shape as shown in Fig. 2c
Foot Pedal	Mild steel bar 200 mm (L) X 90 mm (W), G.I. sheet 90 mm (L) X 10 mm (W) X 3 mm (T) were used to fabricate it. A rectangular frame was made by bending the mild steel bar into foot Shape. The foot shape G.I sheet was welded on the frame as shown in Fig. 2d
Horizontal type pedal	540 mm (L) X 50 mm (W) X 5 mm (T). It was a mild steel flat of given size and used with one pedal mechanism only as shown in Fig. 2e
Hanging Pedal	250 mm (L) X 150 mm (W) X 8 mm(d),mild steel It was made by banding the bar in rectangular shape and used with two pedal designs only as shown in Fig. 2f
L– Shape mild steel flat for adjusting height of sink	AB–660 mm (L) X 25 mm (W) X 5 mm (T), FC–105 mm (L) X 25 mm (W) X 5 mm (T), DE– 550 mm (L) X 25 mm (W) X 5 mm (T). AB and FC flats were welded at one end as shown in Fig. 2g
Clamp for holding L–Shape flat.	52 mm (L) X 50 mm (W) X 5 mm (L), Three nos. of given size mild steel flats were used to fabricate it. All flats were placed in series and the ends of middle flat was overlapped on both ends of side flats and welded as shown in Fig. 2 h
Pulley	23 mm (D) X 8 mm (d), Flat width–2.5 mild steel 6 nos. of pulleys were used to run the cotton rope tightly and smoothly as shown in Fig. 3a
Pulley holder	30 mm (L) X 25 mm (W) X 3 mm (T), pulley holder was fabricated by welding three nos. of mild steel flat in U–Shape as shown in Fig. 3b
Lever	330 mm (L) X 25 mm (W) X 3 mm(T). Fabricated by mild steel flat of given size as shown in Fig. 3c
Frame for Lever	60 mm (L) X 60 mm (W) X 30 mm (H), It was made of mild steel in rectangle shape by given size flats as shown In Fig. 3c
Hole fast for frame	70 mm(L) X 8 mm (d), It was made of TMT bar of given size as shown in Fig. 3c
Studs	320 mm (L) X 8 mm (d), 4 Nos., mild steel as shown in Fig. 3d
Helical Spring	65 mm (LO) X 19mm (D) X 3mm (d), mild steel as shown in Fig. 3e
Casing for spring and two nos. plates welded above , lower end of casing	Four nos. of flats, size 200 mm (L) X 35 mm (W) X 35 mm (H) were welded in rectangular Shape. It was made by 3 mm thick mild steel flat. Two flats of 37 mm (L) X 37 mm (W) X 3 mm (T) were welded on the top and bottom of casing to make it a closed rectangular box. A hole of 10 mm diameter was drilled in the centre of both flats, welded on top and bottom as shown in Fig. 3 f
Attachment to alter cap	Dimensions as shown in Fig. 5b, G.I sheet as shown in Fig. 3g
U–Shape Clamp	55 mm (L) X 25 mm (W) X 6 mm (d),mild steel as shown in Fig. 3h
Holder clutch wire knob	Two mild steel flats, size 30 mm (L) X 25 mm (W) X 3 mm (T) were overlapped and welded. In one flat a 5 mm dia. hole was drilled into the centre of the flat. In another flat, a slit of 10 mm (L) X 4 mm (W was cut from the centre of edge of the flat up to the centre of flat and also a hole of 5 mm dia. drilled in the centre as shown in Fig. 4a
Clutch wire	300 mm (L) X 3 mm (D), Steel and PVC as shown in Fig. 4b

(*Contd*.)

Table 1 — Specification of various parts of fabricated foot operated water spout devices (*Contd*.)

Holder/stand for clutch wire	250 mm (L) X 30 mm (W) X 3 mm (T), Curved mild steel flat of given size was used as shown in Fig. 4c
Flats for holding clutch wire	Three nos. of mild steel flats, size 30 mm (L) X 12 mm (W) X 3 mm (T). A curve of 5 mm radius was given in the centre of flats as shown in Fig. 4d
Stand for supporting cotton rope	It was made by mild steel flat as shown Fig. 5a. Dimensions as per given drawing as shown in Fig. 4e.
L–Shape mild steel flat	AB–1200 mm(L) X 40 mm (W) X 5 mm (L) and BC–200 mm X 40 mm X 5 mm, Fabricated by welding two mild steel flats of given size (AB,BC) at the ends of flats as shown in Fig. 4 f
Bronze lug	50 mm (L) X 10 mm (W), Bronze as shown in Fig.4g,Capable to resist corrosion, light in weight, flexible, anti–fatigue
Hinge	Leaf–50 mm (H) X 18 mm (W) Pin–18 mm (L) X 4 mm (D), mild steel as shown in Fig. 4h

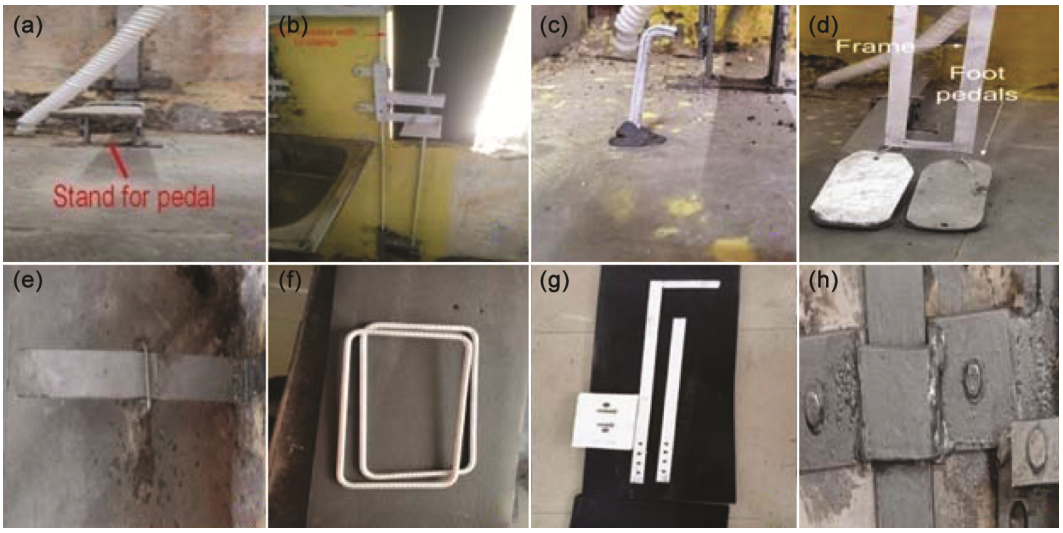

Fig. 2 — a) Mild steel stand for holding horizontal pedal, b) Bar welded with U–Clamp and pedal, c) L–Shape Hook for holding pedal, d) Foot pedal, e) Horizontal pedal, f) Hanging pedal, g) L–Shape mild steel flat for adjusting theheigth of one pedal design and h) Clamp used for holding L-Shape flat.

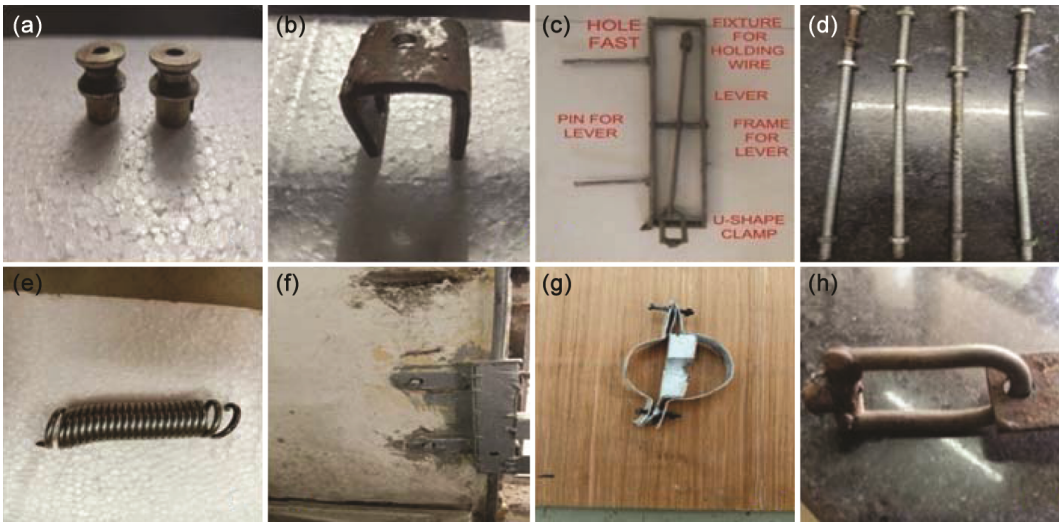

Fig. 3 — a) Pulleys, b) Pulleys holder, c) Lever and lever frame and hole fast, d) Studs, e) Helical spring, f) Rectangular sealed casing for spring, g) Attachement for handle tap, and h) U–Shape Clamp welded with mild steel bar.

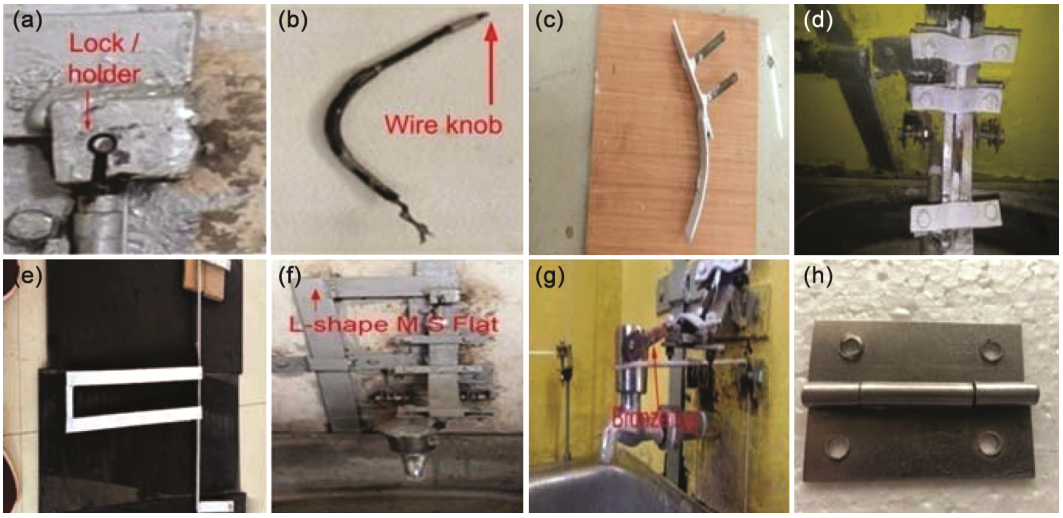

Fig. 4 — a) Lock/holder for clutch wire, b) Clutch wire, c) Stand for Clutch wire, d) Mild steel flat for holding clutch, e) Stand for supporting cotton rope, f) L–Shape mild steel flat, g) Bronze lug, and h) Hinge.

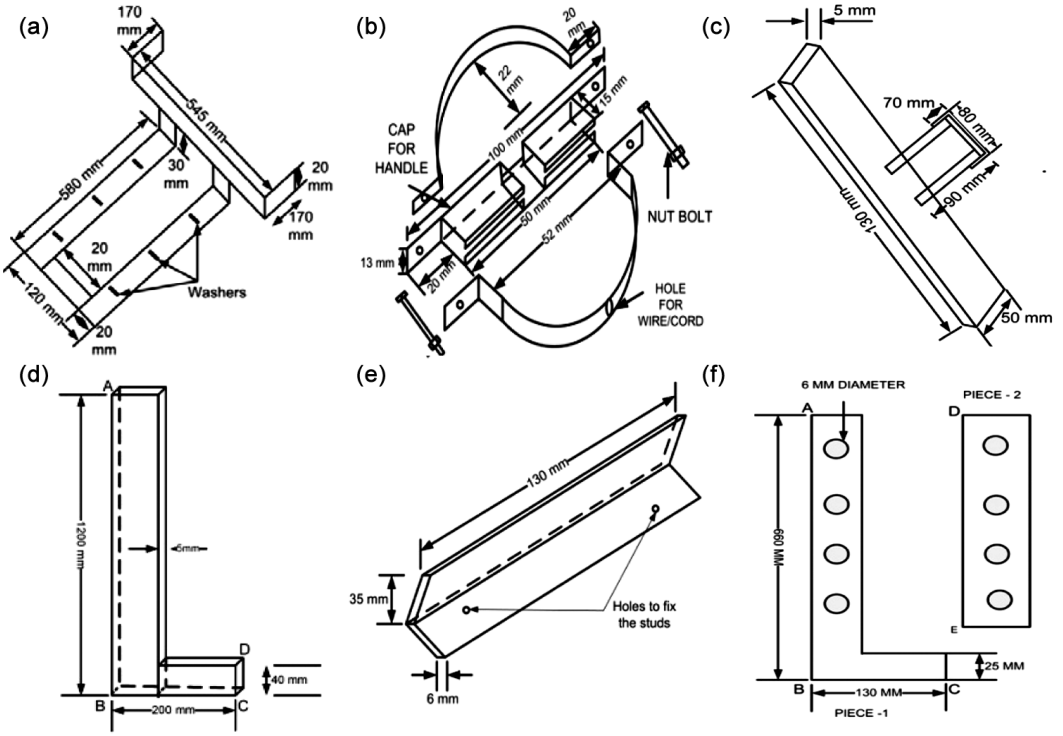

Fig. 5 — Isometric view of (a) frame to support the cotton rope, (b) attachment for the handle of tap, (c) stand for horizontal pedal, (d) L–Shape mild steel flat, (e) stand for studs, and (f) front view of L–Shape flat for adjusting the height of mechanism according to sink height.

The isometric view with the drawings of some parts i.e. frame to support cotton rope, attachment for the handle of tap, stand for horizontal pedal, L–Shape mild steel flat, L–Shape flat adjusting the height according to sink, stand for studs, used with ceramic wash–basin are shown in Fig. 5 (a–f)

2.2 One pedal, lever and wire operated hand free water tap (OPLW)

The one pedal, lever and wire operated hand free water tap (OPLW) design was based on the concept of hand pump operation, shown in Fig. 6 (a–d). It uses human power and mechanical advantage to feed fluids

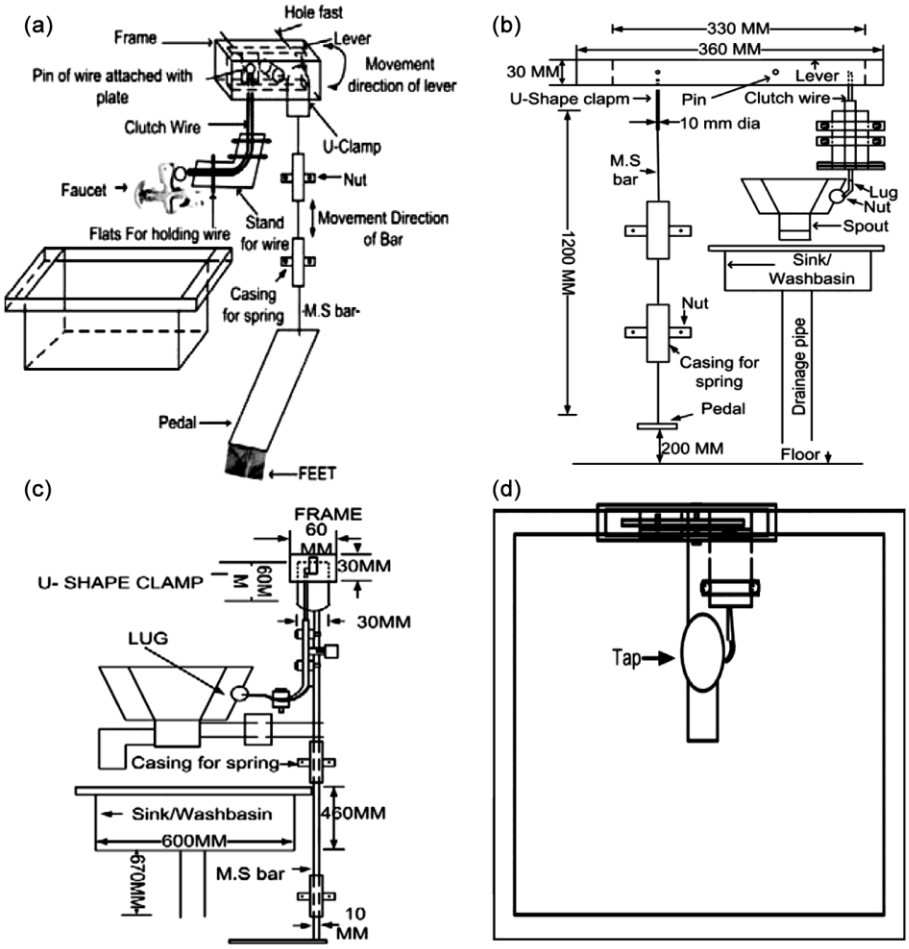

Fig. 6 — Efficient one pedal, wire operated hand free water tap (a) Isometric view, (b) front view, (c) side view, and (d) top view.

from tap to user. It was fabricated utilizing the lever, rectangular frame for the lever, clutch wire along with its outer, holder for griping wire knob, mild steel flats to grip wire, stand for fixing wire, the horizontal pedal of mild steel flat, mild steel bar, helical spring, the rectangular sealed casing of mild steel for helical spring, U–Clamp, nut, and fastener etc.. The pictures of various parts used for fabrication as per specifications (Table-1) and different views of the design are given in referred Fig. 6 (a–d). The clutch wire was utilized to change over the linear movement of the mild steel bar into the rotational movement of the tap. The clutch wire stand was fabricated by giving a curve in mild steel flat and welding the two hole-fast on the rear of stand. The mild steel flats with half round curve of 4 mm radius in the middle were utilized to hold the clutch wire on the stand appropriately.

The clutch wire stand was grouted into the wall simply just behind the tap subsequent to fixing the clutch wire on it with the assistance of mild steel flats, nut and fasteners as shown in Fig. 4 (c &d). Two mild steel flats were used to for fabricate wire knob holder, the detailed dimensions were given in given in Table 1. In first flat a 4mm dia. opening into the focal point and 2 mm slit from focal point to edge were bored and cut respectively. In second flat a 4 mm dia. bore was drilled into the focal point. These two flats were overlapped and welded with one another and the assembly welded toward one side of the lever.

The handle/knob of the clutch wire and the bronze lug were fixed with the holder/lock and the tap. U–Shape Clamp was connected through a 9 mm dia. Opening at focal point of lever end. Mild steel bar was welded with the closures of the U–Clamp. Two springs along with rectangular sealed casing were put in the way of mild steel bar and grouted into the divider at 850 mm center to center distance. The distance between the upper end of bar and spring casing was 135 mm. First and second finishes of the mild steel bar were welded with the U–Clamp and flat

pedal respectively. The 100 mm gap between floor and pedal was utilized to push down the pedal for opening the tap.

When the pedal was pressed (input), it exerted a downward force resulted in pulling of the mild steel bar, lever downward and clutch wire into upward direction respectively. The development of tensile force in the clutch wire was resulted in the opening of the faucet. The action of the horizontal pedal was gently needed fewer forces to open the tap, even very easy to run by children also.

At the point when the pedal was released (output), the spring action pushes back the pedal to its original position to shut down the tap. Continuous flow of water was obtained by attaching the pedal with L–Shape hook grouted to the floor. The drawbacks of the design were analyzed and found that pedal was on the side of the sink so the user needed to push the pedal down from the side.

2.3 Efficient one pedal, wire operated hand free water tap (EOPW)

The design was fabricated by utilizing L–Shapemild steel flat, clutch wire with its PVC outer, clutch wire knob holder and stand for clutch wire, mild steel flats for holding wire, horizontal pedal, stand for pedal, helical spring, nut and bolt. The different parts and views of design are shown in Table 1 and Fig. 7 (a–d) respectively.The assembly which includes clutch wire, stand for clutch wire, flats for holding wire, wire knob holder were same as used for OPLW design. The wire knob holder was welded with one finish of L–Shapemild steel flat. The L–Shape mild steel flat was put 5 mm apart against the divider and held by clamp with the goal that it can go all over uninhibitedly.

The one finish of the clutch wire was fixed into knob holder/lock and other one with lug. The lug was connected to the tap. A hinge was fixed with nut bolt at different closures of the L–Shape mild steel flat and the flat pedal to join both to allow the movement of both parts. A suitable stand was used to rest the pedal. A pedal stand was fabricated by bending the mild steel flat in U–Shape and welded it with a flat in the topsy turvy position. A U–Shape bar was likewise welded on the top of U–Shape of mild steel flat. The flat pedal was inserted in between the opening of U–Shape flat and bar.

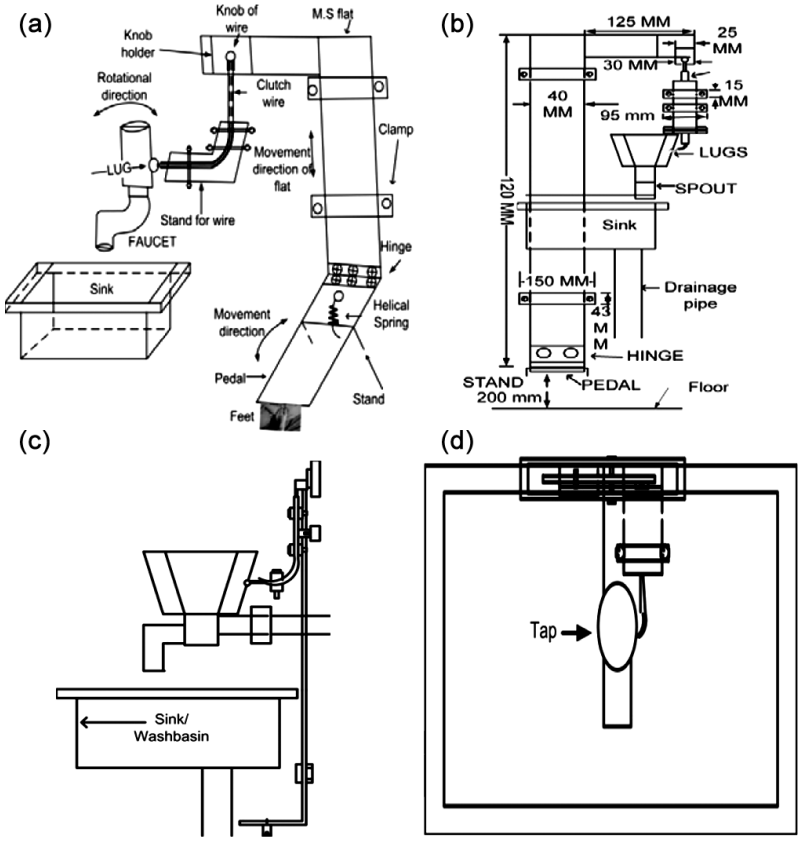

Fig. 7 — Efficient one pedal, wire operated hand free water tap (a) Isometric view, (b) front view, (c) side view, and (d) top view.

The pedal stand was grouted into the floor a good way off of 250 mm from the divider. The pedal was refreshed at the stand. A spring was fixed between the flat pedal and floor, close to the hinge joint. The input/output were given to tap by the user by squeezing the even pedal a descending way. At the point when the pedal was released, the spring energy pulled the pedal once again into the down/rest position. So the clutch wire was additionally pushed down into the rest position by the L–Shape flat to shut down the tap.

2.4 Two pedals and stud operated hand free water faucet (TPS)

The two pedal designs was fabricated using mild steel studs, pulleys, pulley holders, hanging/foot pedal, cotton rope, nuts and screws. The different views of mechanism are shown in Fig. 8 (a–d). Four openings were bored at the extreme corner edge of the metal sink. The pulley holders were fabricated by welding the three mild steel flats in U–Shape. The pulleys set into the pulley holders with the assistance of stray pieces. The holders along side pulleys were welded at the one finish of studs in particular manner.

The entire congregation of studs, pulley, and pulleys holder were fixed at four openings. The stature of the studs was 110 mm (up to the focal point of the pulley) from the upper edge of the sink. The tap height was coordinated with the gathering stature. The studs were fixed in a way that the stature of the gathering was coordinated to the tap's height. An opening was bored into the cap of the tap. The center mark of the cotton rope was appended into the opening of the cap's tap with the assistance of a nut. The two closures of the line were strung individually into the left and right pulleys.

At last, the finishes of the rope were attached with hanging pedals. The right/left pedals were hanged in a vertical position, 200mm over the floor. The input/output was given by the user through right/left pedals (pressing the pedal downward) to work the tap. At the point when the right/left pedal was squeezed by the user a descending way, the rope changed over the linear movement of the pedal into the rotational movement of the tap. The tap was opened by right pedal and closed by left pedal. The design creates hindrance during the utilization of the tap and also occupies more space on the sink. The pedals were moreover not remained in stable condition while giving input/output.

2.5 Efficient two pedals and pulley operated hand free water tap (ETPP)

This design was fabricated utilizing pulleys, pulleys holders with hole fast, hanging/foot pedal, string/cotton rope, nuts, and fasteners. The different views of design were shown in Fig. 9 (a– d). The

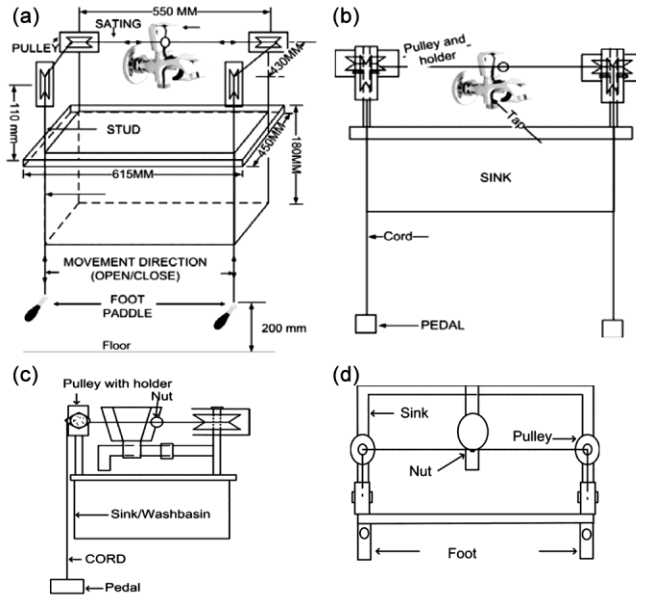

Fig. 8 — Two pedals and stud operated hand free water faucet (a) Isometric view, (b) front view, (c) side view, and (d) top view.

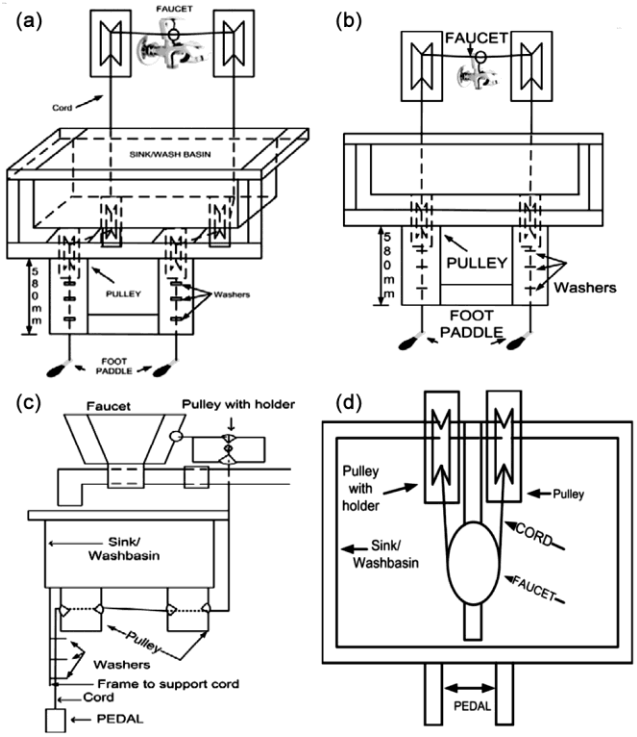

Fig. 9 — Efficient two pedals and pulley operated hand free water tap (a) Isometric view, (b) front view, (c) side view, and (d) top view.

pulleys were fixed to the pulleys holders with the assistance of stray pieces. The pulleys and pulley holder's assembly were equivalent to the above expressed. The two congregations of pulleys and holders were grouted into the divider simply behind the tap at the tap's stature and at 100 mm separated from one another. Four same congregations were welded at the lower part of the sink in a way with the goal that both pulley gatherings coordinated with the line of the pulleys grouted into the divider.

The distance between the gatherings was 100 mm and an opening was penetrated into the cap of the tap. The center mark of the string was appended into the opening of the cap's tap with the assistance of a nut. The two finishes of the rope were, strung individually into all pulleys. A T–Shape outline was welded at the front edge sink to help the foot pedals. Three metal washers were welded with an edge of T–Shape outline at 260 mm apart from each other. The rope was strung from these metal washers.

At last, the ends of the rope were attached with hanging pedals. The privilege and left pedals were hanged vertically, 200 mm over the floor. The input/output was given by the user through right/left pedals to work the tap. At the point when the pedal was squeezed by the user a descending way, the line changed over the linear motion of the pedal into the rotational motion of the tap.

3 Results and Discussion

Proposed design modification for changing the tallness of efficient one pedal, wire operated hand free water tap. The length of L–Shape mild steel flat was made adjustable by cutting the L–Shape flat into two pieces and got together with a nut fastener to change the stature of sink/wash–basin according to the height of sink/wash–basin. Additionally, the wire stand can likewise be made movable by joining the substitute two pieces. The handle type tap was modified into a round cap tap by fixing the connection on the handle type tap. For the fabrication of all four designs in place of mild steel flats, suitable plastics strips/bar can be used.

The advantages of the proposed design that there was no need to change the existing tap and touch the faucet during operation. These designs save water as flow was made controlled through pedal. It will protect from infection or virus with easy operation of faucet. These were detachable designs and easy to install with zero leakage problems. Continuous flow of water was achieved by attaching the pedal with hook/clamp. All four designs are economical and require lesser maintenance. All designs can also be used with the tap fitted at below/above of the sink with some proposed adjustment. Physically challenged person and children were able to operate easily the tap. Use of PVC materials would reduce the corrosion problems and reduce the materials cost also.

4 Conclusions

The current innovation gives design and manufacture of foot–worked tap which is a need to mitigate spreading of Covid 19 by using existing knob of taps during pandemic. The tap was installed at Fire Research Laboratory, CSIR–CBRI, Roorkee, tested for three months and worked properly without any troubles. The current designs can be introduced with round cap tap in a public place, schools, trains, home etc. On the off chance that the current tap is of "handle type" a connection can be fitted with a tap handle to change the handle into a round shape Fig. 3(g). The element of connection might be taken cotton rope to the current tap handle. The current development will give a contamination–free system, as no compelling reason to contact the tap to work, stops the wastage of water, one can control the progression of water with the pedal. The developed designs were practically fabricated and tested the performance of the four devices which found technically sound and adoptable for public use.

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