Analysis of Leg Cum Hand Clutch

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Abstract- *the goal of the leg cum hand clutch is that can be used by paraplegics to control manual transmission automobiles. The efforts required in achieving the desired output can be effectively and economically be decreased by the implementation of better designs. The dry type hand clutch is used where it is attached to the clutch pedal (leg) by means of Bowden cable at bottom. When the hand clutch gets engaged the Bowden cable will transmit the mechanical force towards the clutch pedal, where the leg clutch will get engaged. For better efficient the spring is used to give the required force to engage the leg pedal. The practical difficulties faced while fabricating the leg cum hand clutch were solved and that offers a tactile response with simple installation process under working conditions.*

Keywords- leg cum hand clutch, paraplegics, dry clutch, Bowden cable, leg pedal

I. INTRODUCTION

The technology level is increasing in day to day life. The efforts required in achieving the desired output can be effectively and economically be decreased by the implementation of better designs. A manually operated clutch in hand for light and heavy vehicles is taken as a product. Hundreds of thousands of individuals live with leg disability in the India, and permanent prognoses of leg injuries are common. It is estimated that more than 250,000 individuals in the India are currently living with spinal cord injuries. Motor vehicle accidents account for 46% of the injuries followed by acts of violence and falls at 25% respectively.

II. EXISTING MODELS

The clutch is connected at the steering rod for user convenient (Figure. 1) and there are disadvantages faced by the user. The rod type clutch will be place behind the steering so when to engage the clutch the user want to simultaneously control the steering and to engage the clutch rod behind the steering in one hand so that the control of the steering will not be in proper position. This device requires the use of both hands on the steering wheel, making it effective only in an automatic car.

Figure. 1 Rod type clutch behind the steering

eLap clutch

The problems faced in above are rectified here, the clutch is attached with the gear rod (Figures. 2&3).The problems overcome compared with the above, the user can easily engage gear alternatively clutch also. And overall steering control as compared with the case above is far better.

Figure. 2 eLap Duck Clutch

Electronic clutch actuation for manual vehicles is a relatively new and technology driven industry. Elap, a UK design, manufacture and installation company for mobility products, offers two hand-clutch interfaces for manual transmission cars. Its first, the “Synchro Drive” clutch, is a button mounted to the gear selector that operates with a computer which reads the engine’s RPM, the car’s speed, braking and acceleration input. When the button is released, the clutch is engaged at a rate decided by the computer. This renders the vehicle nearly impossible to stall, as control the clutch is left to the clutch control unit. It can be adjusted statically to fit different driving techniques, but not dynamically, so on-the-fly adjustment of the clutch engagement is not possible. Elap also offers the “Duck” clutch, which is another semi-automatic clutch control system that offers a variable lever instead of the synchrodrive’s button. The lever operates the clutch by a fly-by-wire method.

Figure. 3 elap Synchro Drive Clutch

Wet vs dry systems

There are two main different kinds of clutches in multiple plate clutch: dry and wet. The wet clutches are used when is necessary to transmit high torque from the engine to the wheels.

A wet clutch is immersed in a cooling lubricating fluid that also keeps surfaces clean and provides smoother performance and longer life. Wet clutches, tend to lose some energy to the liquid. Since the surfaces of a wet clutch can be slippery (as with a motorcycle clutch bathed in engine oil), stacking multiple clutch discs can compensate for the lower coefficient of friction and so eliminate slippage under power when fully engaged. The wet clutch that relied entirely on viscous effects, rather than on friction. A dry clutch is not bathed in liquid and uses friction to engage.

III. MATERIALS

Various materials have been used for the disc-friction facings, including asbestos in the past. Modern clutches typically use a compound organic resin with copper wire facing or a ceramic material. Ceramic materials are typically used in heavy applications such as racing or heavy-duty hauling, though the harder ceramic materials increase flywheel and pressure plate wear.

In the case of "wet" clutches, composite paper materials are very common. Since these "wet" clutches typically use an oil bath or flow-through cooling method for keeping the disc pack lubricated and cooled, very little wear is seen when using composite paper materials.

The main characteristics of a good facing material are listed below:

a) High friction coefficient
b) Wear resistance
c) Mechanical resistance
d) Thermal resistance
e) Good thermal conductivity
f) Lifetime
g) Good feasibility
h) Environmental comparability

Symbols, abbreviations and nomenclature:

As in [5], The symbols, abbreviations and nomenclature used in the calculation part are listed below:

TABLE 1 SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

kg	Kilogram
F	Force
cm	Centimeter
mm	Millimeter
n	Number of active coils
D	Mean diameter of the spring
d	Wire diameter
P	Pressure
y	Axial deflection
Y	Maximum deflection
G	Modulus of rigidity
L	Length of the spring
σ	Stress
Ʈ	Shear stress
k	Wahl’s stress factor
D_o	Outer diameter of the coil
D_i	Inner diameter of the coil
l_o	Free length
n'	Number of additional coils
a	Clearance
F_o	Rate of spring
p	pitch

IV. CALCULATION

i) Pressure calculation

As in [6],

Force of 20 to 30 pounds is required to move a vehicle for 4” to 6”

1 pound	=0.45kg	
(0.45*20) to (0.45*30)	=9.071kg to 13.607kg	(1)
1kg	=9.81N	
(9.071*9.81)to (13.607*9.81)	=88.96N to 133.44N	(2)
1 inch	=2.54cm	
(4*2.54) to (6*2.54)	=10.16cm to 15.24cm	(3)
	$=103.225cm^2$ to $232.25cm^2$	(4)
Pressure, P	=F/A	(5)
P	=9.071/103.22	
P	$=0.0892kg/cm^2$	(6)
P	=13.607/232.25	
P	$=0.0512kg/cm^2$	(7)

ii)Spring calculation

Consider as a closed coil helical spring
As in [2], [7]

i)Diameter of wire:

Mean diameter of the spring, D =70mm
Wire diameter, d =10mm
Number of active coils, n =50

Spring index, c =D/d
=70/10
c =7 (8)

Wahl’s stress factor, k = (4c-1)/(4c-4) + (0.615)/c
= ((4*7)-1/(4*7)-4+0.615/7
= 1.125+0.087
k = 1.212

Assume F= 133.46, for 6”

Shear stress, Ʈ $= 8FDk/\pi d^3$
$= (8*133.44*70*1.212) /\pi*(10)^3$
Ʈ $=28.82\ N/mm^2$

ii)Diameter of coils:

outer diameter of coil, D_0 =D+d
D_0 = 80mcm
Inner diameter of coil D_i = D-d
D_i = 60mm

iii)Number of coils or turns:

Assume y = 23mm
As in [3],
Axial deflection $y = (8FD^3n) / Gd^4$
$23 = (8*133.44*70^3*50) / G*10^4$
$G =0.795*10^5 N/mm^2$

iv)Free length:

$l_o \geq (n+n')d+Y+a$

where,Y = Maximum deflection assume 5mm
clearance ‘a’ = 25% of maximum deflection or a =xdi,
n’ = number of additional coils
assume squared and ground end n’=2
a =(25/100)*23
a =5.75mm
$l_o \geq (40+2)1+5+5.75$
$l_o \geq 52.75mm$

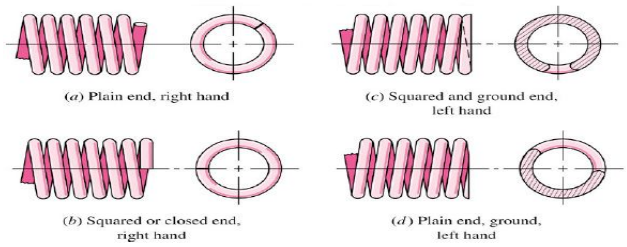

TABLE 2 END CONDITIONS AND LENGTH OF SPRINGS

As in [1],

Type of end	Total coils	Free length (L_f)	Solid height (L_s)
Plain	n	pn+d	dn+d
Plain and ground	n	pn	dn
Squared	n+2	pn+3d	dn+3d
Squared and ground	n+2	pn+2d	dn+2d

v) Rate of spring:

F_O =F/y
=133.44/23
F_O =5.801N/mm

vi)Pitch

$p = (l_o-2d)/n$
= (52.75-(2*10))/40
p = 0.818mm

vii) Material

From PSG data book, Page Number 1.1

For the modulus of rigidity value obtained as seen above we can see that C65 Steel (0.60%-0.70% C & 0.50%-0.80% Mn) is the suitable material.

From PSG data book, Page Number 1.10

It is observed that C65 Steel is typically suitable for manufacturing springs and so C65 Steel is chosen as the spring material.

Break-even point:

The fabrication cost for the prototype calculated as follows.

Fixed cost (FC) = Rs. 2000
Variable cost per unit (VC) = Rs. 500
Quantity sold (Q) = 1000 per month
Total cost (TC) = FC + VC
= Rs.2500
Selling price (SP) = Rs.3000
Total revenue (TR) = SP×Q
= 3000×1000
= Rs.3000000
Break even quantity (QBEP) = (TR) ÷ (SP - VC)
= 1200
Break point in Rupees = (QBEP) x SP
= Rs.360000
Contribution = SP – VC
= 3000– 500
= Rs.2500
Contribution ratio = ((contribution) ÷ (SP)) × 100
= ((2500 ÷ 3000)) × 100
= 83.34%
Profit volume ratio = (contribution ÷ sales) × 100
= (0.833÷ 1000) × 100
= 8.33%

Therefore, breakeven point is calculated and results are given below

Break even quantity = 1200 units per month
Breakeven price = Rs.360000

Leg cum hand clutch description

The main function of this hand operated clutch is manual convenient(new user)and handicap person convenient(one leg handicap).The pedal order in vehicles is accelerator, brake, clutch(right to left). Any one leg is used to control the two pedals. The hand clutch will be attached to gear rod. The Bowden cable is used to connect the hand clutch and leg clutch inter relatively. The clutch pedals are actuated at the speed required by traditional driving standards and allows for traditional vehicle operation (forward, reverse, and gear change) .To achieve a required force, use a Bowden cable to actuate the clutch. The Bowden cable has a steel cable within a housing cable. The housing cable is fixed, the steel cable inside can move. Starting from the clutch pedal, the cable is attached at the lowest point of the pedal and travels straight back. The cable travels along the up and to the shifting. The brake tighter will be placed over the leg pedal and the steel wire of the cable will be tightened inside it. The same force will not be attained while controlling the leg clutch in hand. Closed coil helical spring is used to attain the force which attain in leg. The hand clutch will be connected to the gear rod, behind the gear knob. The Bowden cable is used to connect the hand clutch to the leg clutch, at that time the spring will be compressed. When hand clutch engaged the leg pedal will get engaged. The prototype of leg cum hand is shown in Figure.4

Figure.4 Prototype of leg cum hand clutch

Bearing force vs Displacement

Bearing force vs Displacement graph is shown in Figure.5. The x- axis indicates displacement in inches and y-axis indicates force in pounds. As in[8]

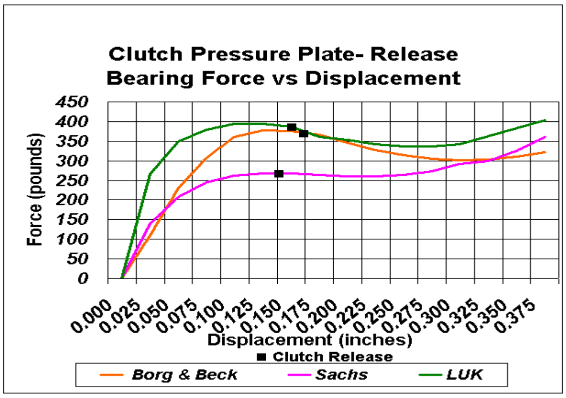

Figure.5 Bearing force vs Displacement

TABLE 2 Parts and functions

S.No.	Part	Function
1	Bowden cable	To connect the leg pedal and hand clutch
2	Hand lever	To control the leg pedal by hand operation
3	Spring	To give the required force to engage the leg pedal

Merits

i. Simple design.
ii. Almost zero maintenance.
iii. Repairing is easy.
iv. Cheaper.

Demerits

i. Not applicable for all the users.
ii. Difficulty on hills.
iii. Spring may get varied for each vehicle

V. CONCLUSIONS

The final goal is to design a mechanism that will be able to afford paraplegics. In order to accomplish this goal there are three important steps. The first is to evaluate the current state of driving assistance devices and determine the market need. Then, to design a first generation prototype of a product that would be minimally invasive, safe to use, and that would grant the user full control of the vehicle.

That there are three main conclusions that can be drawn from our work on this project, universal compatibility, cost effectiveness, and a more satisfactory driving experience. With slight modification this device could potentially work in any vehicle. Some existing market devices can potentially cost upwards of ▪ .8, 000. This device is capable of being manufactured and installed for under ▪ .2, 000, giving it a significant advantage. The device enables the user to actuate the complete range of motion of the pedal that allows a tactile response by way of the hand controls.

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