

Design and Fabrication of Improved Mecanum Wheel by Drag Reduction Method

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Abstract: Robots with Mobility like Omni-directional wheels can generate instant Omni-directional motion including lateral motion without any extra space for changing the direction of the body. So, they are capable of travelling in every direction under any orientation to approach their destinations even in tight areas. Especially, if a construction tool is combined to the mobile robot, it can be a mobile construction robot to be able to move from one position to another. An attempt has made in this paper that disadvantage like power loss due to drag force by the wheels has been reduced. Developed wheel and its arrangement has been fabricated and tested for the feasibility for industrial purposes. Nano arduino controller is used to control the model by using mobile application. Velocity performance and straightness for each directional motion were selected as performance indices to assess the Omni-directional mobile robot.

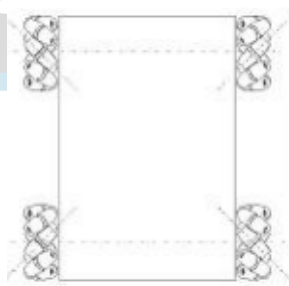
Index Terms: Mecanum wheel, Orthogonal Wheel, Multi-directional automobile wheel

I. INTRODUCTION

Omni-directional wheel design or Mecanum wheel was design and invented by Bengt Ilon, an engineer with Swedish company in Sweden during 1975. Mecanum wheel is consists of a central wheel on its boundary the numbers of rollers are positioned at definite angle. The roller on boundary with define angle translate a force in the rotational direction of wheel to force normal to wheel direction. Depends upon rotation of each single wheel direction and speed the total resulting force produces a force to move in any desired direction. Omnidirectional wheels are well known for generating holonomic movement I.e. it can change its direction of movement without changing its orientation these wheels are controlled by independent drive for each wheel and control system is much needed to control all drives(motors). By looking at its application ability it requirement is much needed in restricted area material handling units. So that it can be used as omnidirectional transport vehicles in industries.

Mecanum driving system consists of four wheels from which, two are "left" wheels and two are "right" wheels. Each wheel is driven independently which requires 4 individual motors. Here the number of rollers to be mounted on the circumference of the wheel are related to the size of the wheel. The rollers placed at an angle translate a portion of the force in the rotational direction to a force normal to the wheel direction. The resultant force from each individual wheel gives a total force vector in any desired direction thus allowing the whole body to move freely in the direction of the resulting force vector without changing the direction of the wheels. The wheels are arranged so that Omni-directional robot motion is achieved and the respective configuration is as shown in Figure.1.

Figure 01: Mechanum wheel



One of the problems associated with omni-wheels is the rough ride associated with changes in wheel radius when changing roller contact which leads to frictional loss and also Traction of Roller is seen in dusty or wet hard surfaces. Major drawback is caused by the discontinuities between rollers, that leads to slip specifically on soft surfaces.

By considering all these factors, we are made an attempt to reduce these drawbacks by using different design and position systems for the wheels.

II. LITERATURE REVIEW

The paper presented by Prof. Mhaske A, Chaudhari Deepak T[1], has done a review researches on multi-directional automobile vehicle design with Omni-directional wheel as component in the forklift vehicle. Multi-directional automobile wheel can perform various types of work in small spaces, such as those commonly found in manufacturing floor, hospitals and offices. These features are expanded at the expense of improved mechanical complication and increased complexity in control mechanism, The main advantage of using Omni-directional wheel systems is that it can move or slide in any required direction with respect to each wheel

rotation in narrow spaces. By replacing conventional wheel with omni-directional wheel the time and space required to handle a product or work is greatly reduced. Sushil Lanjewar, Pradeep Sargaonkar[2] concentrated on fabrication and simulation of mecanum wheel for automation, they have fabricated mecanum wheels using rollers. These rollers are made up of rubber polymer named Delrin and aluminum is used for hub. An automated prototype of mecanum drive is developed using mecanum wheels for material handling. We are following a particular path demonstrating the motions followed by mecanum wheel along with an obstacle detection program for avoiding collision in path.

III. DESIGN AND CALCULATIONS

Static friction is a force that keeps an object at rest. It must be overcome to start moving the object. Once an object is in motion, it experiences kinetic friction. If a small amount of force is applied to an object, the static friction has an equal magnitude in the opposite direction.

Following notations are used for the design of wheels

- F_s - Force of static friction
- n - Normal force.
- m - Mass of the model.
- g - Gravitational force.
- μ - Coefficient of static friction.
- N - Speed of the motor.
- T - Torque of the motor.
- Standard bearing count = 18
- D - Diameter of the disc.
- N - Number of bearings.

□ Frictional force on the wheel is given by

$$\begin{aligned} F_s &= 2(n \times \mu) \\ &= 2 \left(\frac{mg}{4} \right) \mu \\ &= 0.5 \times 8 \times 9.81 \times 0.6 \\ &= 23.54 \text{ N} \end{aligned}$$

$$\begin{aligned} \text{Motor power} &= \left(\frac{2\pi NT}{60} \right) \\ &= \left(\frac{2\pi \times 90 \times 9.81}{60} \right) \\ &= 92.36 \text{ W} \end{aligned}$$

$$\begin{aligned} \text{Bearing to bearing length (pitch)} = \text{Distance} &= \left(\frac{\pi D}{N} \right) \\ &= \left(\frac{\pi \times 150}{18} \right) \\ &= 26.17 \text{ mm} \end{aligned}$$

Special wheel designs are done that reduce active traction of the wheels. The CAD model of the design is as shown in Figure02 & Figure03.

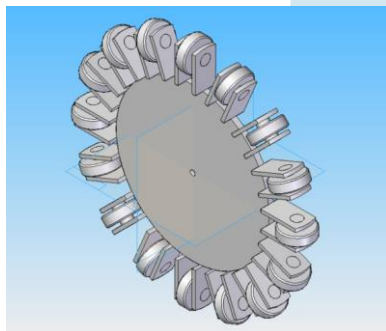


Figure 02: CAD Model (Iso)

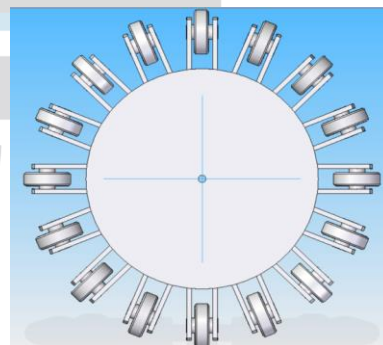


Figure 03: CAD Model (Front)

Chassis is a support structure where all machine parts are assembled. Material used for chassis is galvanized iron.

The Figure04 &05 shows the complete assembly of Omni directional robot wheel four wheels are attached to a chassis perpendicular to each other. The wheel is mounted at the center of each side of the chassis. Two bars are attached to the chassis to maintain the balance and to carry the controller board, battery and other accessories. Four clamps are made at each side of the chassis to hold the motors which are connected to wheel. In the below figure the isometric and front view of the assembly is shown.

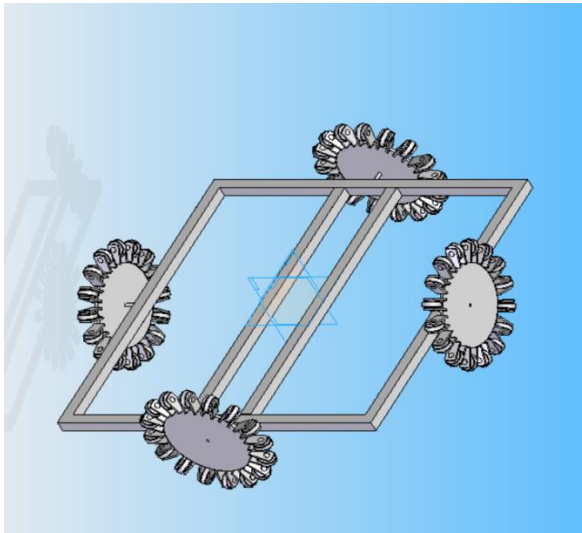


Figure 04: Assembly (Iso)

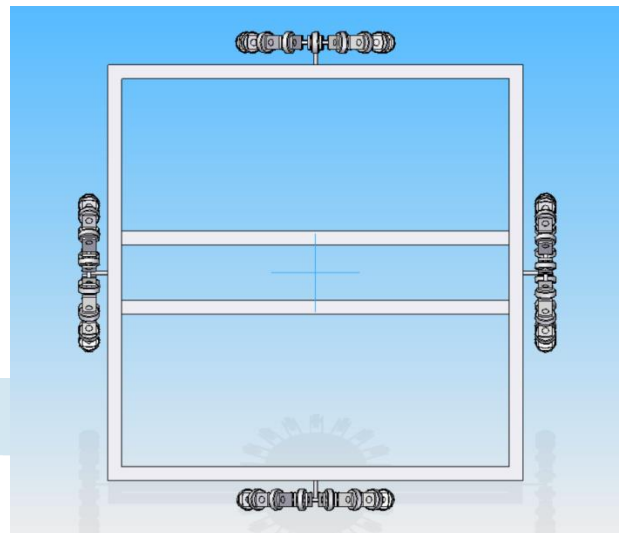
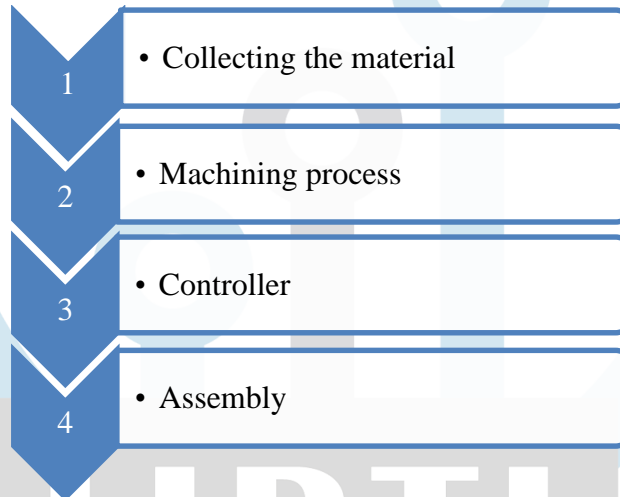


Figure 05: Assembly (Top)

IV. FABRICATION

Following process flow is adopted for the fabrication.



- **Collecting the material:** we collected the materials from different sources like industries, electrical stores, mechanical workshops, etc. The materials like bearings, mild steel plate, GI pipe, bolts & nuts etc. The electrical items like arduino controller relay controller, resistors, Bluetooth device, battery, motors, LED display and wires.

- **Machining process:** first we cut the steel plate into discs as per the dimensions. The disc diameter is 150mm and its thickness is 5mm, four discs are made for four wheels. According to the dimensions, marking the points for roller (bearing) attachment. A 6mm diameter hole is drilled to the disc to mount the required motor.

Mild steel bar is cut into small pieces according to the dimension, each bar has 30mm height, 20mm width and 3mm thickness, after that we drilled a hole having 10mm diameter. The shaft is made up of mild steel having 10mm diameter and 13mm length. In between the two bars the bearing is fixed along with the shaft. According to the calculations, 18 rollers (bearing) are welded into the circumference of each disc, by using arc welding method. The distance between the two rollers is about 26mm. after finishing of welding; filing is done for smooth and fine surface. Chassis is made up of GI pipe. A square shaped chassis is fabricated having 2ft length at each side. Another two bars are fixed in middle of the square chassis for balancing and hold external equipment. Here also used arc welding method to connect the links. After that four clamps are made over the body of the chassis at each side, for holding the motor.

- **Controller:** Controller is an external device that manages and regulates the operation of the device. We have used nano arduino controller, relay controller with Bluetooth model and one LED 16x2 display. There are one nano arduino controller and 8 relay controllers are used because the motors are having more than 5v, the nano arduino controller is only limited to 5v. Here we adopted wireless controlling system i.e, Bluetooth controlling system. So we can operate the movement of the model through mobile application. Instead of Bluetooth controller we can also use IR (Infrared) controller.

- **Assembly:** The figure shows the complete assembly of Omni directional robot. Four wheels are attached to a chassis perpendicular to each other. The wheel is mounted at the center of each side of the chassis. Two bars are attached to the chassis to maintain the balance and to carry the controller board, battery and other accessories. Four clamps are made at each

side of the chassis to hold the motors which are connected to wheel. In the wheel is assembled with chassis as shown in Figure06 along with wheel the arduino controller is assembled to the chassis as shown in Figure07.

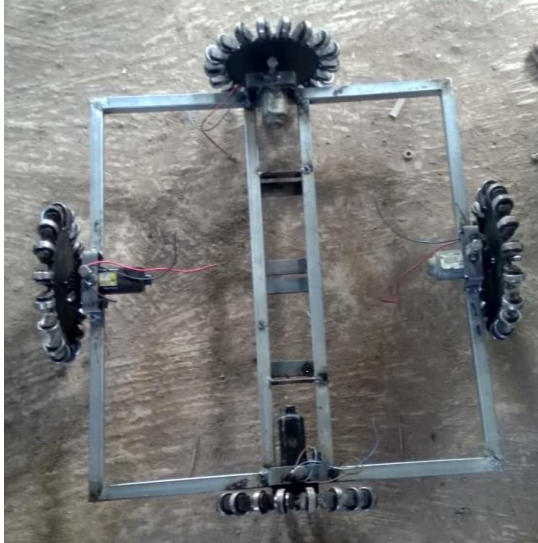


Figure 06: Chassis with Wheel

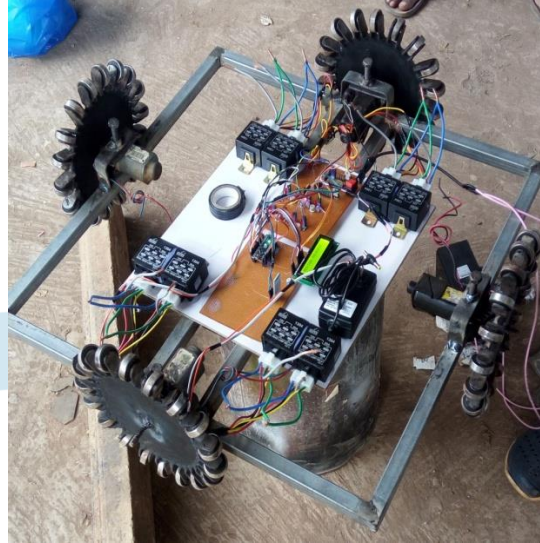


Figure 07: Assembly

V. RESULTS AND DISCUSSIONS

Omni wheels rotate when power like any other and give flexibility of side movement as well. The rollers are aligned perpendicular to the wheel axis; this allows the wheel to roll on the rollers when a side force is applied. The sideways wheels on an Omni wheel are not powered, they just make sideways friction. Omni directional enable conventional forward and backward movement as well as side to side and even rotation. To accomplish this, each wheel turns independently.

The Omni directional wheel can move in any direction without changing the direction of the wheel, by using Omni directional wheel we can achieve 360 degree rotation without moving the body of the robot. By using Mecanum wheel we can move 45 degree of angular movement. Here we are adopting wireless Bluetooth controlling system, the desired program is dumped into arduino controller. We can control the model in mobiles by giving the required commands i.e., when we give command 1 the motor will rotate in clockwise direction at the same time the model will move in forward direction, if we give command 2 the wheel is going to rotate in ccw direction and the model is move in backward direction during forward and backward motion the other two motors will remain stable and the rollers will rotate along with running wheels this can prevent friction between the surface and the wheel. When we give command 3 and 4 the model will move left (ccw) and right (cw) respectively. If we want to stop the motor we should give command 0(stop).

Table: 01 Direction Commands

COMMAND	DIRECTION
1	Forward (cw)
2	Backward (ccw)
3	Left side (ccw)
4	Right side (cw)
0	Stop

VI. CONCLUSION

In this paper basic functions of the Omni directional mobile robot such as Design of wheel and roller, control system design, and experimental performance evaluation were tested. Among different varies of design we use a special type of wheel which reduces in frictional forces that will be generated during transverse motion of the robot and the same is observed in the experimentation results. We provided complete details of fabrication which includes hardware requirement and simplest procedure for assembly of the given model. Hence from this paper we can conclude that the Omni-directional wheel technology will bring about a revolution not only in the automobile industry but also will change the scenario with regards to its numerous applications in robotics, medical fields that will enhance our day to day life.

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