Wear behavior of MMC's by stir casting process.

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Abstract - ***Terrorism is one of the greatest threats to national security nowadays. Military or police forces are not sufficient to prevent these activities. In the year 2009 India faced one of the biggest terrorist attacks in Mumbai. According to the report published by Times of India, more than 600 people have been killed and several hundreds of people ravaged in various terrorist attacks in India in the last 6 years. The main problem behind this massacre is the group which is acting behind this who already know the ineffectiveness of our security systems. Even now we are following traditional metal detection doors and hand held metal detectors. No autonomous system is being used by any security forces in India till now. Here we are proposing a highly effective sensor robot to tackle this problem. In the present scenario the application of robots is quite common to reduce the human effort in several areas. The stair climbing robots are used to climb the stairs for different applications up to now, but the main disadvantage of the rugged terrain robots is not adjustable according to the structure of the stairs. To overcome this, we have developed a stair climbing robot to climb the stairs up and down according to the dimensions of the staircase by using standard step ratio (i.e.,) rise=7.5inch, run =11inch, angle = 30-36 degree. The main features of the robot include the mechanical gears components which is attached to the body frame to lift the materials up and down as per the motor capacity. The main application of this robot is to detect the bombs placed on the buildings, temples, schools by carrying the sensors and cameras on the body frame for rescue operations. Now, we decided to fabricate the robot initially and then we put forward our project to detect the bombs using sensors and cameras and diffuse it by using robotic arms.***

I. INTRODUCTION

The main reason behind this concept is the increased rate of terrorist attacks in India in recent years. There are several reasons for this and one of the main reasons is terrorists utilizing the advantage of the lack of a full proof security system. Robots are increasingly being integrated into working tasks to replace humans. They are currently used in many fields of applications including office, military tasks, hospital operations, industrial automation, security systems, dangerous environment and agriculture [1].Several types of mobile robots with different dimensions are designed [2-8] for various robotic applications. The robot has been designed for the purpose of aiding rescue workers. A stair climbing robot is one of the most attractive performances of robot in legged and wheeled. Developments have been made on various kinds of stair climbers, considering how to make its climbing ability higher and its mechanical complexity reasonable and practical. The research includes realizing a large step negotiating. Reducing body weight and energy consumption is also the important matter of developing. We use a standard step ratio of stairs, to make our robot to climb any universal steps. The standard step ratio is nothing but the height, length and angle of the stairs. The length of the stairs is called as rise, and the height of the stairs is called as run. The standard size of the stairs are rise=7.5inch, run=11inch and angle=30-36 degree. A machine is a collection of mechanisms which transmits force from the source of power to the load to be overcome, and thus perform useful mechanical work. Robotics is the area of automation which integrates the technology in variegated fields like mechanisms, sensors & electronic control systems.

2.OBJECTIVES

After discussing amongst our group,and the following objectives were established at the beginning of the project.

1) To design and manufacture a stair-climber which can climb up and down the stairs of universal stairs specifications.
2) To simplify the complex driving mechanisms into a simple mechanisms and develop a Arduino program to control the movement of the wheel.
3) To maintain simplicity of our design throughout the project.

3.0 TECHNICAL REQUIREMENTS AND CONSIDERATION

The size of the robot must fit those of the stairs;

1) It will not be too large to be accommodated by each step of the stairs.
2) The width of the robot must be well-defined within a suitable range such that it is zygomorphic for body balance on both sides. This can be achieved by a symmetric design and positioning of components.
3) Since the stair-climber will be lifted up to climb the stairs, its weight to be supported must not be too large such that it will not burden or exhaust the weight supporter, which most probably, is the motor.
4) Components must be concisely designed and manufactured with proper materials. The center of mass is arranged at the front side of the climber (the side ahead when going upstairs) such that it can facilitate the actions of climbing upstairs and prevent the robot from toppling and flipping over when going downstairs.
5) The method of controlling the robot must be well-considered. If a manual approach is employed, the user must be trained to familiarize with the robot; On the other hand, an automatic robot will involve the use of a digital computer such as the Programmable Logic Controller (PLC) for the purpose.

3.1 PRODUCT DESIGN & SPECIFICATIONS.

The engineering requirements are further comprehended to generate a list of product design specifications which are concluded in Table 2.3.1.

Table 2.3.1: Product Design Specifications of the stair-climber

1. Functional Performance:

I. Movement:

A. The movement of the robot on the stairs is based on the drag and reaction forces acting on the body.

B. The movement of the robot will be stable and consistent.

C. The safety factor is assigned to be 2.

II. Power source:

A. DC High Torque Gear motor with working voltage of 12V will be selected.

B. A battery with regular voltage capacity 12V is used to give a required current to the motor.

III. Material selection:

A. The solid base will be manufactured with less weight material such as Wood.

B. The shafting materials will be manufactured with stainless steel.

2. Physical Requirements:

I. Size:

A. The outermost dimensions of the stair-climber will be less than width: 40cm; length: 72cm.

B. The size of the stair-climber will not affect its movements.

II. Weight:

A. As suggested by our supervisor, the total weight of the robot must not exist 25kg such that the mechanical motion drivers will not be overloaded easily.

B. The centre of mass of the stair-climber will be designed to locate in the front region, probably 32.5cm from the centre position of the robot, so that the robot can stay close to the higher steps to facilitate proper and safe movement.

3.2 CONCEPTUAL DESIGN.

3 At the beginning of the design stage, our group searched for existing methods for climbing stairs through the Internet. Several of them were deliberately observed and analyzed and some conceptual designs were generated through constructing a simple mind-map. Functions and criteria will be defined and put into the decision matrix to select viable designs while the Pugh's Method will be used to weigh and combine viable features for the final design.

3.3 DETAILED DESIGN

In this chapter, the final design of the stair-climber will be discussed. The working principle of the stair-climber is illustrated with the breakdown of the design structure. The required torque driven by the motor is computed, while experiments are performed to test for the functionality of the motor. Figure 3.3 shows the target setup.

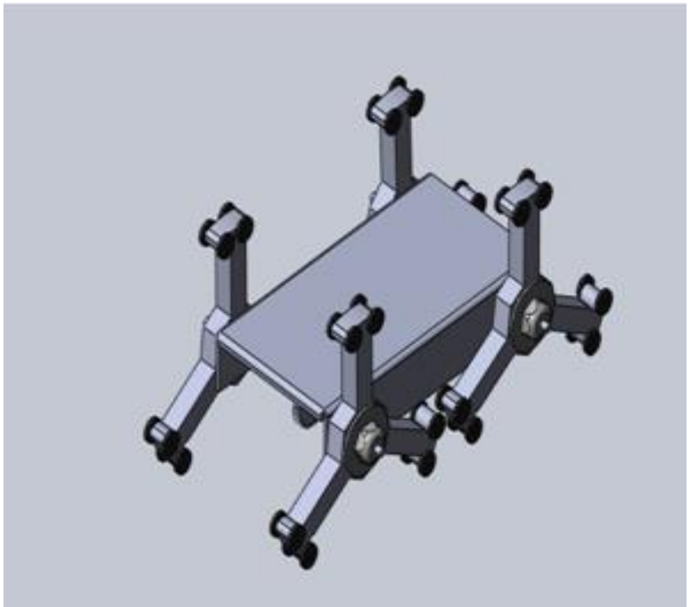

Figure 3.3 Target setup of the stair-climber

Our group believes that a simple design similar to this stair-climber can be capable of satisfying all the requirements as mentioned in the project statements.

3.3.1. STRUCTURE OF THE DESIGN

The stair-climber consists of numerous components. All of them have their own specific use. Only the proper assembly can result in their smooth motions. The exploded view of the stair-climber is shown in Figure 3.3.1 below.

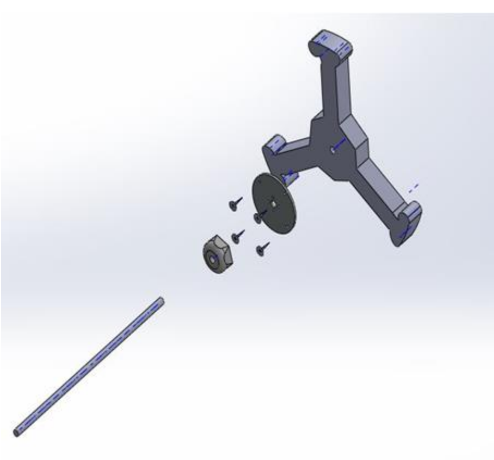

Figure 3.3.1: The exploded view of the stair-climber Wheel assembly

The final design of the robotic climber installs one motor, one battery, six gears, ten bearings, five aluminium shafts, four wood wheels, and two wood body frame. The motor is responsible for the linear propulsion and responsible for the moving up or down motion of the robot. The reason of using one motor is to ensure the horizontal motion and moving up or down motion and thus obtain the stability of the robot.

The robot can be commonly divided into two major parts. One is the base part and another one is gear part. For the former part, most of the components are mounted on the base plate. It is because the base plate is made of the wood, which can provide a support and even withstand the impact when the climber moves up or down. In the final design, the forward or backward motions are mainly depended on the wheels. There are four wheels, 2 front wheels and 2 rear wheels. The front wheels are responsible for driving the robot and the rear wheels are responsible for supporting the robot when it lifts up. The wheels are connected onto the 16 mm shaft. The bearings are installed on the sides of both wood bases, to maintain the wheels alignment correctly and rotate with ease.

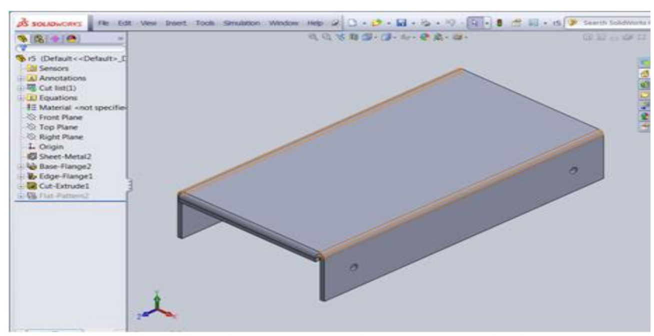

Figure 3.3.2: The exploded view of the stair-climber Body Frame.

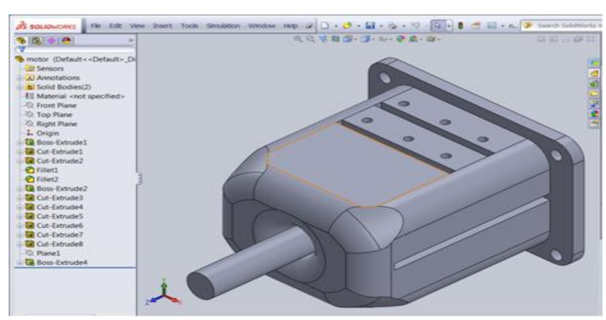

Figure 3.3.3: The exploded view of the stair-climber Motor.

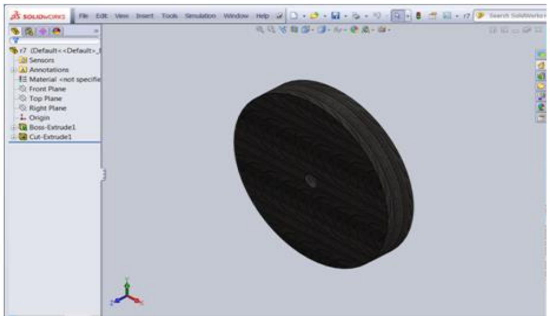

Figure 3.3.4: The exploded view of the stair-climber Wheel Bush.

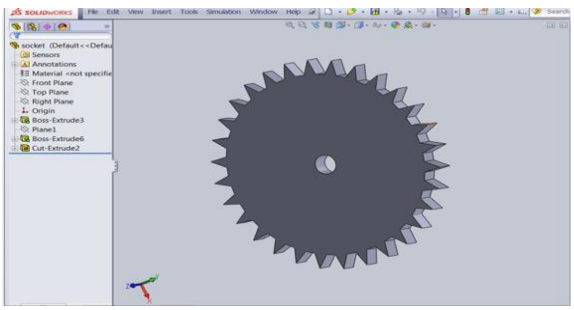

Figure 3.3.5: The exploded view of the stair-climber Sprocket.

For the gear part, the elevation of the robot is mainly relied on the gear; the rotational force generated by the motor is transmitted by the 17 teeth pinion gear to the aluminum gear. With the assistance of the front wheels, the robot can transform its motion from standing to moving. There are two sprockets mounted on the wheel shafts. Their function is to connect the front and rear wheels and to rotate them at equal speed. Once the robot without the sprockets, it cannot move on the ground firmly and during climbing motion there will be lot of damage to the gears and wheels, even it may break.

4.0. WORKING PRINCIPLE

Our team makes use of a simple mechanical design to fulfill the requirements of climbing up and down the stairs. Simplifying the working mechanisms, there must be an upward and forward displacement for the robot when it is climbing upstairs, while a downward and backward displacement when downstairs.

4.1. CLIMBING UPSTAIRS

When the robot is switched on, the battery gives the required current to the motor (i.e., 1.2-2.0 amps) and the motor gets rotated and it transmits the rotational force the pinion gear of 17 teeth and from the pinion it gets transferred to the aluminum gear of 41 teeth and then by series transmission, it reaches the final gear which is attached to the front wheel shaft. Now the front wheel rotates and by the chain drive mechanism, the rear wheels also rotated and thus the motion of the robot id done.

The stair-climber can travel in a straight line and it will stop when the front wheel touches the first step of the stairs. Then the front wheel design gets lock with the stairs, and it pulls the robot to climb up. Then with the help of sprockets and chains the rear wheel also climbs the stairs.

Thus, our robot climbs the stairs with simple mechanism.

4. 4.2 MOTOR SELECTION

4.2.1. REQUIREMENTS

Before selecting an adequate motor for the robot, some assumptions are made and listed as follow:

1) The total weight of the robotic climber is about 25 kg.
2) The safety factor is 2.
3) The efficiency of selected motor nearly attains 85%.
4) The friction between the gears is negligible.

4.2.2. STAIR WHEEL DESIGN

The Universal stairs are designed based on the height and width, which is called as rise and run.

Height of the stair = Rise of the stair =11inch = 27.94 cm.

Width of the stair = Run of the stair = 7.5inch = 19.05 cm.

Radius of the stair wheel = $\sqrt{\{(a^2 + b^2)/3\}}$

$= \sqrt{\{(19.05^2 + 27.94^2)/3}$

$= \sqrt{\{(362.9025 + 780.6364)/3\}}$

$= \sqrt{(1143.54/3)}$

$= \sqrt{381.18}$

$= 19.52 \approx 20$

Radius of the stair wheel = 20 cm.

4.2.3. TORQUE CALCULATION

When the body is initially at rest, only body weight acts on the slope.

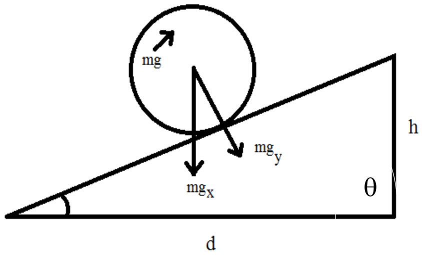

Figure 4.2.3.1: The SLOPE DIAGRAM of the body.

$$mg_x = Mg*\sin(\theta) \qquad -(1)$$

$$mg_y = Mg*\cos(\theta) \qquad -(2)$$

To hold the body in steady condition, frictional force (f) must act between the body and the slope.

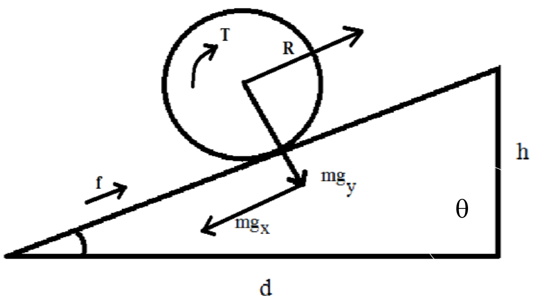

Figure 4.8: The forces acting on the body which is placed on the slope inclined to a certain angle

Torque= Force*Radius. **-(3)**

When the Robot moves on the slope, there will be acceleration acting on the body and there will be a radial force displacement.

To balance the force on X- direction.

$$\Sigma f_x = M*a = f - mg_x \qquad -(4)$$

Inserting the equation of the Torque equation and mg_x from (3) and (1) respectively;

$$M*a = (T/R) - M*g*\sin(\theta)$$

$$T = R*\{(M*a) + (M*g*\sin\theta)\}$$

$$T = R*\{M(a + g*\sin\theta)\} \qquad -(5)$$

NOTE:

Acceleration, (a) = (Final Velocity - Initial Velocity) / Time.

where,

Final Velocity = 0.5 m/s.

Initial Velocity = 0 m/s.

Time Taken = 1 sec

(a) = (0.5 - 0)/ 1

Acceleration, (a) = 0.5 m/s².

Equation (5) represents the total Torque required to accelerate the robot up and incline. In order to arrive a Torque needed for each drive motor, divide the total Torque by number of drive wheels.

$$T = \frac{R*\{M(a + g*\sin\theta)\}}{N} \qquad -(6)$$

Considering the efficiency of the motor, gearing and wheel (slip);

$$T = \frac{R*\{M(a + g*\sin\theta)\}*(100)}{N*(e)} \qquad -(7)$$

Considering the factor of safety, as 2;

$$T = \frac{R*\{M(a + g*\sin\theta)\}*(100)*2}{N*(e)} \qquad -(8)$$

$$= \frac{(0.2)*\{25(0.5 + 9.81*\sin 36)\}*(100)*2}{4*(85)}$$

$$= 18.43 \approx 19$$

T = 19 Nm.

Hence the torque of the motor must be greater than the calculated torque (i.e.,) the torque of the motor should be T > 19 Nm.

$$\text{Power} = \text{Torque}*\omega \qquad -(9)$$

$$= \{19*(2\Pi N)\}/60$$

P = 596.90 watts.

The power of the motor should be more than 600 watts.

4. 5. GEAR CACULATION

5.1. SPEED OF GEARS

Our motor speed is 300 rpm. So this becomes the initial speed. (**N_1= 300 rpm.)**

Our motor has high torque (i.e., 30Nm) so wheel speed will be low. Our required wheel speed is 10 rpm.

4. 5.2. TEETH CALCULATION

According to ***"Design Of Transmission System"*** a gear must have minimum 17-25 teeth. So we consider our pinion gear having 17 teeth. We decided to have a velocity ratio as 3.

Therefore, by the velocity ratio formula; **Z_2 = 17*3 = 51 Teeth.** Hence the No. of teeth on driven gear is 51 teeth.

Fig-5.2.1 COMPOUND GEAR DIAGRAM

Compound gears are used in engines, workshop machines and in many other mechanical devices. Sometimes compound gears are used so that the final gear in a gear train rotates at the correct speed. So we used compound gears to reduce the motor speed to the required output speed. In our project, gear 'B', gear 'D' are actually two gears attached to each other and they rotate around the same centre.

By Speed Ratio Formula;

The speed ratio is given by relating the speed and the number of gears. The compound gears have the teeth as Gear A = Gear C = Gear E = $\mathbf{Z_1 = 17}$ **Teeth,** and

Gear B = Gear D = Gear F = $\mathbf{Z_2 = 51}$ **Teeth.** The pinion gear rotates with the speed of motor, so the initial speed is 300rpm.

$$\frac{\textbf{Driven}}{\textbf{Driving}} = \frac{\textbf{51}}{\textbf{17}} = \textbf{3}$$

Since Gear A rotates at 300rev/min, the rotational speed of gear B will be obtained by DIVIDING it by 3. Thus, Gear B moves at 300/3 = 100 rev/min.

As the Gear B rotates at the speed of 100rev/min, the Gear C also rotates at the same speed of Gear B, since they are attached to the same shaft. Now, the speed of the Gear C is 100rev/min.

$$\frac{\textbf{Driven}}{\textbf{Driving}} = \frac{\textbf{51}}{\textbf{17}} = \textbf{3}$$

Since Gear C rotates at 100rev/min, the rotational speed of gear D will be obtained by DIVIDING it by 3. Thus, Gear D moves at 100/3 = 33.3 ≈ 33rev/min.

As the Gear D rotates at the speed of 33rev/min, the Gear E also rotates at the same speed of Gear D, since they are attached to the same shaft. Now, the speed of the Gear E is 100rev/min.

$$\frac{\textbf{Driven}}{\textbf{Driving}} = \frac{\textbf{51}}{\textbf{17}} = \textbf{3}$$

Since Gear E rotates at 33rev/min, the rotational speed of gear F will be obtained by DIVIDING it by 3. Thus, Gear F moves at 33/3 = 11rev/min

As the Gear D rotates at the speed of 11rev/min, the wheel also rotates at the same speed of Gear D, since they are attached to the same shaft. Now, the speed of the wheel is 100rev/min, which is the required speed.

TT This is the reason for using 3 driving gears and 3 driven gears; **Totally = 6 gears.**

5.3. PITCH CIRCLE DIAMETER (PCD) CALCULATION

$$\textbf{Module(m)} = \frac{\textbf{Pitch Circle Diameter}}{\textbf{Number of teeth on gear}}$$

1) No. of teeth in driving gear (Z_1) = 17 Teeth.

2 $$= \frac{\text{Pitch Circle Diameter}}{17}$$

Pitch Circle Diameter for Driving Gear =34mm.

2) No of Teeth on driven gear (Z_2) = 51 Teeth.

2 $$= \frac{\text{Pitch Circle Diameter}}{51}$$

Pitch Circle Diameter for Driven Gear =102mm.

6.0 ADVANTAGES:

- Simple mechanical design.
- Stable.
- Simple gear arrangement.
- Universal stairs to climb.
- It can be controlled by smart phone.

6.1 DISADVANTAGE:

- It can only to move in forward and backward direction.