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Analysis of Variable Linkage Mechanism to Reduce Pedal Effort

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ABSTRACT

This research article present a optimization technique by which can reduce the pedal effort effectively with the help of variable linkage ratio. The pedal effort is directly relation to the human comfort and in India farming is done by the largest population. The farming practices adopted in India tend to be aggressive than other countries. This includes maximum use of tractors for agricultural applications which are carried out under severe environmental conditions. This has given rise to various health issues due to pro-longed tractor usage in extreme conditions. Reducing force required to operate the pedal will subsequently reduce the driver fatigue for both men and women. It will also reduce/ eliminate subsequent health issues, thus allowing the farmers to work for longer hours. This will improve the usability of the tractor and may also help in improving the Customer Satisfaction Index
This optimization technique is carried out on the clutch pedal of the agricultural tractor.

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I. INTRODUCTION

Clutch is a mechanical device that engages and disengages the power transmission. It plays an important role for driving any automobile by helping us to give as well as cut the power transmitted to the Wheels. Applications of clutch can be seen on various automobile categories that include Cars, Trucks, Buses, Motorcycles, Tractors, Bulldozers, etc. In case of Off-Road vehicles such as Tractors, mechanical linkage is commonly used to engage and disengage the Clutch, unlike bikes and cars which use cables.

The current situation shows that the average pedal force required to operate the Brake & Clutch pedal is greater than or equal to 25 Kg.
However, as per the suggestions given by the, 'Central Institute of Agricultural Engineering (CIAE)' from Bhopal, Madhya Pradesh;
The effort required for:

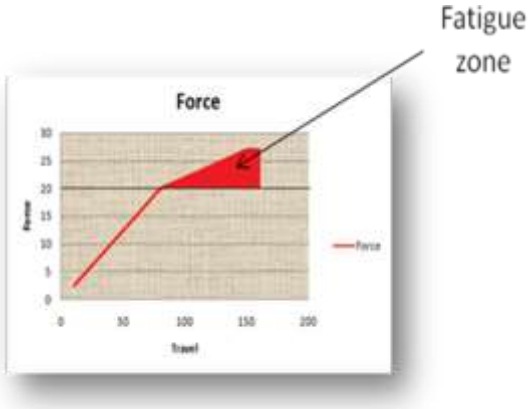
- Brake Pedal should be < 26 kg
- & Clutch pedal should be < 20 kg.

Indian farming practices are different from those practised in other countries. Rice is the major crop here and is cultivated in most of the India. The land preparation for rice involves application called puddling. This application requires the tractor to perform in a submerged Condition in mud. The skill required to control the tractor in such condition is immense, in order to avoid toppling. The use of clutch is made very frequently in this application. Since the force required to operate the clutch pedal is already more, working under such extreme conditions, for longer hours tend to raise health issues such as damage and other issues to knees.
With women working shoulder-to-shoulder along men, they are seen driving tractors nowadays. The number of female tractor drivers has increased considerably. The physical strengths of male and female workers are totally different from each other.
Hence, the need to improve the tractor ergonomics for the Women's anthropometric conditions and to resolve health concern in men, becomes imperative. It is important that the force required to operate the Clutch pedal has to be less or optimum. It must comply with the rules and regulations as per the standards laid by the Government of the country. It should also be cost effective in terms of manufacturing, serviceability and have less maintenance cost.
This projects aims to design Pedestal Linkage in order to reduce effort required for operating the clutch. As already

stated, Brake & Clutch pedals are generally designed with mechanical linkages. In order to reduce the pedal effort there is a need to innovate and develop a new Linkage mechanism which will drastically reduce the operating force without affecting the working and efficiency of the Clutch mechanism

Problem Statement

Tractor Clutch pedal effort is high due to which driver unable to drive for long hours & after few hrs driver started knee pain & fatigue



Objective of Study

- Reduction of pedal effort without affecting working efficiency
- Reduce driver fatigue.
- Encouragement for woman driver
- Increases the customer satisfaction

II. Literature Survey

1 .C.R.MEHTA, M.M.PANDEY, P.S.TIWARI, L.P. GITE & ABHIJEET KHADATKARI

In this research paper various actuating force acting on the different controls are given for the human comfort in which for clutch pedal it given as 125 N also in this research paper ergonomics conditions like reach & efforts are given.

VOICE OF CUSTOMER

ACCORDING TO USE (OF PEDAL)			
CUSTOMER	Tractor Owner	Tractor Driver- Male (Farm & CE Appl)	Tractor Driver- Female
BRIEF DESCRIPPTION	- Customer having tractor for his own farm use - This tractor is driven by any of the male member of the family - Use of tractor is seasonal & intermittent (5-6 hrs/day)	- Customer driving his own tractor for his farm as well as taking the local farming contracts - Drivers working on contracts (8-12 Hrs/day)	- Lady drivers, having tractor at their homes want to help their family by operating tractor (New Segment explored)
TYPE OF CUSTOMER	External	External	External
PRIORITY	Low	High	High

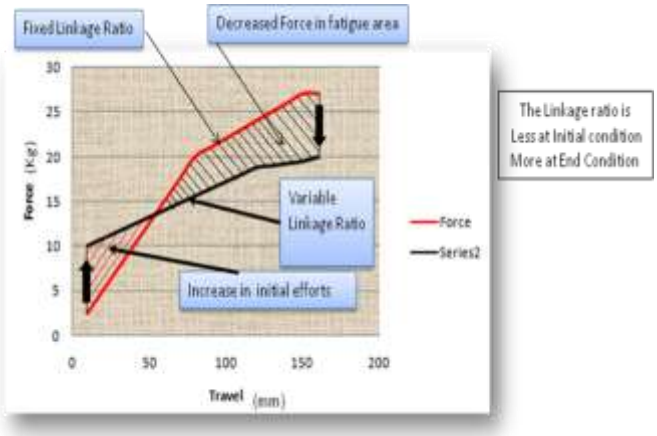
III. Required Design Calculation

For Existing Linkage

Operating Force = 250 kg (As per drawing)
Pedal length = 433 mm
Link 1 Length = 57 mm
Link 2 length = 100 mm
Sleeve length = 70 mm
Linkage Ratio =10.85 (calculated on linkage layout)
Force on Pedal = Operating Pedal / Linkage Ratio
Force on Pedal = 250/10.85
Force on Pedal = 23 kg

For New Linkage

Operating Force = 250 kg (As per drawing)
Pedal length = 332 mm
Link 1 Length = 62 mm
Link 2 length = 100 mm
Link 3 length = 86 mm
Link 4 length =57 mm
Sleeve length = 70 mm
Linkage Ratio Initial =11(calculated on linkage layout)
Linkage Ratio Final =14 (calculated on linkage layout)
Force on Pedal = Operating Pedal / Linkage Ratio
Force on Pedal = 250/11
Force on Pedal Initial= 22.7 kg
Force on Pedal Final = 250/14
Force on Pedal Initial= 17.8 kg



IV. CAD MODELLING

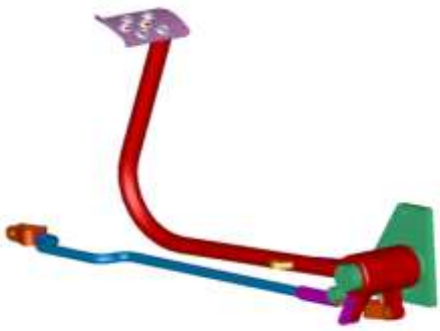


Fig.1.CAD Existing Pedal Linkage

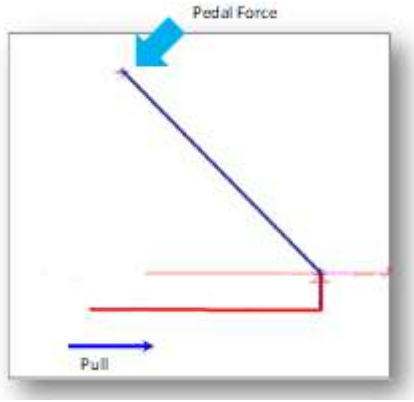


Fig.2. 2D CAD Existing Pedal Linkage

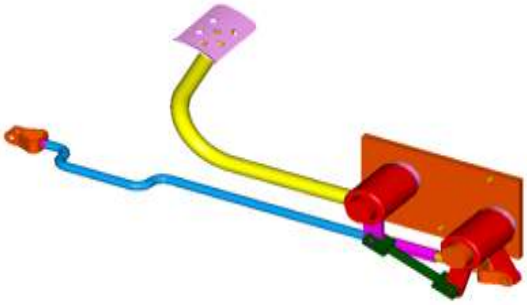


Fig.3. CAD New Pedal Linkage

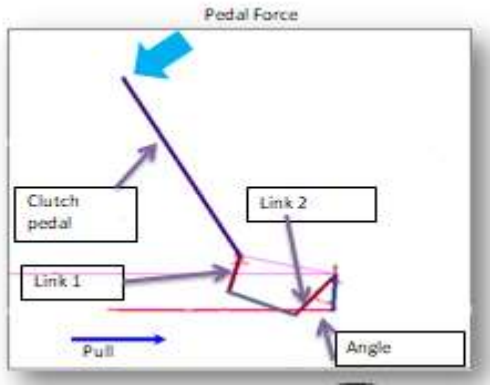
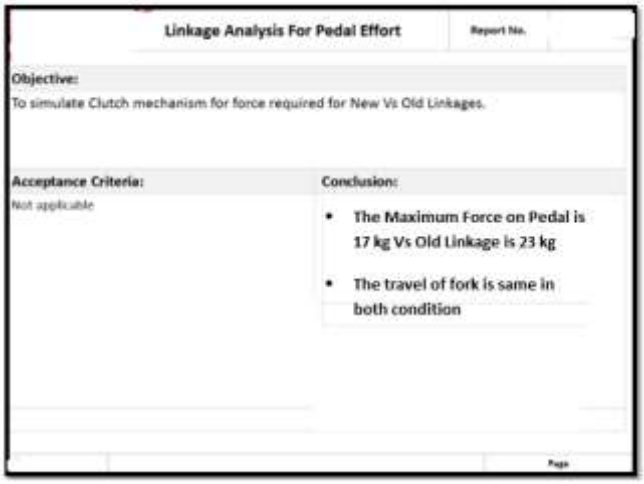


Fig.4. 2D CAD New Pedal Linkage

V. FEA ANALYSIS (ADAMS)

The ADAMS software used to analyse multi-body dynamic simulations Adams has a full graphical user interface to model the entire mechanical assembly in a single window. Graphical Computer-aided design tools are used to insert a model of a mechanical system in three-dimensional space or import geometry files such as STEP or IGS. Joints can be added between any two bodies to constrain their motion. Variety of inputs such as velocities, forces, and initial conditions can be added to the system.



Linkage Analysis For Pedal Effort

Report No.

Objective:

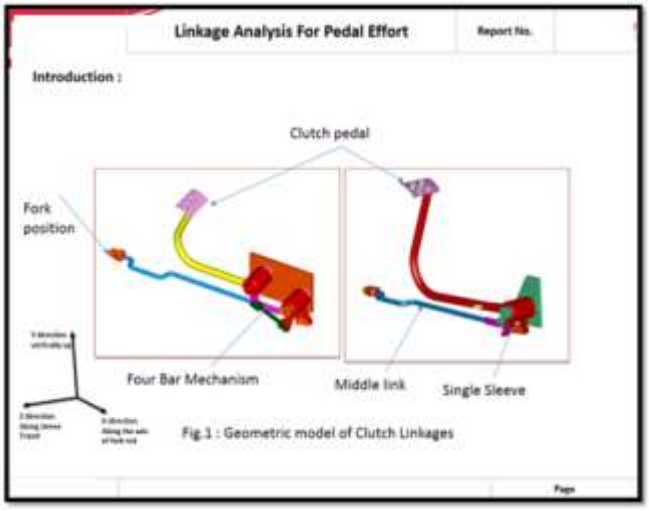
To simulate Clutch mechanism for force required for New Vs Old Linkages.

Acceptance Criteria:

Not applicable

Conclusion:

- The Maximum Force on Pedal is 17 kg Vs Old Linkage is 23 kg
- The travel of fork is same in both condition

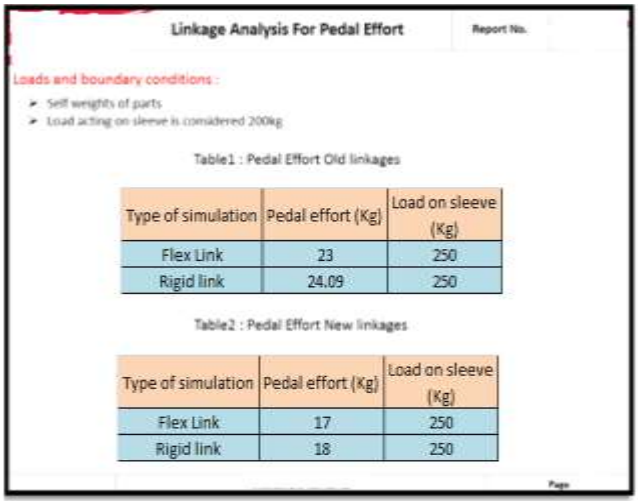


Linkage Analysis For Pedal Effort

Report No.

Introduction :

Fig.1 : Geometric model of Clutch Linkages



Linkage Analysis For Pedal Effort

Report No.

Loads and boundary conditions :

- Self weights of parts
- Load acting on sleeve is considered 200kg

Table1 : Pedal Effort Old linkages

Type of simulation	Pedal effort (Kg)	Load on sleeve (Kg)
Flex Link	23	250
Rigid link	24.09	250

Table2 : Pedal Effort New linkages

Type of simulation	Pedal effort (Kg)	Load on sleeve (Kg)
Flex Link	17	250
Rigid link	18	250

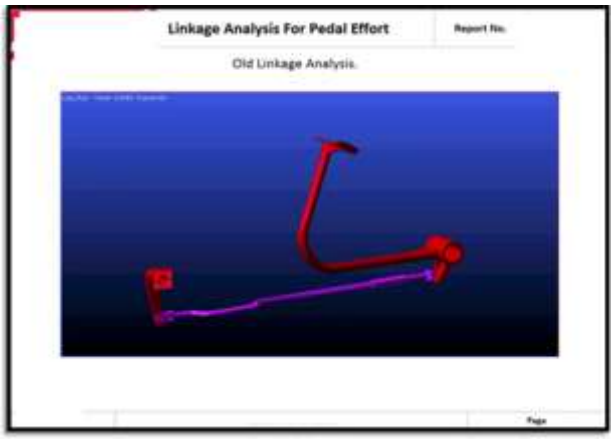


Fig.5. Old Pedal Linkage

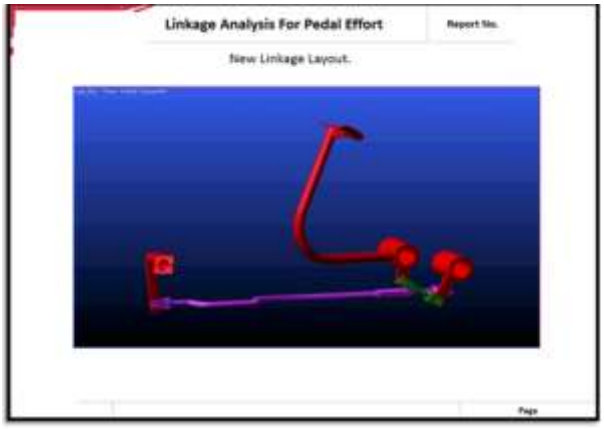


Fig.6. New Pedal Linkage

VI. RESULTS

A dynamic analysis is carried out based on which it is found that it is equivalently matching with the design calculation also it is clear that Force on pedal is reduced from 23 kg to 18 kg.

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VII CONCLUSION

1. Based on Variable Linkage ratio force on pedal is reduced form 23 kg to 18 kg
2. Based on reduction on pedal customer/driver feel comfortable while driving
3. This variable linkage ratio can be adapted to further mechanical linkages to reduce the forces.

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