Int. J. Mech. Eng. & Rob. Res. 2012

International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 1, No. 2, July 2012

Research Paper

DESIGN, SYNTHESIS AND SIMULATION OF FOUR BAR MECHANISM FOR WHEELS FOR CLIMBING

R R Gurpude[1]*, R D Ashkhedkar[1], C C Handa[1] and S K Choudhary[1]

Corresponding Author: **R R Gurpude, ✉ gurpude.rahul@gmail.com*

In this paper a mechanism is designed for the desired performance output of the machine and these mechanisms are being used in case of climbing wheels. In cities the buildings are generally three or four storied and it is not convenient and also financially not easy to fit electric lifts everywhere. A four bar lift can be used by old or disabled person to climb one floor as subjected to lift. Hence a four bar mechanism to be implemented on every wheel to make the frame to be moved and to make synthesis and simulation for same mechanism to track its actual path and to understand its motion of stair of height of 220 mm. Taking into consideration the available dimensions of the four links a software is prepared with help of Fraudenstein's equation being compared graphically with existing dimensions so as to calculate the actual deviation graphically and programmatically. Also the sensitivity of each link being carried out for variation of +1 mm and –1 mm in actual dimensions available.

Keywords: Four bar, Simulation, Synthesis

INTRODUCTION

This paper reveals about design, synthesis and simulation of four bar mechanism for guiding wheels for climbing mechanism. Machines consist of number of mechanisms for their successful operation and to give desired output. Mechanisms like four bar mechanism, single slider crank mechanism, double slider crank mechanism, etc., are used for transmitting motion, force, torque, etc.

Generally a mechanism is designed for the desired performance output of the machine and these mechanisms are being used in case of climbing wheels. In cities the buildings are generally three or four storied and it is not convenient and also financially not easy to fit electric lifts everywhere. A chain lift can be used by old or disabled person to clime one floor as subjected to lift.

In this project it is proposed to design synthesis and simulate the chain lift mechanism of climbing mechanism.

For synthesis of mechanisms following method:

[1] Department of Mechanical Engineering, K D K C E, Nagpur, India.

- Function generation
- Path generation
- Body guidance
- Fraudenstein's equation

It is time consuming to carry on the analysis, mathematical or graphical to simulate a mechanism. Software is required to be developed for the same purpose.

To design the basic mechanisms for finding different positions, synthesize that mechanism simulates it by taking or exist dimensions, a CAD model is to be developed.

Also an C-language software is being prepared along with formulation of Fraudenstein's equation so as to calculate the deviation in dimensions by plotting graphs for variation of about 5 degrees in input value and programmed values to find (*x*, *y*) co-ordinates for different positions. And also the sensitivity of each link being carried out for variations of +1 mm and –1 mm in actual dimensions available.

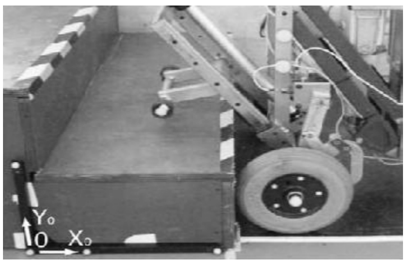
CONCEPT

The aim of the mechanism is, wheel to climb obstacles, steps, or slopes with a suitable smooth path. The proposed four bar linkage can be installed on each wheel of vehicle, which therefore can capable to climb stairs with suitable comfortable motion. A straight line trajectory for centre of wheel is ensured through an easily controlled motion, and compactness of mechanism design makes it suitable for staircase climbing wheelchair for aiding people with disabilities.

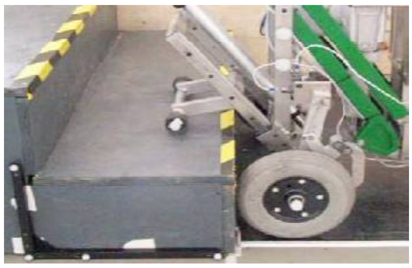
Figure 1a, 1b, 1c and 1d shows the exact motion for mechanism which will be actually implemented on assembly wheels.

Figure 1: The Actual Concept

(a) The Position of the Wheel at the Stair on the Urge to Climb



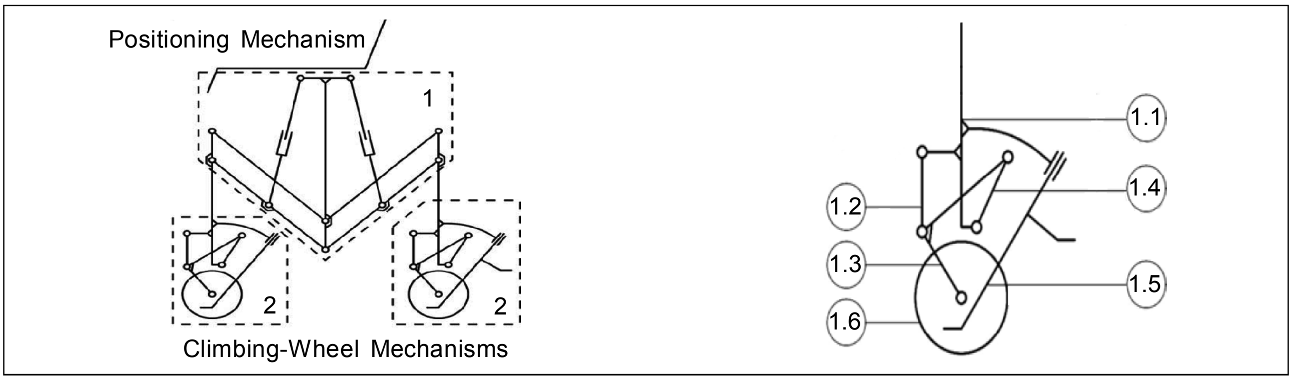
(b) The Actual Locking Position of the Wheel at the Stair



(c) The Motion of Input Links and will Pull the Wheel on Stair

(d) The Climbed Position of the Wheel and Locked Wheel

Figure 1 (Cont.)



The Actual Mechanism

The actual mechanism consist of four links, i.e., 1.1, 1.2, 1.3 and 1.4 has an input link 1.5 which is the slider makes input for mechanism and also the Figure 2 shows the actual position of mechanism along with wheel passing over the obstacles.

Degree of Freedom

1) Kutzbach criterion

$n = 3(l - 1) - 2j - h$

where l: Number of links

j: Joints

h: Number of higher pair

2) Grublers criterion

$n = 3(l - 1) - 2j$

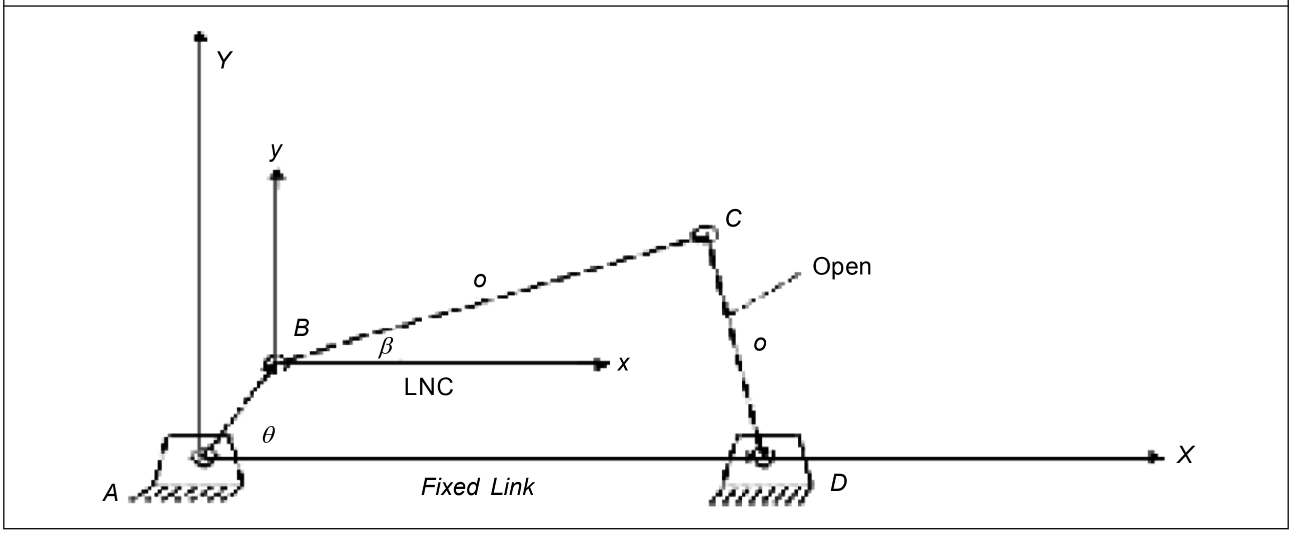
where l: Number of links

j: Joints

Synthesis

There are several methods by which synthesis can be carried out as discussed earlier. Out of which we will go for Fraudenstein's equation because of advantage that all values are being arranged in analytical manner and also calculation are being arranged simple formulation hence will leads towards accuracy as compared to other methods as that of

Figure 2: The Four Bar Mechanism



graphical which will leads to an huge error in case of small mistakes.

To solve resolving all forces in *x*-direction and *y*-direction on adding both we have

$\cos\theta_1 \cdot \cos\theta_1 + \sin\theta_1 \cdot \sin\theta_2 = k_1\cos\theta_1 - k_2\cos\theta_2 + k_3$

$\cos(\theta_2 - \theta_1) = k_1\cos\theta_1 - k_2\cos\theta_1 + k_3$

where,

$k_1 = r_1/r_2,\ k_2 = r_1/r_4,\ k_3 = r_{22} - r_{32} + r_{42} + r_{12}/r_2 \cdot r_4$

RESEARCH METHODOLOGY

- Synthesis of climbing four bar mechanism by Fraudenstein's method.
- Preparation of cad model of synthesized climbing mechanism.
- Simulation of climbing mechanism.

The Actual Programme

```
#define PI 3.14
#include<stdio.h>
#include<conio.h>
#include<math.h>
void main()
{
float ab=220,bc=100,cd=111,da=97,A,B,C,D,E,F;
int theta;
float figh,figh1,figh2,beta,beta1,beta2,rtheta,i;
float x1=0.0,y1=0.0,x2,y2,x3,y3,x4=da,y4=0.0;
float k1,k2,k3,k4,k5,cnst1,cnst2,cnst3,cnst4;
clrscr();
printf("Enter the value of theta\n"); scanf(" %d",&theta);
rtheta=theta*PI/180;
printf("x1=%f,y1=%f\n\n",x1,y1);
x2=ab*cos(rtheta); y2=ab*sin(rtheta);
printf("x2=%f,y2=%f\n\n",x2,y2);
k1=da/ab; k2=da/cd;
k3=(pow(ab,2)-pow(bc,2)+pow(cd,2)+pow(da,2))/(2*ab*cd);
k4=da/bc; k5=(pow(cd,2)-pow(ab,2)-pow(bc,2)-pow(da,2))/(2*ab*bc);
A=(1-k2)*cos(rtheta)+k3-k1; B=-2*sin(rtheta);
C=k1+k3-(1+k2)*(cos(rtheta)); D=(k4+1)*cos(rtheta)+k5-k1;
E=B; F=((k4-1)*cos(rtheta)+k5+k1);
cnst1=(-B+sqrt(B*B-4*A*C))/(2*A); cnst2=(-B-sqrt(B*B-4*A*C))/(2*A);
figh1=2*atan(cnst1)*180/PI; figh2=2*atan(cnst2)*180/PI;
cnst3=(-E+sqrt(E*E-4*D*F))/(2*D); cnst4=(-E-sqrt(E*E-4*D*F))/(2*D);
beta1=2*atan(cnst3)*180/PI; beta2=2*atan(cnst4)*180/PI;
for(i=-25;i<=70;i++)
{
   if(figh1<0)
   {
      figh=figh1;
   }
}
figh=figh2;
if(beta1>0)
   {
```

Table 1: Comparison of Results Graphically and Programmatically

Input	Actaual Dimensions				Gra./Anal.		Analitical		Graphically		Differance		Analitical		Graphically		Differance		Gra./Anal.		Anal.	Gra.	Dif.
θ	ab	bc	cd	da	x1	y1	X2	Y2	x2	y2	X2-x2	Y2-y2	X3	Y3	x3	y3	X3-x3	Y3-y3	x4	y4	Φ	Φ	Φ - Φ
0	220	100	111	97	0	0	219.9	–0.7	220	0	–0.1	–0.7	70.93	–85.37	71	–86	–0.07	0.63	97	0	–51	–50	–1
5	220	100	111	97	0	0	219.16	19.16	219	19	0.16	0.16	83.54	–73.07	84	–73	–0.46	–0.07	97	0	–40	–41	1
10	220	100	111	97	0	0	216.66	98.18	216	98	0.66	0.18	94.3	–58.54	95	–58	–0.7	–0.54	97	0	–32	–32.4	0.4
15	220	100	111	97	0	0	212.57	56.91	212	57	0.57	–0.09	102.64	–42.25	103	–42	–0.36	–0.25	97	0	–20	–19.3	–0.7
20	220	100	111	97	0	0	206.74	75.2	207	75	–0.26	0.2	108.2	–24.78	108	–25	0.2	0.22	97	0	–12	–12.31	0.31
25	220	100	111	97	0	0	199.4	92.93	199	93	0.4	–0.07	110.79	–6.71	111	–7	–0.21	0.29	97	0	–2	–1.9	–0.1
30	220	100	111	97	0	0	190.55	109.94	191	110	–0.45	–0.06	110.41	11.38	110	11	0.41	0.38	97	0	5	4.18	0.82
35	220	100	111	97	0	0	180.25	126.13	180	126	0.25	0.13	107.13	29.02	108	29	–0.87	0.02	97	0	20	19.4	0.6
40	220	100	111	97	0	0	168.57	142.35	169	142	–0.43	0.35	101.1	45.18	101	45	0.1	0.18	97	0	25	25.9	–0.9
45	220	100	111	97	0	0	155.62	155.56	156	156	–0.38	–0.44	92.46	61.4	92	62	0.46	–0.6	97	0	47	46.2	0.8
50	220	100	111	97	0	0	141.48	168.46	141	169	0.48	–0.54	81.35	75.51	81	76	0.35	–0.49	97	0	43	42.8	0.2
55	220	100	111	97	0	0	126.27	180.15	126	180	0.27	0.15	67.81	87.87	68	88	–0.19	–0.13	97	0	53	52.36	0.64
60	220	100	111	97	0	0	110.1	190.46	110	190	0.1	0.46	51.7	98.72	52	99	–0.3	–0.28	97	0	64	62.26	1.74
65	220	100	111	97	0	0	93.9	199.93	94	199	–0.1	0.93	32.41	106.16	33	106	–0.59	0.16	97	0	74	73.06	0.94
70	220	100	111	97	0	0	75.37	206.68	75	207	0.37	–0.32	6.74	110.7	7	111	–0.26	–0.3	97	0	90	86.56	3.44
355	220	100	111	97	0	0	219.16	–19.16	219	–19	0.16	–0.16	56.64	–95.46	57	–96	–0.36	0.54	97	0	–60	–59.34	–0.66
350	220	100	111	97	0	0	216.66	–38.18	217	–38	–0.34	–0.18	42.44	–102.56	42	–103	0.44	0.44	97	0	–69	–67.8	–1.2
345	220	100	111	97	0	0	212.51	–56.91	212	–57	0.51	0.09	28.54	–107.2	29	–107	–0.46	–0.2	97	0	–73	–75.13	2.13
340	220	100	111	97	0	0	206.75	–75.2	207	–75	–0.25	–0.2	15.5	–109.9	16	–110	–0.5	0.1	97	0	–84	–82.2	–1.8
335	220	100	111	97	0	0	199.4	–92.93	199	–93	0.4	0.07	3.63	–110.9	4	–111	–0.37	0.1	97	0	–88	–88.16	0.16
330	220	100	111	97	0	0	190.55	–109.94	191	–110	–0.45	0.06	–6.8	–110.8	–7	–111	0.2	0.2	97	0	–97	–93.55	–3.45
325	220	100	111	97	0	0	180.25	–126.13	180	–126	0.25	–0.13	–15.72	–109.8	–16	–110	0.28	0.2	97	0	–98	–98.19	0.19
320	220	100	111	97	0	0	168.12	–141.88	168	–142	0.12	0.12	–23.15	–108.55	–23	–109	–0.15	0.45	97	0	–102.5	–102.1	–0.4
315	220	100	111	97	0	0	155.12	–155.99	155	–156	0.12	0.01	–29.1	–107.1	–30	–107	0.9	–0.1	97	0	–105	–105.2	0.2
310	220	100	111	97	0	0	140.95	–168.91	140	–169	0.95	0.09	–33.6	–105.8	–34	–106	0.4	0.2	97	0	–108	–107.6	–0.4
305	220	100	111	97	0	0	125.7	–180.55	126	–180	–0.3	–0.55	–36.57	–104.8	–37	–105	0.43	0.2	97	0	–109	–109.3	0.3
300	220	100	111	97	0	0	109.5	–190.8	109	–191	0.5	0.2	–37.7	–104.4	–38	–105	0.3	0.6	97	0	–110	–109.95	–0.05

```
        beta=beta1;
    } else
    {
        beta=beta2;
    }
    printf("figh=%f \n\n",figh);
    x3=cd*cos(figh*PI/180); y3=cd*sin(figh*PI/180);
    printf("x3=%f,y3=%f\n\n",x3,y3); printf("x4=%f,y4=%f\n\n",x4,y4);
getch();
```

GRAPHICAL RESULTS

Simulation

Step 1: Identify the problem.

Step 2: Formulate the problem.

Step 3: Collect and process real system data.

Step 4: Formulate and develop a model.

Step 5: Validate the model.

Step 6: Document model for future use.

Step 7: Select appropriate experimental design.

Step 8: Establish experimental conditions forums.

Step 9: Perform simulation runs.

Comparison

1. Curb assistive mechanisms for wheelchairs:
    - Negative Point
        – Increased frontal area rear required for turning

Figure 3: Actual Graphs with Dimensional Results

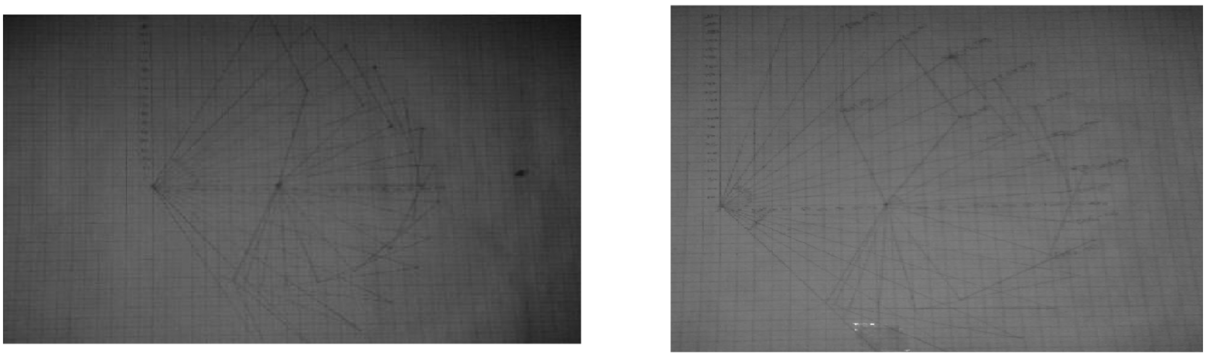
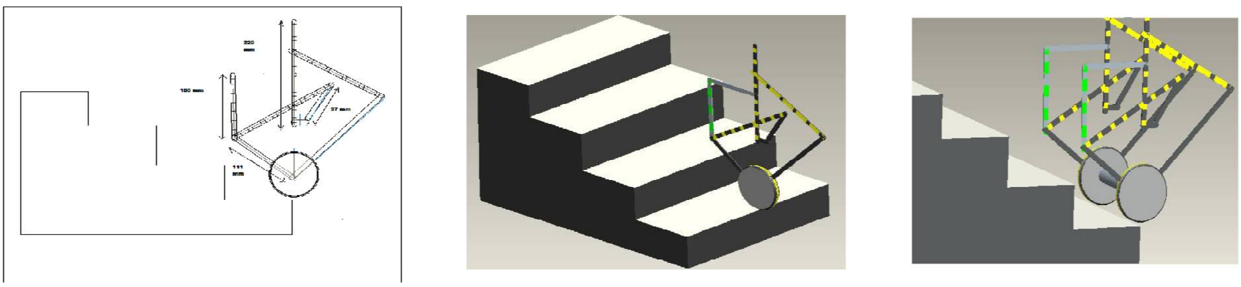


Figure 4: The Actual Simulation



   – Cannot operate backward
   – Not available for or compatible with all type of wheel chair
- Feature
   – Raise the crub negotiating ability of a wheel chair's front wheels
   – Retrofitable to a wide range of manually propelled and powerd wheel chair
   – Low cost
   – Light weight

2. Lightweight wheelchair stair-climbing attachments:

- Features
   – Stair-climbing ability
   – Suitable to almost all stairs(max. step height up to 25cm scale mobile/ 21cm C-max)
   – Compact
   – Uses existing wheel chair-no transfer required Lightweight(25kg plus wheel chair scalamobil
- Negative point
   – Required special instruction regarding usage
   – Dedicated assistant operated wheel chair-transfer required

Figure 5: Curb Assistive Mechanisms for Wheelchairs

a) Additional Wheel Illustration **b) Additional Wheel Photo** **c) Curb Catcher Illustration**

Figure 6: Lightweight Wheelchair Stair-Climbing Attachments

a) C-Max Stair-Climber **b) Stair Edge Brakes** **c) Climber Operation**

– Orbital motion tends to be uncomfortable for passenger

– Auto brake mechanism does not suit roughly surfaced stair

LITERATURE REVIEW

Literature review is an assignment of previous task done by some authors and collection of information or data from research papers published in journals to progress our task. It is a way through which we can find new ideas, concept. There is lot of literatures published before on the same task; only three to four papers are taken into consideration from which idea of the project is taken.

Gonzalez (2008) explained the a mechanism that aims a wheel to climb obstacles, steps, or slopes with a suitable smooth path. The purposed at our entire bar linkage can be installed on each wheel of vehicle, which therefore can capable to climb stairs with suitable comfortable motion. A straight line trajectory for centre of wheel is ensured through an easily controlled motion, and compactness of mechanism design makes it suitable for staircase climbing wheelchair for aiding people with disabilities.

Morales and Feliu (2007) explained a new advance in mobility assistance came with development of wheelchair of negotiation architectural barrier. The first commercial model was based on a single-section track mechanism.

He also mentioned about a complete mechanical and kinematic design methodology of a new wheelchair with additional properties like, a capability of adapting to the new environment overcoming special profile characterized by obstacle with vertical slopes, a capability to move system, in a comfortable way for passenger, over continuous smooth profile and a capability to ascent and descent staircase. It is very important to remark these new qualities are obtained without necessary of personal assistance. All mechanical design methodology is described. Also sections involve description of different mechanical devices, the performance of these mechanisms in real situation and mechanical synthesis design used to obtained a compact solution. Also a kinematic design methodology which performs the forward and inverse kinematic over smooth profile. Moreover, this methodology can be easily particularized to a special profile characterized by obstacles with vertical slopes. Also gives a short description of experimental prototype designed.

CONCLUSION

The graphical and programme results are being analyzed and comparison is carried out results into less than1% deviation .Also with variations in dimensions as mentioned there will be a very little variation in (x, y) co-ordinates for every single change in dimensions out of which ,when change in dimension for input link as compared to other link is very less as C-programmed. Hence input link is more sensitive than the others.

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