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Design and Fabrication of a Walking Chair using Linkage Mechanism

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Abstract— **A machine is designed with the intentions of exploiting the advantages of the walking motion over the traditional rolling motion. Over the years people with locomotive disability have struggled to live a life of independency, many ideas were developed to kill the dependency but those ideas were lost either in research or the heavy expenses doomed them.**

For a country like India, whose majority of the movement disabled population resides in the rural areas, it is very important to develop and alternative to their woes at very minimal cost. The answer to this was sought in the development of the walking chair. The project is intended to develop a chair that can be used on varied terrain and that can overcome small obstacles at the price of most basic wheelchair available in India.

This idea utilizes a parent idea of Theo Jansen, a Dutch physicist who invented a mechanism for the leg like motion of a system and called it the Jansen linkage. Now using these linkages we intend to build a chair that is propelled by hand using a chain and sprocket mechanism in order to make it cost effective.

Hence to sum up in a line our project changes the history of 8000 years in locomotion technology keeping in mind the social need for a change.

I. INTRODUCTION

According to a recently conducted census about 2.13% of total population of India comprises of physically disabled people. 75% of the disabled live in rural areas, only 49% are literate and only 34% are employed. While earlier the focus was on medical rehabilitation of these people now the focus has shifted to the social rehabilitation of the same and hence independency remains an untold parameter in this. Another important factor that restricts the modern technology invading and improvising the lives of these people is the cost involved.

The poorer section of the disabled is found on the streets of India making their living through various sources. Due to the terrain and the road conditions these people face difficulty in adapting themselves in any public facility and hence are very often assisted by another member. This puts underdevelopment stress not only on the differently abled but also on the person assisting him. Hence the idea of making them independent and adaptable to Indian terrain was thought of in the form of walking chair. The concept was then thought of to make it cheap and available to all sections of the society.

II. LITERATURE SURVEY

Different mechanisms were thought of before choosing the most suitable ones. Different projects were studied and researched that could facilitate the cost effectiveness and the varied terrain capabilities. Some of them are compared in the table below:

Parameter	Top chair	Tri-wheeled stair climber	Walking beam transfer mechanism	Strandbeest
Durability	Highly durable	Not durable	Highly durable	Durable
Cost effectiveness	Most expensive	Not very costly	Very costly	Very cost effective
Implication	Complicated yet possible	Very easy	Very difficult and complicated	Very easy
All terrain capability	Excellent capacity	Limited lift	Slow and bumpy ride	Natural walking motion with limited lift

Table 1: Comparison of the mechanisms studied

After the above comparison the Jansen mechanism was chosen as the best mechanism to meet the objectives of the project.

III. WORKING PRINCIPLE

A. Introduction to walking mechanism

The Jansen's linkage is basically a crank based mechanism wherein the rotary motion of one link of the mechanism is converted into the walking motion of the entire mechanism. The foot of the linkage is the contact with the ground which has the four phases of lifting, returning, supporting and lowering which in combination propels the system forward. The locus of the foot represents the way the linkage actions.

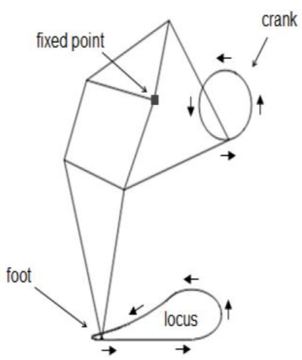


Figure 1: Crank based Jansen linkage mechanism also called the leg system

B. Walking Mechanism

The Jansen Linkage in its raw form cannot be utilized for the purpose of making a walking chair as it was designed for a single leg on huge Strandbeest. Hence there should be a proportionate reduction in the linkage lengths without losing the desirable traits mentioned in the previous section.

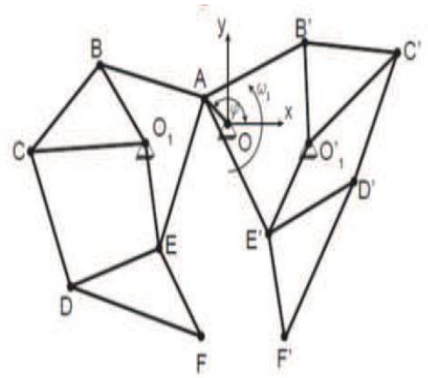


Figure 2: Proportionately reduced Mechanism utilized in the project

The lengths of the Links with respect to the Figure are as follows:

- $BO_1 = CO_1 = B'O_1' = O_1'C' = 173$ mm
- $CD = O_1E = O_1'E' = C'D' = 173$ mm
- ED = E'D' = 173 mm
- EF = E'F' = 260 mm
- OA = 71mm
- $O_1 O_1' = 572$ mm
- AB = AB' = 253 mm
- EA = E'A = 278 mm

These lengths were chosen in order to achieve optimal working space of the project and also to ease the fabrication process and avoid errors due to unsize machining. Here the link OA is the crank which drives the entire mechanism about the three fixed points O_1, O and O_1'. The points F and F' represent the foot of the mechanism that traces the locus for the four phases of the walking motion.

If we consider the above shown pair of limbs to be a set of limbs that act together in the entire project, then four of such sets were utilized for the complete locomotion of the project. Two sets were fixed on the right side of the seat and the other two on the left side. The orientation of the entire setup is as shown in the Figure 3.

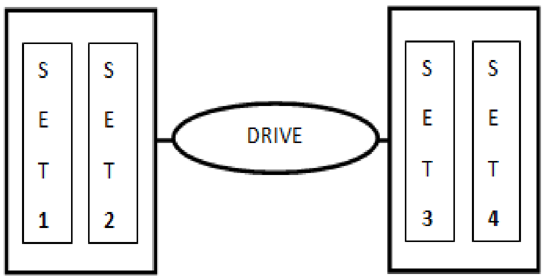


Figure 3: Orientation of different linkage sets on the entire set up

C. Drive Mechanism

For the driving of the chair, amongst the options available like electric motor drive, leg pedal drive and hand pedal drive, hand pedal drive was chosen. It was chosen simply because use of Electric motor would increase the cost of production and vulnerable on streets due to water (housing would add extra weight and cost on production along with battery) and leg pedaling was impractical since it the objective was to develop this project for the movement disabled people.

Two hand pedals were used to drive two chain sprocket mechanisms on either side of the driver to aid in reducing the effort required to propel the chair forward. The orientation of the hand pedaling system is shown in the Figure 4.

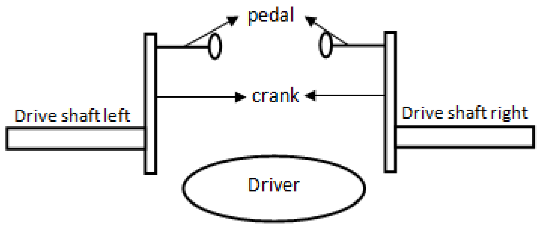


Figure 4: orientation of the hand pedals in the project

IV. DESIGN AND MATERIAL USED

A. Preliminary Design

1) 3D Assembly of the initial concept

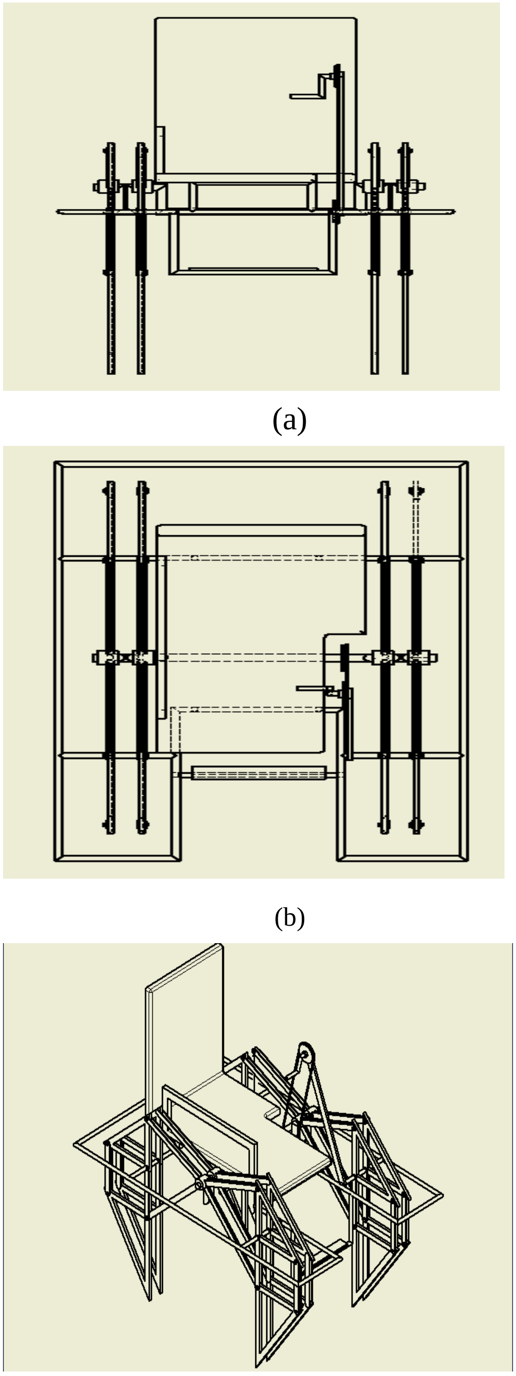
It was of primary importance that the idea was developed into a shape. Fabricating it on a small size or prototyping it was ruled out due to time and work space constraints. Hence we chose to model our idea on Autodesk Inventor – 2014. The primary considerations that were taken in before we started the modeling of the assembly were:

- Simplicity in understanding the project
- Work volume to be reduced as much as possible
- Keeping it explainable to everyone

Figure 5: Autodesk Inventor rendering of the initial idea of walking chair

2) 2D drawings of the assembly

The assembly was converted into drawing and drafted for the purpose of explaining and understanding the model from different views. The Drafting was again done in Autodesk Inventor after importing the assembly into the Drawing file. The different views of the assembly are shown in the Figures below:



(a)

(b)

(c)

Figure 6: Drawings of the assembly in Autodesk Inventor; (a) Front view, (b) Top view and (c) Isometric view

B. Frame

1) Material used

The frame was made out of mild steel square cross section ERW pipes. The dimensions of the pipe chosen were (31 x 31) mm. The gauge of the frame material used is 2.2 mm. Following are some of the benefits of choosing this material:

- Yield strength of 365 MPa, sufficient for our project
- Easily available
- Good weld ability
- Square cross section assists in easy fabrication and proper alignment
- Thick gauge ensures strength and also good weld at higher current
- Stability of mountings on the flat surface of the frame
- Cost effectiveness.

Mild steel chosen for frame members also has a disadvantage of an increased weight. The weight density of mild steel is 7850 kgm^{-3}.

Volume of 1m length of the above chosen pipe is $(0.031^2 - 0.0266^2) \times 1 = 0.000253\ m^3$

Hence weight of one meter of mild steel of the above cross section:

$0.000253m^3 \times 7850kgm^{-3} = 1.989$ kg.

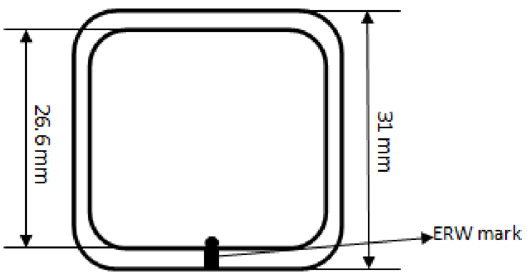


Figure 7: Material used for the Frame

2) Frame Design

The frame design during the fabrication process was kept more or less the same as that was thought during the preliminary design process. Though maintaining the work space of the frame was difficult due to the stability of structure it was ensured that the working space is a square. Though the middle of the frame the crank shaft passed with the fixed points of the mechanism also attached on the frame.

The seat mounting on the frame was elevated by a distance of 175 mm from the top side of the frame using the same material. The supports for the seat mount had a distance of 600 mm between them.

Hence the total length of material on the frame based on its design is 5.75m

Therefore, the total weight of the frame is 5.75m x 1.989kg/m = 11.436 kg.

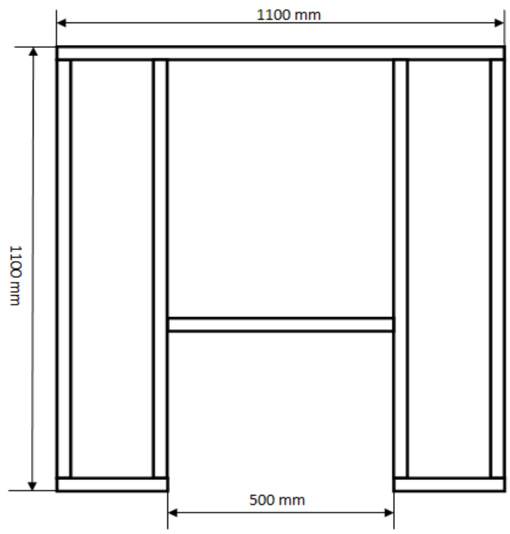


Figure 8: Design of the frame

C. Linkage System

1) Triangular links

The triangular links are denoted as O_1BC and DEF of one particular set in the fig. 2. These are the links who's angle does not change with respect to other and act as a single link together i.e., all the three sides are fixed to each other. Then primary factors considered while selecting the material for this are:

- Weld ability
- Less weight
- Less width of the material to reduce the work space
- Broad surface in order to drill the attachment holes at exact lengths

The material hence chosen for this was rectangular cross section ERW mild steel bars whose dimensions are 40mm x 20mm with gauge of 1.6 mm. The volume per unit length of this material is given by $((40 \times 20) - (36.8 \times 16.8))\ mm^3 = 181.76\ mm^3 = 0.0001817\ m^3$

Hence the weight of the material is $0.0001817m^3 \times 7850\ kgm^{-3} = 1.427\ kgm^{-1}$

The design of the triangular links was basically set to the dimensions as discussed in the topic III.B. But the cutting and joining of the joints was done in order to facilitate a lap and a butt joint together on the material.

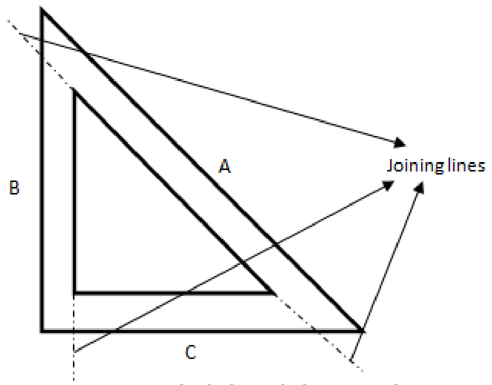


Figure 9: Triangular links with the joining lines

As shown in the Fig. 9 the triangular links are made by joining 3 individual parts i.e., the part A, B and C but cutting the pieces of the material according to their length and joining them by welds along the joining lines shown. This type of joining was advantageous in the following ways:

- Easy fabrication
- Enough surface area for perfect drilling of attachment holes
- Good surface for welding hence stronger joints.

The same procedure was followed to make the lower triangular linkage of the set. This was repeated for all the sets.

3) Flat link bars

The flat links are used to join the upper and the lower triangular linkages by means of hinge joints. There are two links in each set of linkage system that are used to join the two triangular links. They are represented as CD and O_1E in the figure 2. These two links are made of two plates each i.e., one on either face of the triangular linkages. This ensures high strength and durability to support the weight of the set up and the person.

There are also two other links, AB and AE that use the flat plates. Again each of these links is made of 2 individual flat plates on either face of the triangular linkages. Hence there are in total 8 flat plates that are used in order to complete half the linkage set.

The material chosen for these attachment links is Mild steel plates with 5mm thickness and 25.4mm width. Hence the weight of the material is 0.997 kgm^{-1}.

4) Gross weight of linkages

Total length of rectangular pipes used per set of linkage = 2.672m

Total length of flat plates used per set of linkages = 2.446m

Hence material weight per set = (2.672 x 1.427 + 2.446 x 0.997) kg = 6.25 kg

Therefore total weight of links in the set up = 6.25 x 4 = 25kg.

D. Drive mechanism

1) Drive Shaft Mountings

It was decided that for the use of common masses the drive system would be the hand pedal. Two different pedals driving the crank shaft are connected by 2 chain sprocket sets. To mount the drive shaft a T structure was used that was mounted directly on the frame. The top of the T was attached with a bearing that held the drive shaft. The length of vertical portion of the T is 600mm while the horizontal portion of this was just 177.8 mm. To support one shaft two T structures were used in order to prevent the shaft from going eccentric. The T structure provided the perfect support at the perfect height without much of material consumption. The vertical height of the T posed a great danger of failure due to the multiplication of force and hence gusseting at the end of the T was provided attaching it to the frame. This triangulation helped in achieving maximum strength to the structure.

The material used for this mount is the same as the material for the frame. This was chosen because of the easy mounting of the bearings and aligning all the T structures in straight line. The total length of the material used here is 3.11m for all the 4 structures.

Hence the weight of all the 4 structures is 3.11m x 1.989kgm^{-1} = 6.19kg.

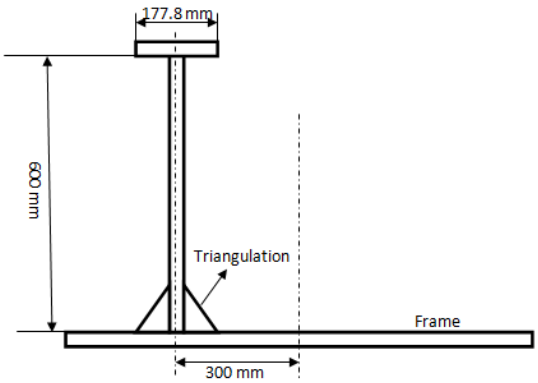


Figure 10: The T-structure for Drive shaft mount

2) Drive Shafts

To drive the entire set up two drive shafts with individual sprockets were mounted right in front of the driver facing each other. While only one shaft could be used to drive the set up two of them were used in order to reduce the amount of effort required to drive the same.

The drive shaft is made up of solid mild steel circular cross section bar with a diameter of 19.1mm which has a step of 20 mm in order to support the driving sprocket and also a step of 14mm in order to lock the pedal lever.

The mild steel shaft is supported by two bearing blocks on the two T structures hence the shaft has a total length of 457mm end to end.

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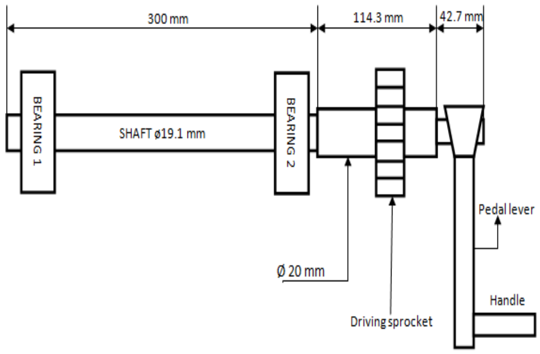

Figure 11: The drive shaft components

The volume of the shaft is π $(0.0191^2 \times 0.3 + .02^2 \times 0.1143 + 0.014^2 \times 0.0427) = 0.000513\ m^3$
Hence the total weight of shaft alone is 4.027 kg. Hence weight of two shafts is 8.05 kg.

The Shaft was chosen to be solid over here just to make sure the shafts are heavy. This was desired because the mass moment of inertia helps in reducing the effort required to pedal this system. In other words it has a distributed effect of a flywheel.

3) Transmission

The chain and sprocket are used as the transmission for the set up. The various options that were available for the purpose of this and their perks and losses are as follows:

Parameter	V-Belt drive	Synchronous belt drive	Chain & Sprocket drive
Slip	Slip evident	Minimal slip	No slip
Initial torque	Low initial torque	Synchronous torque	High initial torque
Weight	In between the other two	Light weight	Heavy
Flexibility	Different std lengths available	Very few standards	Highly flexible
Machinability	Pulleys easily machinable	Very easy to machine	Difficult to machine
Maintenance	Least maintenance	Over heating is a problem	Heavy greasing is required

Table 2: comparison of various drives

It seems very evident that from the above comparison the synchronous belt drive is a perfect choice for the set up but yet chain and sprocket was used for the transmission. The major disadvantage of the synchronous belt drive is it is available only in limited sized and is a closed belt. Hence assembly on a completed set up would mean disassembling of the entire crank shaft. However in case of a chain sprocket drive this is very flexible and can be adjusted to the required center distance. The fact that the chain can be opened and locked after putting it on the sprocket gives it extra points on our project and the high initial torque aids in the starting of the movement.

Due to human ergonomic a person is always comfortable using his two hands to drive rather than one and this also distributes the effort required between both the hands equally. To satisfy this ergonomic condition, two pedals were used with two different sets of chain & sprocket systems that drive a single shaft. They are placed on the right and left side of the driver as shown already in Fig. 4.

The specification of the chain drive is as follows:

Parameter	value
No. of teeth on driver	14
No. of teeth on driven	43
Reduction ratio	3.07
Centre distance	750 mm
Chain pitch	9.525 mm
Inside width	5.7 mm
Roller diameter	6.35 mm

Table 3: Specification of Chain drive

Average number of RPM in hand pedaling = 70 rpm
Distance by which each link travels = 160 mm every half rotation of crank
Hence total distance in 1 rotation = 320 mm
Speed of main shaft = 70/3.07= 22.08 rpm
Hence speed of the chair = .11m/s

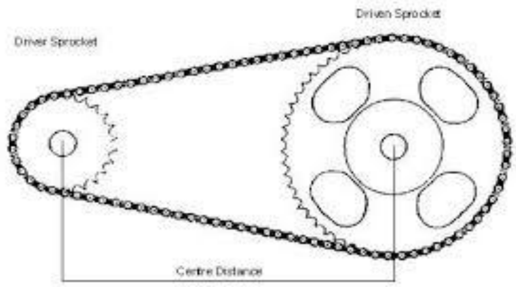

Figure 12: chain sprocket transmission

E. Crank Shaft

The crank shaft after the linkages is the most important part of this project. The factor that was considered while making the crank shaft was it had to be made removable so that the assembly of other components on this crank becomes simpler. Hence for the sake of simplicity the crank shaft can be divided into two main components:

1. The main shaft
2. The crank

1) Main Shaft

The main shaft is the part of the crank shaft that receives the power from the driving component and in turn drives the crank and hence the linkages. The main shaft is made of seamless drawn circular cross section hollow mild steel pipe. The outer diameter of the main shaft is 32 mm and the inner diameter of the shaft is 22 mm. Hence the gauge is 5 mm. This thick gauge was a necessity because the shaft has to drive the heavy linkage system and also the mass moment of inertia would help in carrying the momentum like a fly wheel. The main shaft rotates about its own axis unlike the crank. This shaft is split in to three different pieces that can be separated from rest of the components. The splitting of the shaft was done in order to accommodate the linkages in between the shaft along with the crank. Making it continuous would hinder the movement of links or rather let the set up not work at all. The main shaft is mounted on the frame by using bearing blocks. Four bearing blocks are used to hold the main shaft in position and aligned in one straight line.

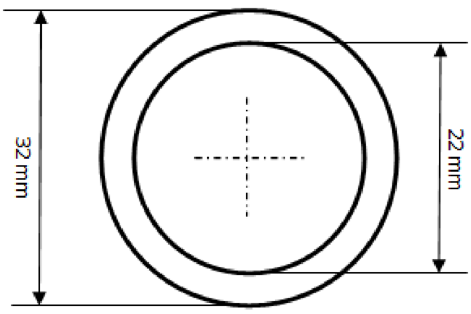

Figure 13: Cross section of the main shaft

2) The Crank

The crank as shown in Fig. 2 is the link AO and its length is 71mm. The meaning of the crank is it rotates about an axis of the shaft at a distance. This distance is called the crank length.

One of the major factors that are to be considered while making a shaft is it should have balanced forces acting on it, or in other words the angular velocity of the shaft should be constant. Hence for this purpose the phase between the two cranks on one side of the set up was chosen to be 180°. This helps in balancing of the shaft completely. As stated earlier the crank shaft was made removable and could be disassembled into smallest of the component, the crank was split into the crank plates and the crank pins.

The crank plates offset the axis of rotation and hence transfer the rotary motion from the main shaft to the linkages at a distance of 71mm. These plates are made of mild steel and the width of the plate is 50mm while its thickness is 12mm. These plates support the crank pins and hence the entire linkages.

There are three crank plates on either side of the driver. The first inside plate is attached to the main shaft on one side and the crank pin on the other side. The second plate is the intermediate plate that is double the length of crank. This is because there is a phase shift of 180° as mentioned earlier. This plate supports crank pins on both its sides. The third plate is on the outer side and hence on one side it is supported by the last split of main shaft and the other side it supports the crank pin. These plates function synchronously in order to vary the position of the foot and perform the four phases of the Jansen's mechanism.

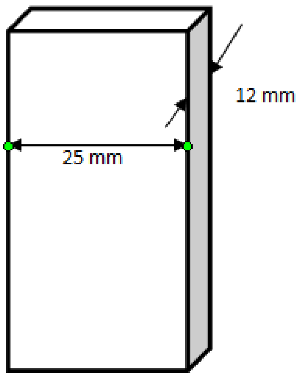

Figure 14: Crank plate

The crank plate supports the crank pin. The crank pin in turn drives the linkage system. While making the crank pin following factors were considered:

- The pin should be strong enough to counter the bending moments developed
- It should be fastened to the crank plates tightly
- It should have a smooth finish to aid easy relative motion between the pin and the links.

Hence considering these factors the crank pin was again further split into a bolt and the hollow pin. The hollow pin has an outer diameter of 18mm while the inner diameter of the pin is 12 mm. An M12 bolt was passed from one crank plate to the other and fastened rigidly with a nylon locknut. This provides the crank the rigidity of a solid pin while still maintaining the flexibility of assembly. The length of the crank pin was determined by the distance between the two outermost links hence the length of each pin was 90mm. according to this length the bolt chosen to support the pin was M12 with 135mm semi threaded hardened mild steel bolt.

The crank pins are placed 6 mm inside the crank plates on either sides. This is to ensure that the pin is fixed rigidly to the plate and there is no relative motion between the plates and the pins.

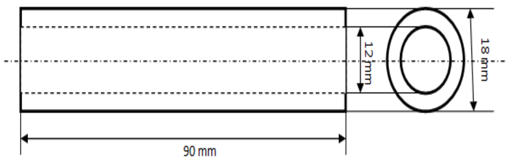

Figure 15: The Crank pin

3) The Crank shaft completely

The crank pin, crank plates and the main shaft have been explained in the previous sections. The completely assembly of the crank shaft is shown below in the fig. 16. This figure shows the one side of the driver while the other side is the mirror image of the other.

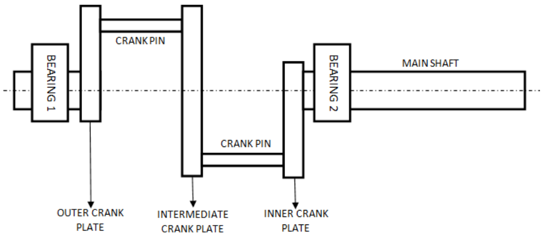

Figure 16: assembled crank shaft (the other half is the mirror image)

4) The Bearings

There are totally eight bearings with blocks that have been used. The 4 bearings are used to support the main shaft on the frame while the other 4 are used on the T structures to support the drive shafts. M18 were used to fasten the main bearings while the drive shafts bearings were fastened by M12. The Main bearings had the journal diameter of 31.75mm against the shaft diameter of 32mm. These were further locked by using Allen bolts. The drive shaft bearings have journal of 19.1mm and hence the drive shaft was machined to 19.1mm.

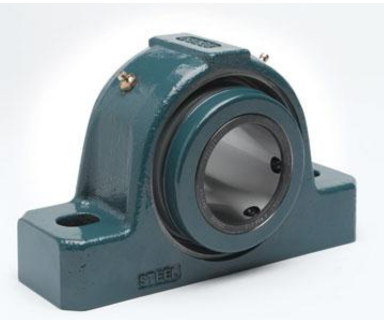

Figure 17: Bearing with block

V. FFABRICATION

A. Fabrication of linkages

Linkages became the first step in fabrication. The processes involved are:

1. Angle cutting
2. Filling
3. Welding
4. Drilling
5. Completed triangular link

Figure 18: The triangular link cut, welded and then drilled

B. Fabrication of the Crank Shaft

The Crank Shaft was the next step towards the fabrication process. This involved a lot of operations from the lathe as mentioned below:

1) Main Shaft fabrication

The main shaft fabrication involved parting of seamless tube at a required length of 650mm, polishing in order to smoothen the shaft and turning & facing in order to fit the crank plates.

Figure 19: Rendered image of the Main Shaft

2) Crank Plate Fabrication

Crank plate fabrication process involved cutting with hacksaw blade in required length, boring a bore of 28mm to fit the main shaft, 12mm and 18mm drill hole to fit the crank pin and tightening drill and the 28mm bore was the split in half at the end in order to pass the main shaft easily and then tighten the bolt.

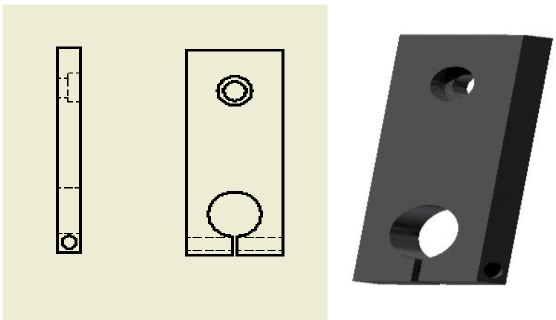

Figure 20: The inner and the outer crank plate showing the machining details

C. Fabrication of Frame

The fabrication of frame was carried out by hand cutter with a 4” blade, grinding using the same machine but by substituting the cutting blade by a grinding wheel in order to remove chips, drilling of 2 inches hole of size 16mm and welding to join the pieces of the frame.

D. Fabrication of Transmission Parts

1) Driven Sprocket Flange

The fabrication process of the driven sprocket flange includes flattening of circular plate by facing, boring of 32mm diameter on one face and 40mm counter boring on rear face, 4 holes are drilled of 8mm diameter, welding of the bush on the counter bore, chamfering as per on the sprocket to fit the sprocket on flange and then turning & polishing.

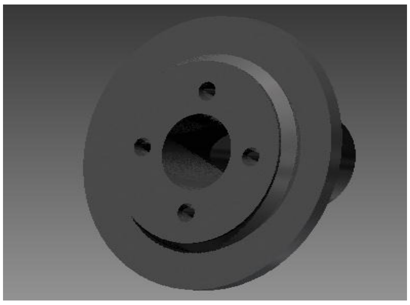

Figure 21: Driven Sprocket Flange

2) The drive Shaft

Unlike the driven sprocket the driver sprocket is much smaller in diameter and hence making of a flange is not feasible. Hence the driver sprocket is directly welded to the drive shaft. To make the drive shaft the following processes were carried out: turning, facing, boring, welding, press fitting.

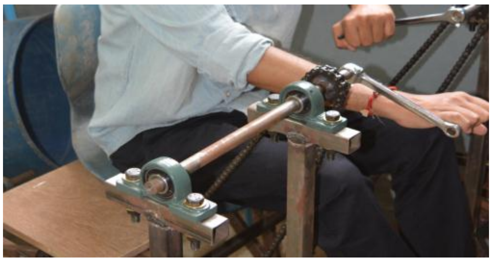

Figure 22: Image showing the drive shaft with driving sprocket and pedal

3) The Drive Shaft Mounts

The drive shaft mounts were created as T-Structures. The primary function of these mounts is to rigidly hold the driving system in its place. The following were the operations carried to build these mounts: cutting, grinding, drilling, aligning, and welding.

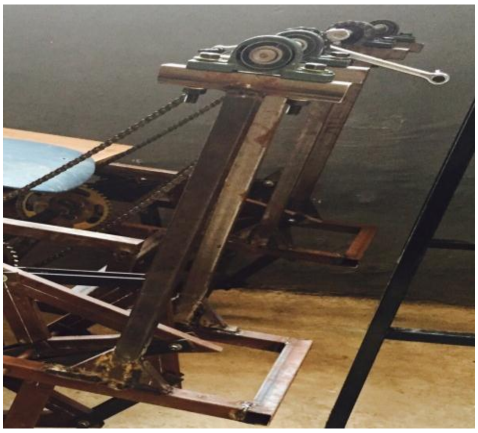

Figure 23: The T-Structures mounted on the frame

VI. ASSEMBLY

The process flowchart for assembly is depicted below:

A) Assembly of links by bolts, lock nuts, doubles washer and sleeve.
B) Assembly of links to the crank by crank pins and crank plates.
C) Assembly of linkages to frame and main Shaft by means of rods passing through fixed points of the frame and then attaching the bearing to the shafts which are fixed on the frame elements.
D) Attachment of the transmission system the flanges along with the driven sprockets are inserted in the shaft.
E) T structures are constructed and chains are attached with the help of bearing and pedals.

VII. RESULT

A. Completely fabricated project

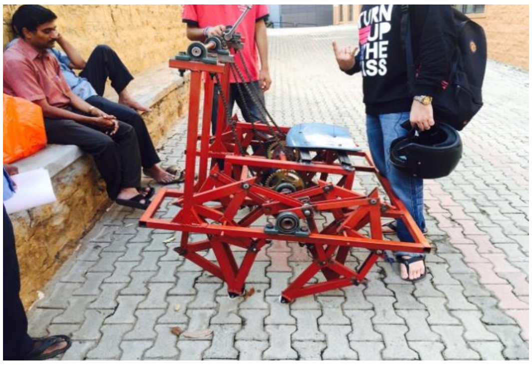

Figure 24: The completely fabricated model of the walking chair

B. Test No. 1 of the model

The first test of the model was conducted on the semi fabricated set up which comprised of the crank shaft, linkages and frame.

Testing condition	In Air
Effort applied	Least
Working	Successful working with smooth relative motion between the links.

Table 4: Test No.1 details

C. Test No. 2 of the model

This test was conducted after the fitting of complete transmission in the set up.

Testing condition	On ground
effort	Maximum
Working	Too tight hence no motion on the ground
Inference	Pointy edges of limbs causing the problem
Solution	Attachment of fixed wheels as the foot

Table 5: Test No. 2 details

Figure 25: The fixed wheels that were attached as the foot of the system

D. Test No. 3 of the model

Changes incorporated	Attachment of fixed wheels
Testing Conditions	On ground with load
Effort	Optimum
Working	Movement exists with slippage
Inference	Wheels are slipping
Solution	Jam the wheels

Table 6: Test No. 3 details

E. Test No. 4 of the model

Changes incorporated	The Fixed wheels were locked
Test conditions	On ground with load
Effort	High effort required
Working	Moving with difficulty on ground. Working fine without load in complete phase

Table 7: Test No. 4 details

F. Analysis of the Test Results

The following conclusions can be drawn from the results of the walking chair:

- The weight of the entire set up is quite heavy
- The system works fine when in no load condition
- The inaccuracy during the fabrication major cause for not working on ground
- The effort required to move the system is quite high
- The phase or the synchronous movement is perfect hence the linkage system is made well
- The linkage system works to propel the set up forward.
- The Linkage system with accurate machining can be further developed into mainstream chairs.

VIII. SCOPE FOR IMPROVEMENT

This project is in the adolescent stage of bringing it into the actual livelihood of the people whose life we plan to change. Though this seems to be having quite a few disadvantages, these disadvantages can be worked on and can be improvised to develop the new locomotion technology. Some of the fields where in work can be done are mentioned below.

A. Material and fabrication

The material used in case of this project is mild steel and it’s an unhidden fact that mild steel has a very high mass density. Hence using a lighter material like aluminum can reduce the overall weight of system by 4 folds and hence make it more efficient than the use of mild steel. With a little of cost addition tempered aluminum of higher series can be used which would provide strength of mild steel with the mass density of aluminum.

The fabrication also plays a major role when it comes to the proper functioning of the system. The conventional machining has been utilized in this system hence machining errors have hindered the easy functioning of the system. By using modern machining processes these errors can be avoided.

B. Steering system

The steering system is an absolute necessity in any locomotive system hence incorporation of steering in this particular project will complete this in almost any sense. The idea for a steering system was developed initially but due to the conventional machining and fabrication errors there was a hesitation to include in the model.

Steering for this particular model can be done by the use of a concept called the differential braking system. To explain it crudely differential braking locks the wheels of that side of a vehicle which it is taking a turn and hence the due to the differential action the vehicle steers itself. This can be achieved in this project by splitting the main shaft in 2 parts i.e., individual drive on the left and the right hand side. This gives the freedom to stop the side which one intends to take the turn in.

C. Other improvisations

- Collapsibility can be introduced in order to make it portable by using lock and release mechanism on frame like the ones used in hood of a car.
- With attachments of electrical components like the motor and the battery the amount of effort required can be reduced.
- Usage of flywheel and variations in the link lengths can improvise the amount of lift achieved.
- Reduction in working volume can be made by use of alternative materials and high strength to weight ratio materials.
- This mechanism can be incorporated into any of the main stream locomotive technology.

IX. CONCLUSION

With the idea of bringing about a small change in society, the concept of walking chair evolved in our minds to make the world more independent. The dependency looms over the category of physically disabled making them vulnerable to depression and also economic set back especially in India. Eradication of this dependency was sought in the form of walking chair.

After months of work a machine is developed that demonstrates the idea of natural motion that excels over the traditional rolling motion. This opens up another era in the locomotion technology. While we have seen the evolution of wheel for over 6500 years, the walking mechanism has developed in less than 10 years though still in its primitive stage. The fact that this stage can be harnessed in order to provide the world with better and more efficient technology promises a bright future for this in coming few years. The development of walking chair is an attempt for the first time in the country using this mechanism and has successfully proved its worth to be the most spoken and improvised topic in the coming days.

To sum up in a sentence our machine aims in improvising the lives of thousands of individuals who depend on others for their basic needs at a very minimal monetary value and hence a refined version of this could mean an industrial potential very soon.

X. REFERENCES

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