Analysis of Lower Body Exoskeleton using MSC ADAMS

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Abstract – In this paper, an assistive lower-body exoskeleton for paraplegic persons is designed in MSC ADAMS with 4 DOF and simulated with relevant data inputs like reference angle and limb length. Position analysis is done by using DH parameters. Finally, the behavior is plotted with respect to each phase of the gait cycle. The individual phase cycles are plotted and the behavior is studied. The simulation helps in finding out the exact components which suit the current design. Here the hip and knee motor torques are deduced using the generated graphs. The maximum torque can be used to select the kind of motor to be used to create walking motion using exoskeleton.

Index Terms – Exoskeleton, paraplegic, MSC Adams, DH parameters, Reference angle.

1. INTRODUCTION

In the Creating mechanical environment age, and physically tested persons would will a chance to be recognized as a not kidding issue, concerning illustration perceiving ahead later on to following thirty a considerable length of time from claiming always expanding of in 65 rates. Consideration will be with be brought on inventive advances should create what's more help elderly and physically tested subjects to restoration. Through days gone by a couple of years, assistive gadgets which have the capacity to furnish main body weight help have been processed. To process gadgets with more portability, exoskeletons which would wearable have picked up ubiquity in the right away existing planet [1].

To bio-mechanical engineering, those expressions "Exoskeleton" methods wearable robots that might be further viewed likewise a robotic orthotics which will be utilized eventually time of months perusing the wearer [3].

Legged strolling structures for assistive what's more restoration utilize are by meant to decrease vitality devoured throughout strolling. Another alternative comprises of transforming that legged strolling structure which is actually unable should help that body weight of the client. However, those last movements are set by the exoskeleton, also oppositely influences the wearer's walk flow. This At long last indicates its effect ahead of the adequacy of the restoration occasion and inescapably raises that Vitality utilization of the assistive model. When the Exoskeleton needs on the face for the secondary diminishing limit joint torques what's more strains, capable actuators must be executed. Likewise, incited exoskeletons must oblige unpredictable control modules [2].

In this paper, a design and simulation of lower body assistive exoskeleton did in MSC Adams 2016 are presented [6].

2. THEORITICAL STUDY OF EXOSKELETON

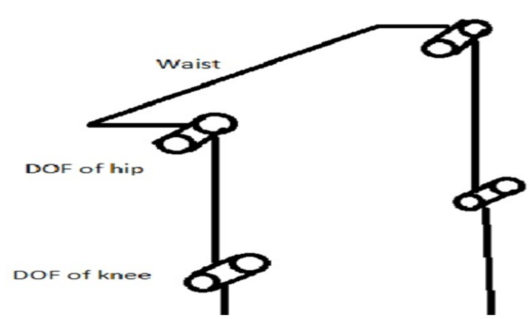

Fig 1 layout of lower body exoskeleton

Right Leg					
S. No.	Joint i	D_i (mm)	Θ_i (degrees)	a_i (mm)	a_i (degrees)
1	1	0	0	0	0
2	2	-L(wasit_1)	0	0	-90
3	3	L (wasit_2)	90	0	90
4	4	-L(hip_1+hip_2)	90	0	90
5	5	-(L shank+Lankle_1)	0	0	90

Table 1 D-H parameters of lower limb exoskeleton [4]

In the over the design of exoskeleton, the position dissection may be carried utilizing DH parameters demonstrated to table 1. 3 level of flexibility may be recognized for hip joint and 2 level of flexibility to the knee joint may be acknowledged. To those "d" parameter those length is taken along z hub. "Θ" point will be taken along the z-axis, point "α" will be made along the x-axis and the length (offset) "a" may be taken along the x-axis. The negative Furthermore certain sign may be made as stated by the position of the join i.e., negative to counterclockwise bearing and sure to clockwise heading.

3. GAIT ANALYSIS

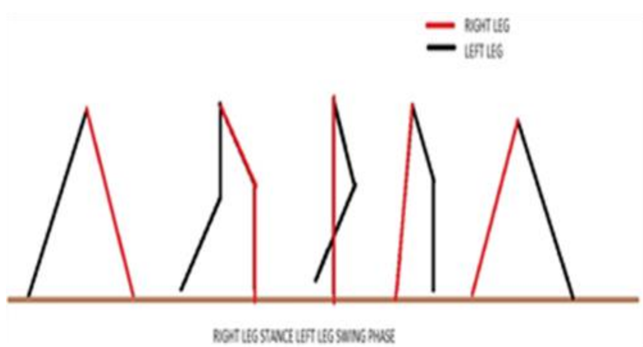

Fig 2 Gait layout

Mankind's strolling movement will be examined over the point of interest on getting the walk dissection. Those walk about common strolling may be translated under those velocity of the exoskeleton. Here we think as of five positions which hint at those strolling movement previously, the point of interest. Starting with straight leg heel strike on exited leg heel strike. The intermediate position of the cleared out leg demonstrates it traverses buzzing around without at whatever contact for those ground. And the good leg acts concerning illustration a turn. Between the ground and the muscle too. The walk may be isolated under two period's stance stage and the swing period. In the stance stage of the correct appendage it undergoes beginning twofold support, absolute appendage stance also second twofold backing. During the same chance, the cleared out appendage undergoes swing stage which comprises for introductory swing, mid swing, and terminal swing.

Reference angles

The following reference angles are considered in the simulation done. These are human walking maximum.

Knee flexion=73

Hip flexion=32

Hip extension=22

4. DESIGN CONCEPT

The exoskeleton design primarily consists of an actuation system, sensing system, and frame. All these necessary components together make it a human assistive device. Here is our model of the exoskeleton, only two joints have actuated the knee and the hip joint. The hip joint actuator must bear more torque than the knee actuator because of the extra mass and length of the complete limb. The frame should be rigid and lightweight to save power. The electronics and battery are kept in a back bag. The sensors placed in some points act as an interface between the human body and the external world. When the user tends to move or maneuver the sensor senses and sends the signal to controlling device connected. This device will actuate the motors according to the sensor signal. The actuators produce locomotion according to the human gait.

5. SENSORS

Sensors are embedded in various parts of the device. This helps good sensing and speed. Angle sensors are installed at all rotational pairs in the device. Force sensors are used to measure the force of the body on the ground. Torso angle measurement sensor is also installed to find out the orientation in the space. Usually, potentiometers are used as angle sensors. All these sensors give the position of all the connected links. Some other sensors used are tape switches, EMG sensors, and inclinometers [1].

6. ACTUATORS

Hydraulic and electrical actuators can be used as actuators. But electrical motors are selected and the best of all due to the less size and high output. There are a number of motors which can be used. Some of the optimal solutions are using a BLDC motor with the variable harmonic drive. The required gearing is coupled for getting required torque output.

7. DIMESIONS

The following are the dimensions of the exoskeleton which is designed and simulated in MSC Adams.

	Dimensions(mm)
Lwaist1	450
Lwaist2	270
Lhip1	0
Lhip2	101
L thigh	420
L shank	480

Table 2 Dimensions of limb links

8. MSC ADAMS (Automated Dynamic Analysis of Mechanical Systems)

It will be claimed for MSC product. It may be a multibody progress reproduction software, the place we might configuration mechanical frameworks and mimic them utilizing Different imperatives. It will plot graphs dependent upon that information Also outline which might make at last used to find a portion measurements of parts clinched alongside an instrument [5].

8.1 MSC ADAMS Model

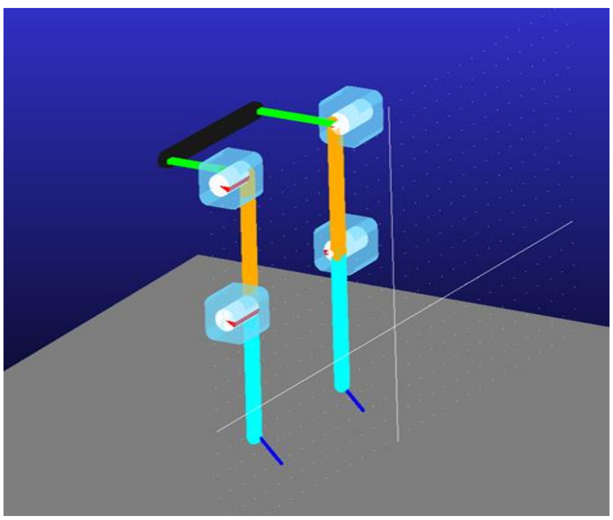

Fig 3 MSC ADAMS Model of lower body exoskeleton

This model is designed in the MSC ADAMS software [6]. The links are connected using joints and motors. BLDC motors are used here. A ground block is designed to make the model move on it. All the gait reference angles are input to acquire exact human walking motion simulation. The overall mass of the system is 90kg. The mass is divided into the body of exoskeleton according to the volume of each part. The stator of the motor is connected to the previous link and the rotor is connected to the next link. The size of the rotor, stator, and shaft can be modified according to the necessity. The lengths of the links are taken according to the reference dimensions.

The designed model is simulated by giving the input of the required gait angles. The simulation is done in four phases.

a) Right heel contact -Left toe-off

b) Left toe off -Right midstance

c) Right mid stance-Left terminal swing

d) Left terminal swing -left heel contact

All these four phases are plotted at an angle with respect to time.

The first two phases have limbs rotating in the same direction so the plots of right and left limb both seem similar.

But in the last two phases, the plots face opposite sides, as one leg rotates clockwise and the other rotates anticlockwise.

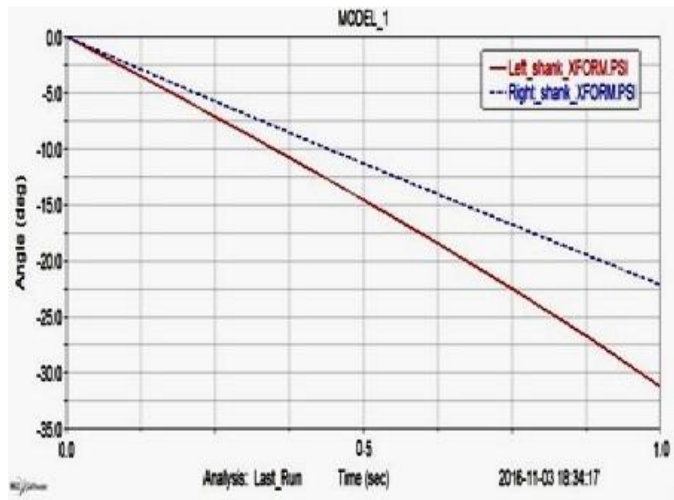

Fig 4 Right heel contact -Left toe-off

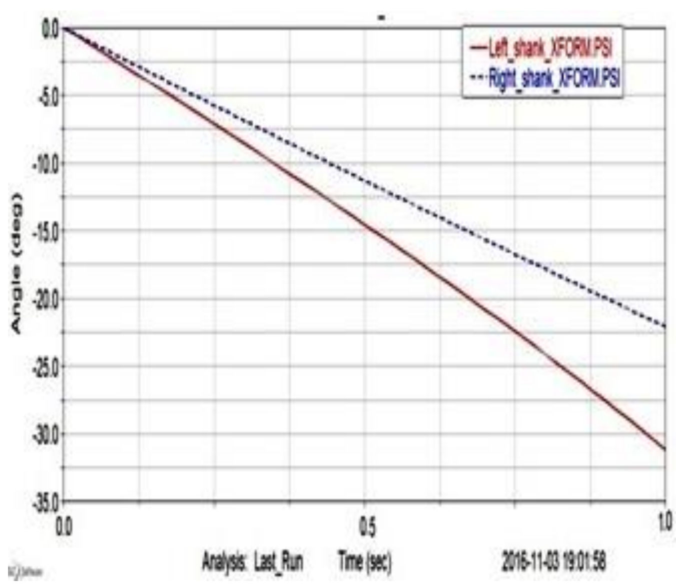

Fig 5 Left toe off -Right midstance

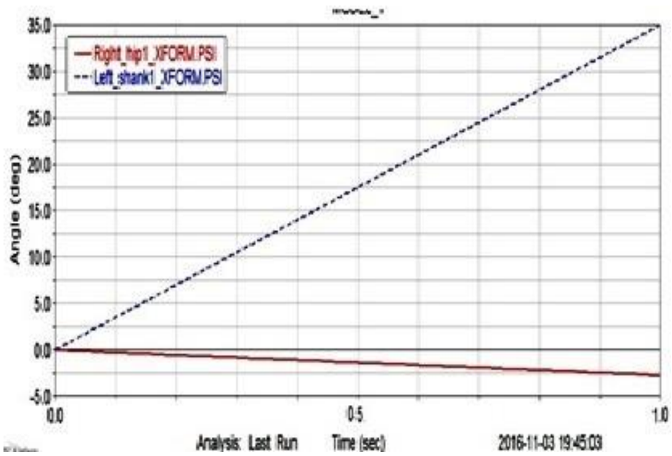

Fig 6 Right mid stance-Left terminal swing

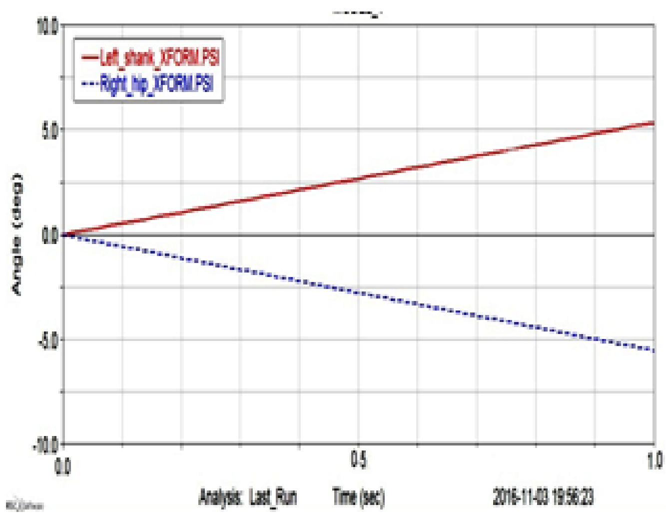

Fig 7 Left terminal swing -left heel contact

The torque vs. time graph is generated for both the limbs. It shows two sinusoidal plots with two different maximum torques. The right knee plot shows the maximum torque is around 50N-m and the left hip element torque goes and reaches 80N-m. This maximum torque can be used to propel the exoskeleton in its path.

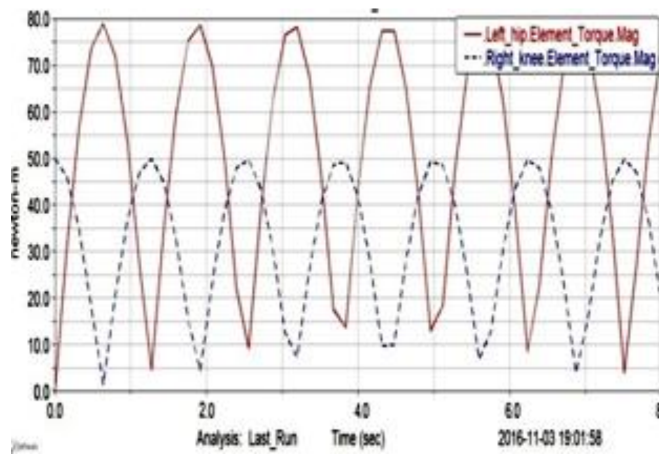

Fig 8 Torque complete cycle

9. CONCLUSION

The simulation output shown depicts the torque required to propel the exoskeleton. This simulation shows that motor to be used as hip actuator should be maxed 80N-m and Knee actuator should be 50N-m.Like this procedure, the design of the exoskeleton can be changed and innovated to get better outputs using simulation. The outputs obtained can be used to fabricate full-scale model.

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