DESIGN & DEVELOPMENT OF MECANUM WHEEL SYSTEM FOR CAR PARKING

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Abstract: This paper presents the design and development of Mecanum wheel on multi-directional automobile as a component in the Parking System. Multi-directional automobile has vast advantages over conventional design like differential drive in terms of mobility in congested environments. Multi-directional automobile could perform important tasks in environments congested with static and/or dynamic obstacle and narrow aisles, such as those commonly found in car parking, manufacturing floor, warehouses, offices and hospitals. A variety of designs of Mecanum wheel have been developed in recent years in order to improve their Multi-directional maneuver and practical applications. These features are augmented at the expense of improving mechanical complication and increasing its complexity in control mechanism. Mecanum wheel systems work by applying rotating force (CW or CCW) of each individual wheel in one direction somewhat similar to regular wheels but, Mecanum wheel systems are able to slide freely in a different direction, in other word, they can slide frequently in most of the directions. The main advantage of using Mecanum wheel systems is that various motions are decoupled for simple motion although in making an allowance for the fastest possible motion this is not essentially the case.

I. INTRODUCTION

One of the common multi-directional automobile wheel designs is Mecanum Wheel or Ilon wheel. Bengt Ilon, an engineer of Swedish company Mecanum invented the mecanum wheel design in 1975 in Sweden. Mecanum wheel is based on the principle of a central wheel with a definite amount of rollers placed at an angle around the periphery of the wheel. Because of this the roller mounted at the periphery transforms a portion of force in the rotational direction of wheel to force normal to the wheel's direction. Based on the speed and direction of the individual wheel, the resultant force produces a force vector in any desired direction thereby allowing the platform to move freely in direction of resulting force vector, without changing the direction of the wheel. A traditional Mecanum wheel design by Ilon consists of roller at the peripheral with 45° degree slope held in place from the outside.

This design only can operate on uniform work surface. When encountering an inclined or an uneven work surface, the rim of the wheel can make contact with the surface instead of the roller, thus preventing the wheel from operating correctly. To encounter this problem Ilon proposed a simple alternative design, which consist two spilt roller mounted centrally on the periphery of the wheel.

This design makes sure that the rollers are always in contact with the work surface, thus allowing better performance on non-uniform surfaces. Using four of Mecanum wheels provides multi-direction movement for a vehicle without needing a conventional steering system. Mecanum wheel system usually tend to slip as there is only one roller which is in point contact with the ground at any time. Due to the dynamics of the Mecanum wheel, it can create force vectors in both the x and y-direction while only being driven in the y-direction .When we position a Mecanum wheel at the four corner of chassis (2-mirrored pairs), causes the resultant forces to be formed in the x, y and rotational direction. Hence, there will be four variables to control three degrees of freedom which will give rise to complication. In this case the system is said to be over determined and it is possible to create conflicts in the actuation. As a result of the constraints associated with the Mecanum wheel some form of controller is required to produce satisfactory motion.

II. PROBLEM IDENTIFICATION

With the increase in population, there is an increase in requirement of private vehicles for transportation. Due to large number of vehicle it becomes difficult to manage the parking of vehicles. Also, it leads to problems such as congestion, wastage of space and time, car napping, long hours of wait in traffic, car vandalism and many more. To overcome these complications we have developed a car parking system which will allow to park a car in comparatively less time and minimum space.

III. RESEARCH AND METHODOLOGY

Prime requirement of the system is to have multi-directional movement which is only possible with the help of Mecanum wheel. Selection of Material for Mecanum wheel is also important from maintenance point of view. To make it more stable and robust, a four-wheel mechanism was selected. Design of Mecanum wheel will be based upon the amount of load it can carry, Hence High Strength Alloy Steel was selected for 4 wheels, and each wheel is powered by an individual motor so that we can get 10 possible motions. Chassis was designed on the basis of maximum load condition. A Linear actuator was used to obtain vertical motion in order to raise or lower the platform. Selection of linear actuator makes response time quicker.

3.1 Data and source of data

For this study we collected data from PSG design data book

3.2 Equations

$$\text{Moment of inertia} = I = \frac{hb^3}{12}$$

Critical buckling Load = $P_{cr} = \frac{\pi^2 EI}{(KL)^2}$

Resultant stress due to buckling = $\sigma_{cr} = \frac{P_{cr}}{A}$

IV. THEORETICAL FRAMEWORK

At first we consider the load which is applied on the system, then this principal load is divided into four equal parts such that one equal part of the load acts on one beam and so on. Hence we get the "Simply supported beam with point load at the center" type of arrangement. These four beams are used to form a chassis and these beams are made up of alloy steel pipes with square shaped cross section. A platform is provided as a parking spot for the car which means that the car rests on the platform. The platform can be lowered or raised with the help of linear actuator installed in the machine. The arrangement consists of four wheels which are powered by four individual motors and the torque calculation is based upon the speed of motor and gearbox of motor. We select low rpm and high torque motor, since we require high torque for the application.

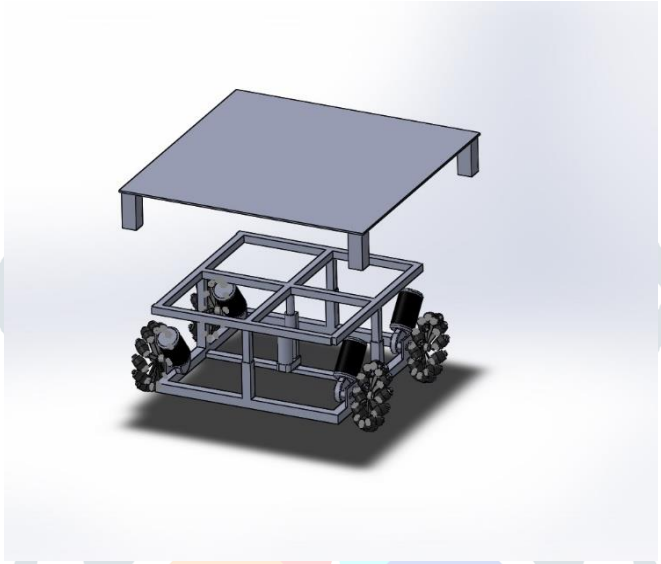

Figure 4.0 Structural Design

4.1 Hub

Hub was used to support shaft of the motor. Motor shaft is too small as compared to actual vehicle's axle, hence design of hub is a crucial step.

Diameter of Hub = 2D
Length of hub = 3D
Where, D is diameter of motor shaft
Figure 1 Hub of the wheel

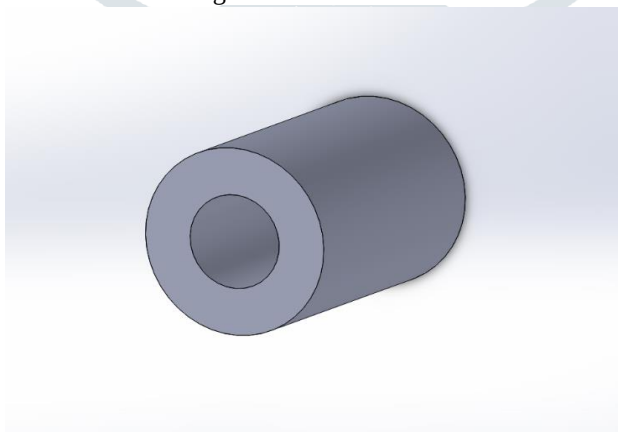

Figure 4.1 Hub of the wheel

4.2 Roller

As a mecanum wheel requires roller, design of roller plays an important role in proper functioning of the system
Roller is designed in such a way that it should have point contact with surface .in this design we are using 12 rollers on each wheel .Roller is directly fitted on Roller pin. It should be tight joint between roller and Roller pin.

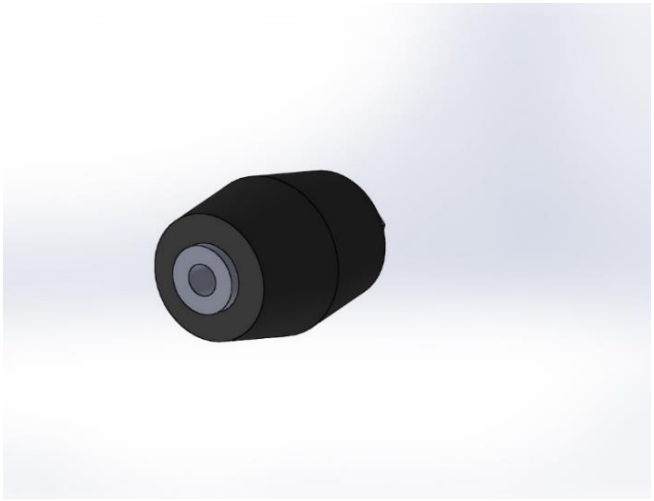

Figure 4.2 Roller of the wheel

4.3 Spokes

It is difficult to setup spokes because rollers are required to be mounted on spokes of the wheel, hence the setup gets congested and messy .To avoid this problem, the rollers are systematically tilted by an angle equal to 45 Degree. This kind of arrangement is possible either by Milling or welding.

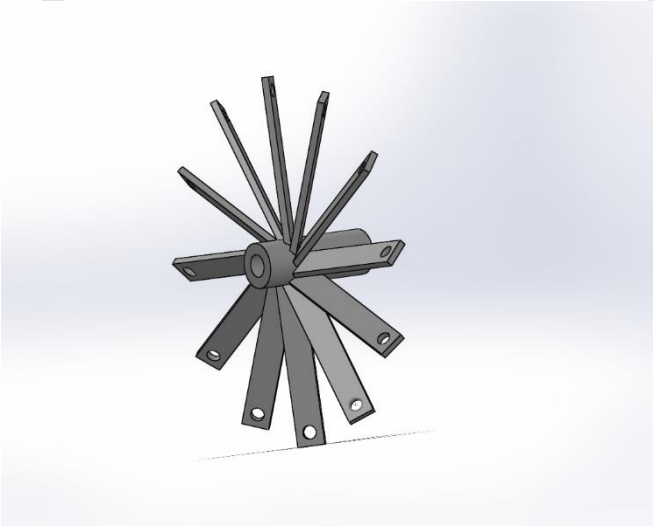

Figure 4.3 Spokes

4.4 Platform

To lift the vehicle we use platform .platform is made of high alloy steel with four legs at each corner. Size of a platform depends on vehicle size. Legs have been welded at the centre of all the four sides.

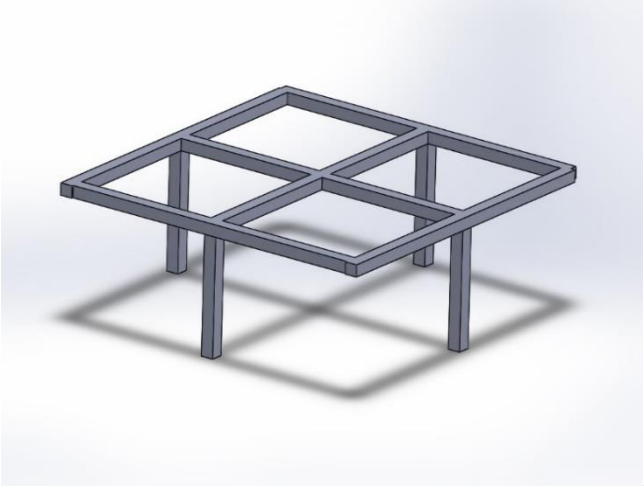

Figure 4.4 Platform

V. RESULTS AND DISCUSSIONS

5.1 Results of experiment

Table 1: Result

Variable	Conventional Parking	Parking (with 1 Mecanum wheel system)	Parking (with 4 Mecanum wheel system)
Layout (in meters)	23×20	23×20	23×20
Capacity	12	15	24
Utilization (%)	-	25	100

The figure below shows the three different cases when the vehicles are parked conventionally, when 1 mecanum wheel system is used and when 4 mecanum wheel system is used respectively for the same parking lot. In all of the layouts below we have assumed the car's dimension (breadth and length) to be approximately 2m × 6m respectively and the overall dimension of the layout is assumed as 23m × 20m. The centerline shows the path of mecanum wheel which carries the car and transports it to the desired location. All the cars are parked on the platform which is lifted by the mecanum wheel system during transportation.

1) Conventional parking layout (Fig.5.1.): As we can see from the fig.5.1 that the cars are parked horizontally in the given layout. There's ample amount of clearance provided in the layout as per the maximum turning radius of the car. Hence, it enables less skilled driver to drive out his car from and to the parking lot. Clearance is also provided between two cars for the driver to get in and out of the car easily.

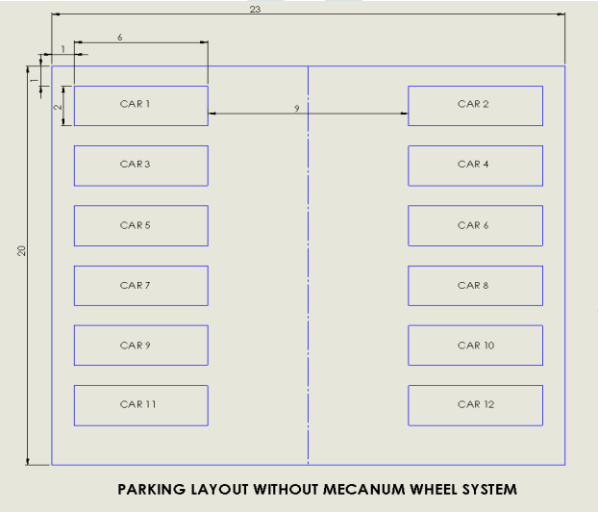

Figure 5.1. Conventional parking layout

2) Parking layout with 1 Mecanum wheel System (Fig.5.2.): As we can see in this layout fig.5.2. that the cars are being parked horizontally with minimum clearance between them. Also there's enough space for the two parallel driveways for the mecanum wheel to carry the car inside the parking lot and vice-versa. Hence, we are able to park more cars then the above layout.

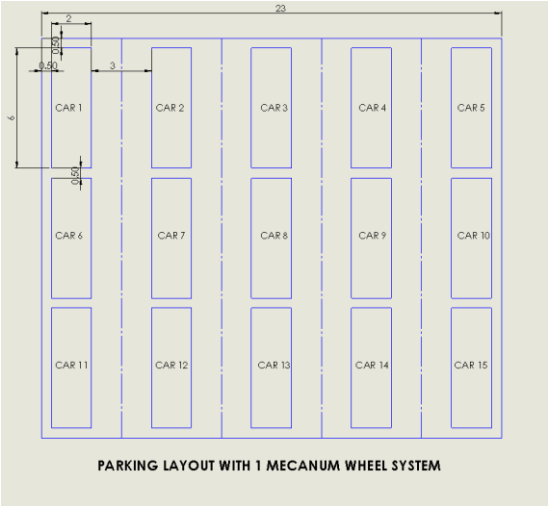

Figure 5.2 Parking layout with 1 Mecanum wheel System

3) Parking layout with 4 Mecanum wheel System (Fig.5.3.): As we can see the layout in fig.5.3. that this layout has the maximum percentage of utilization of space then the layouts in fig.6.1 and fig.6.2. Therefore, here more number of cars can be parked. Since there's no requirement of clearance for the driver to get in and out of car, and also minimum turning radius is not required here as the cars are being carried on the mecanum wheel system.

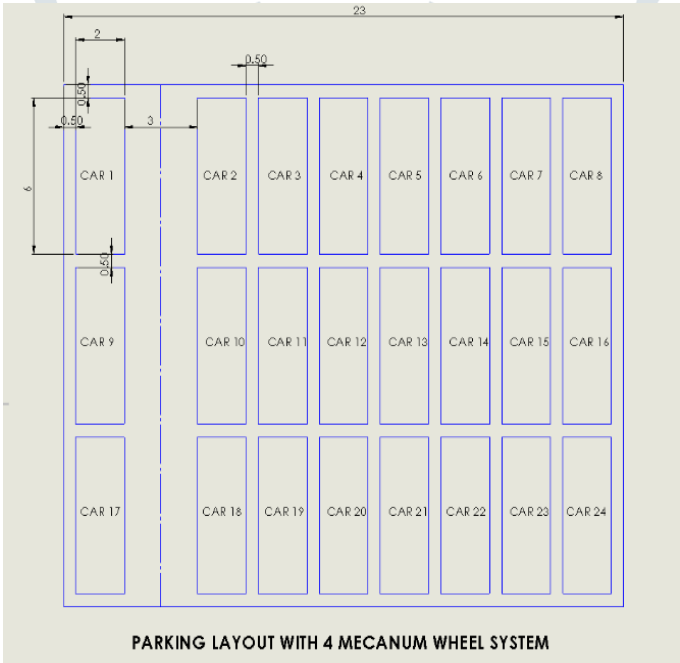

Figure 5.3. Parking layout with 4 Mecanum wheel System

5.2 Profit Projection

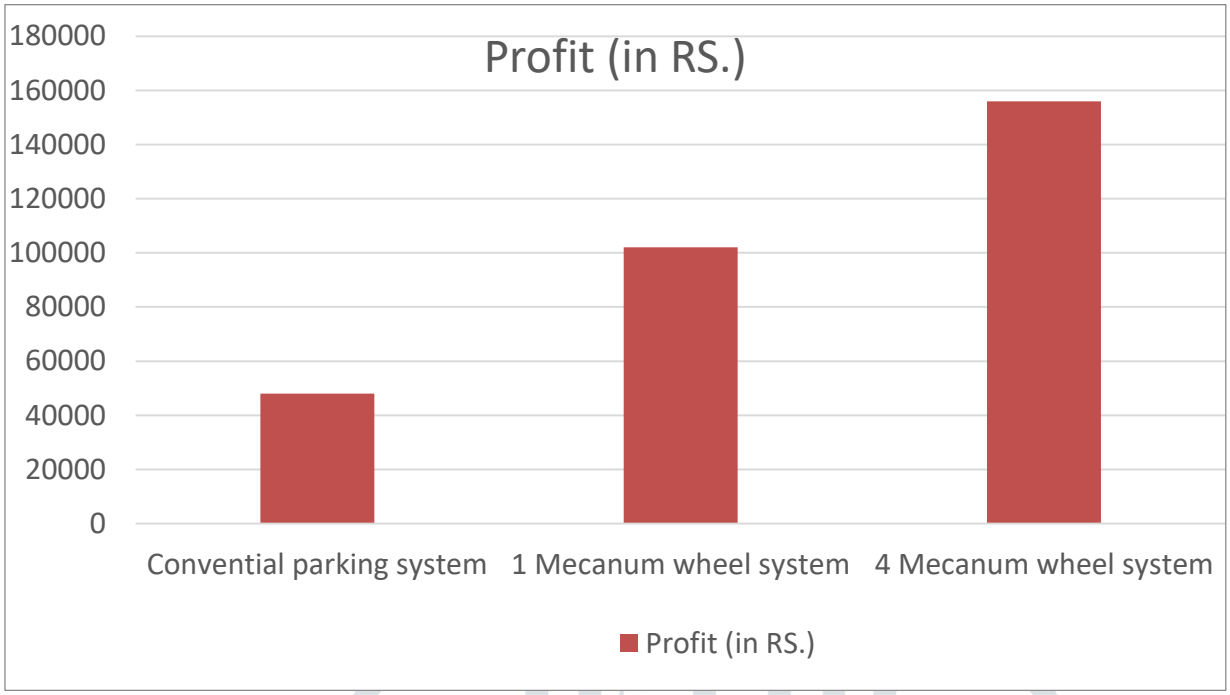

Fig.5.2 Profit Chart

Considering:
1) Rs.50 pay and park cost/hr
2) 12hrs of car parking
3) Continuous car parking

VI. ACKNOWLEDGMENT

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