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Mecanum Wheels Based Platform For Industrial Forklifts

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Abstract: The study examines investigation about multi directional automobile construction by focusing on the implementation of Mecanum wheels in forklift vehicles. Multi-directional automobiles demonstrate superior performance compared to conventional designs through their use of differential drive systems because they excel at moving in dense environmental conditions. The vehicles offer exceptional obstacle navigation and space maneuverability which makes them valuable for use in manufacturing floors together with warehouses and offices and hospitals. The development of Mecanum wheel-equipped forklifts through multiple designs has improved their ability to move in multiple directions and their applicability in practical settings since recent years. The technological improvements of these devices require additional complex mechanical structures and sophisticated control systems. An application of rotational torque to each wheel enables them to glide in perpendicular directions relative to the torque vector within a Mecanum wheel system. Mecanum wheels provide their main benefit by dividing cross-movement from turning motions making simpler motions possible. The normal force between tires and the ground does not maintain its decoupled relationship in the pursuit of peak speeds.

Keywords: *Dynamic Modeling, Mecanum Wheels, Wheeled Mobile Robot (WMR), Actuator Faults*

I.INTRODUCTION:

The Mecanum wheel, sometimes referred to as the Ilon wheel, is among the most popular varieties of omni-directional wheels. In 1975, Swedish engineer Bengt Ilon, working for the company Mecanum, invented the Mecanum wheel. This wheel consists of a central hub with multiple rollers attached at an angle around its edge. These angled rollers redirect part of the wheel's rotational force into a sideways force, enabling smooth movement in any direction without needing to turn first [1]. The platform can move smoothly in any direction without affecting the orientation of the wheels by varying the speed and rotation of each individual wheel, which adds up to a total force vector Ilon's original Mecanum wheel design, with externally mounted 45-degree rollers,is depicted in Figure 1.Because they can carry out physically taxing and repetitive tasks like handling and transportation, mobile robots have grown in value in both industrial and research applications. On the other hand, flat, level surfaces are ideal for conventional Mecanum wheels. The wheel's movement may be hampered when driving on uneven or sloping terrain because the rim may make contact with the ground rather than the rollers. Ilon suggested a different design with split rollers positioned in the middle of the wheel's rim to solve this problem, as seen in Figure 2.

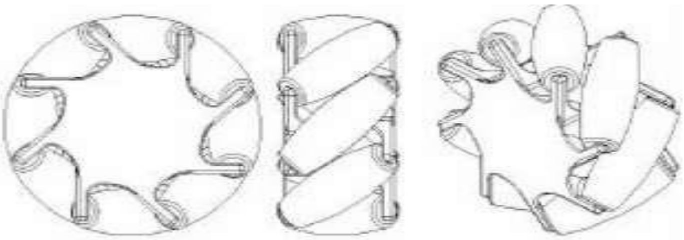


Fig 1. Mecanum wheel, which is designed based on Ilon's concept.

Performance on uneven terrain is enhanced by this design, which guarantees that the rollers maintain constant contact with the surface A vehicle equipped with four Mecanum wheels can achieve omnidirectional movement without the need for conventional steering. The key is the roller orientation on each wheel, which allows each wheel to exert forces in different directions simultaneously. However, as you mentioned, this design comes with some slipping issues due to the nature of the wheel's contact with the ground[2].

The Mecanum wheel's special mechanics allow it to be driven only in the y direction while producing force vectors in both the x and y directions. As shown in Figure 3, the robot has four special wheels, called Mecanum wheels, positioned at each corner of its base in a mirrored arrangement. This setup allows the robot to move in any direction—forward, sideways, and even rotate—by combining the forces generated by the wheels.The problem with this setup is that it overdetermines the system by adding four control variables for only three degrees of freedom. This may result in actuation conflicts, necessitating a specialized control system to guarantee accurate and seamless movement[3].

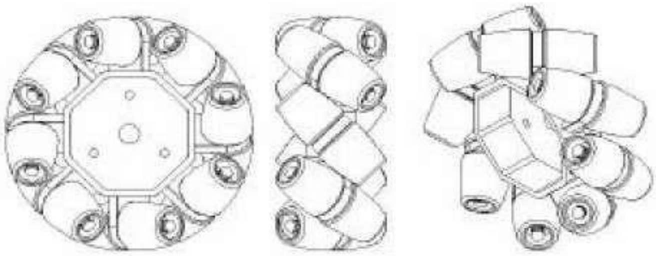


Fig.2. Mecanum wheel featuring rollers mounted at The center.

Through this design mechanism each roller maintains continuous interaction with the work surface therefore improving system performance on irregular terrain conditions. A vehicle using four Mecanum wheels achieves omnidirectional movement without traditional steering mechanisms. The key to this is the **angled rollers** on each wheel, which allow for complex motion patterns by adjusting the speed and direction of individual wheels [5]. A driven motion in the y axis allows the Mecanum wheel to produce force vectors which simultaneously aim toward x and y directions. A frame with four Mecanum wheels set symmetrically in pairs at each corner enables the production of controlling x-directional and y-directional forces as well as rotational forces. The method introduces four control variables when functioning to manage three degree of freedem thus producing an overdetermined system[6]. The multiple control variables in this configuration produce conflicts in the actuation process. Some form of control system must be in place to get satisfactory motion since Mecanum wheels require management of their associated constraints.

II.DRIVE MECANUM

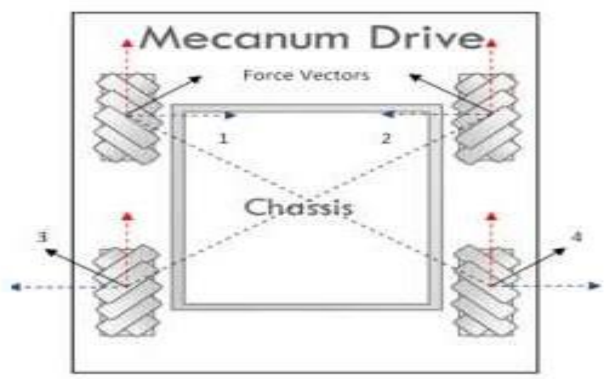


Fig.3 Mecanum Drive

The illustration depicting drive platform alignment appears to the right. The wheel pairs should align as the first wheel opposes second wheel in a cross formation with third wheel opposing fourth wheel. Failure to set up the wheels according to this configuration will result in dysfunctional operation. Mecanum drive belongs to the category of holonomic drive bases where each wheel applies force by aligning at 45 degrees rather than pointing along its physical axis[7]. Controlling translational movement of your robot becomes simpler through angled force applications that let you modify the vector powers. The robot system maintains a fixed direction through its front section as it shifts towards any direction. Different combinations of wheel rotation allow robots to perform multiple movements as shown in the following illustration.To effectively operate When using a Mecanum drive system, you must have the following details on hand

- Desired Angle.: The robot should move at a specific angle which the system refers to as
- Desired Magnitude: The robot needs to achieve its movement velocity. .
- Desired Rotation: The robot should transition its facing direction at this specified speed.

Specialized Mecanum wheels form the basis of Mecanum drive systems to enable robot and vehicle movement in all directions without needing vehicle rotations. Special roller arrangements are mounted on wheels at an angle to produce advanced locomotion designs. through simple adjustments to the speeds and directions of the wheels[8].

- Control System: This system manages the speed and direction of the motors connected to each wheel.
- Typically, it includes a microcontroller, motor drivers, and various sensors for precision control.

Wheel Arrangement: A common configuration for vehicles or robots is a four-wheel setup, with one mecanum wheel located at each corner. The directional movement of a Mecanum-wheeled vehicle depends on how each wheel rotates. By varying the speeds and directions of the four wheels, the vehicle can move in any direction without needing a traditional steering mechanism

- Forward/Backward: The entire vehicle operates with wheels that make even rotations while maintaining uniform speeds.
- Lateral (Sideways): Vehicle wheels function differently between left and right side since their rotational motion operates against each other.
- Diagonal: This movement combines forward and lateral motions by varying the speeds of the wheels.
- Rotation (Turning): Opposite wheels rotate in opposite directions, allowing the vehicle to spin in place. Chassis Design: • Dimensions: Design a rectangular or square frame to ensure stability. Make sure there is sufficient clearance for the wheels to rotate freely.
- Movement Directions: Vehicle wheels function differently between left and right side since their rotational motion operates against each other[10].

III.ELECTRONIC ARC

The most frequently employed welding processes consist of the following:

1. SMAW also known as stick welding/electric welding makes use of flux-coated electrodes for puddle protection throughout welding operations. Operation control occurs through electrode holder because it yields gradual electrode dissolution through contact. Protecting the weld puddle from contact with surrounding air happens when the developing slag layer ensheathes it.
2. TIG (tungsten inert gas) welding operates under the Gas Tungsten Arc Welding method for its ability to create welds by using a non-consumable tungsten electrode. The welding zone requires protective shielding gas composed of argon or helium to defend against environmental pollutants..
3. GMAW (Gas Metal Arc Welding) operates through a gun that supplies metal wire at differing speeds using the

MIG (metal inert gas) welding technology. Protection from atmospheric contaminants reaches the weld puddle through shielding gas which consists of pure argon or argon with carbon dioxide (CO_2) added as an ingredient.

4. FCAW operates identically to MIG welding through its use of metallurgical wires which come with a built-in flux. Performing this method with shielding gas depends on the selection of filler material but it also offers an alternative without shielding gas.

5. The SAW process needs both hidden electrodes and protective granular fusible flux blankets which should envelop the weld area. The protected zone includes both the molten weld section and the arc area due to the submersion under the protective blankets. Different welding systems function through distinct methods suited for different applications with their own specific combined advantages and operational conditions[11].

IV. WORKING SYSTEM

4.1 Machine Design:

Inside machine design exists the skill of making machines and structures. Construction of machines includes limited resistant materials which retain mobility restrictions within their relative positions. Machines serve two functions which include transforming different energy types into mechanical energy and distributing existing energy while making necessary modifications. A design objective is to produce modernized machines and structures which exhibit enhanced motion transformation capabilities when transmitting power functions.

The practical implementation of machinery principles through machine design leads to the creation of machines and structures. The creation of effective simple components depends on fundamental applied scientific expertise. Understanding material properties and strengths together with fundamental metrology concepts stands as the most vital information for designing purposes. To understand forces acting on moving links knowledge of machine theory as well other applied mechanics principles is required. The mechanical aspects of machinery establish essential value during development processes.Chemical Composition of EN C45 steel.

4.2 The chemical composition of EN C45 steel

Properties of steel C45 (1.0503)

Grad	C (%)	Si (%)	Mn (%)	P (%) max	S (% max	Cr (%) max
C45	0.42 - 0.50	0.03	0.8	0.023	0.023	0.20

V. MATHMATICAL ANALYSIS

The selection of **C45 (1.0503) medium-carbon steel** for your project depends on several key factors. Here are some common reasons why **C45 steel** is chosen:

- It is readily accessible in various sections.
- Can be welded efficiently.
- Easy to machine into desired shapes.
- Can be cut with ease.
- cheaper than alloy steels and stainless steels

Material = C 45 (mild steel)

Take fos 2

$\sigma t = \sigma b = 540/2 = 270$ N/mmA2

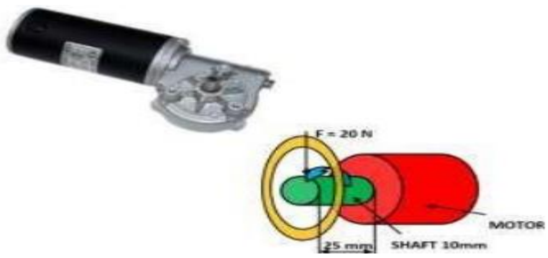
$\sigma s = 0.5\ \sigma t$

$= 0.5 \times 270$

$= 135$ N/mmA2

Both the total weight of the machine and its distribution across the four wheels do not exceed 18kg.The weight division across the wheels amounts to 4.5 kg each.

The motor has a power rating of 15 watts, operates at a 12V supply, and runs at a speed of 20 RPM.



Weight =4.5 kg x 9.8 = 44.1Newtons , M= 44.1 N x 25 mm =1102.5 N-mm P=2πNT/60

T= (15.00 x 60) / (2 x π x 20)

T= 7.16 N-m or 7162 N-mm

Te= √ (M2+T2) = √1102.52+71622

= √1215506+51294244

= √ 52509750

Te=7246.52N-mm = 7.24 x 103N-mm

Te=π/16

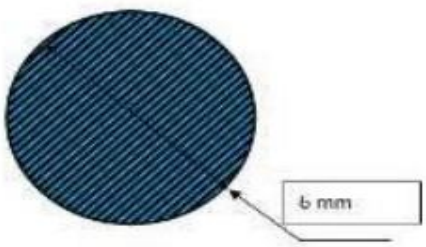
xσsxd3 d3=7246.52x103x16/πx135=272.53

d =3√272.53= 6.47 mm

d =6.47mm

However, since we are using a 10 mm shaft, it is safe.

The rollers are attached to the wheel using pins that have a diameter of 6mm.



M=W×L=44.1×40=1764 N-mm

Z= π/32 x d3
Z= π/32 x 6 3

Z= π/32 x 216

Z=21.2 mm3

σb = M/Z = 1764/21.2 = 83.21 N/mm²

Since the induced bending stress is lower than the allowable bending stress 270 N/mm², the design is considered safe.The rollers are mounted on an MS flat with dimensions 12×3 mm and a length of 74 mm.

W = maximum force applied = 50 N
M = W x L

M = 44.1 x 74 = 3263 N-mm

And section modulus = Z = 1/6 bh2

Z = 1/6 x 3x122 Z = 72 mm3.

The induced bending stress is calculated as:

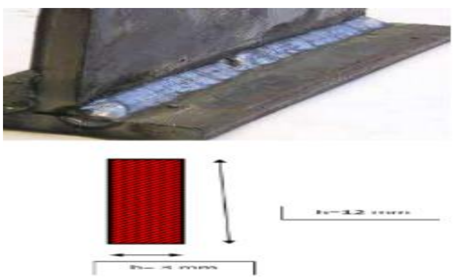
σb=M/Z

=723263

=45.3N/mm2

Since the induced bending stress of 45.3 N/mm² is significantly lower than the allowable bending stress of 270 N/mm², the design is considered safe.

Designing a transverse fillet weld joint



Thus, choosing the size of the weld rod = 3.2mm

Weld Area=0.707×Weld Size×L

Weld Area=0.707×3.2×12

=27.15mm2

Force Exerted=σ×Weld Area

- Weld area = 27.15 mm²
- Stress induced (σ) = Force exerted / Weld area

21 = F / 27.15

F= 570.21 N = 58.12 kg

The maximum permissible stress for welded joints is 21 N/mm².

linear velocity (V) of the machine, Diameter of the Mecanum wheel

= **198 mm**

V = πDN/60

= 3.142 x 0.198 x 20/60

= 0.2073m/sec

V = 0.2073 x 3.6

= 0.75 km/h

Battery 12V x 7.5 amp = 90 watt 15 x 4= 60 watt

90/60= 1.5 hours

Fork lift motor ,

- P = Power (W) = 10 W
- NNN = Speed (RPM) = 15 RPM P=2πNT/60

T= 10 x 60/2x π x15

T= 6.36 N-m = 6.36 x 1000 6360 N-mm.

Fig.-Final model of Mecanum wheel for industrial purpose

Fig-Working Steps of Designing at Workshop

VI.ADVANTAGES AND DISADVANTGES

Advantages:

- Mecanum wheels allow a vehicle or robot to move in any direction without needing to turn first.
- It can move forward, backward, sideways, diagonally, and rotate in place.
- Movements are controlled by varying the speed and direction of individual wheels, making it easier to program and control.
- Useful in industrial robots, forklifts, and automated systems for improving workflow efficiency.
- Reduces the need for extra space to maneuver large loads.

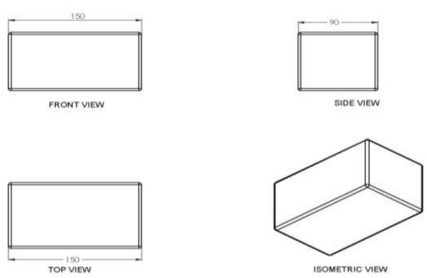
Disadvantages

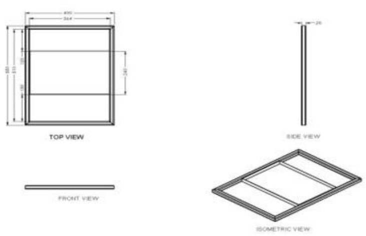
- Mecanum wheels have lower traction compared to traditional wheels because of their angled rollers.
- This makes them less suitable for rough, uneven, or slippery surfaces.
- More power is required to control the independent motors for each wheel, leading to higher energy consumption.
- This can reduce battery life in battery-powered robots or vehicles.

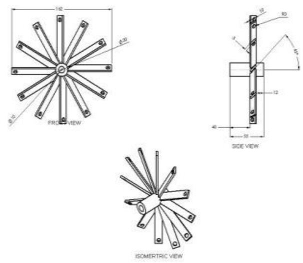
Future Scope:

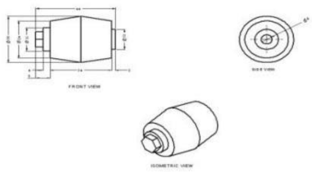
- Future Mecanum wheels may use **lightweight and durable materials** (e.g., carbon fiber, advanced polymers) to improve efficiency and reduce wear and tear.
- 3D printing and **smart material integration** could enhance wheel durability and performance.

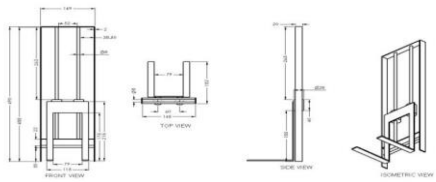
3D module and drafting

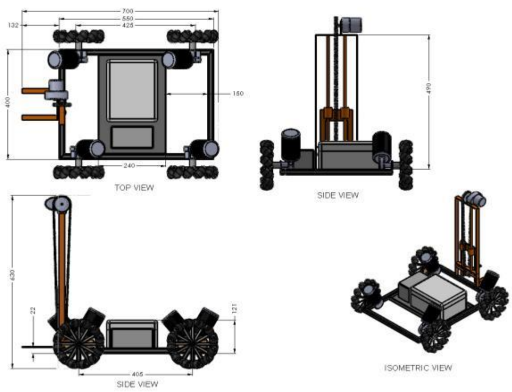












VII.CONCLUSION

A two-layer kinematic behavioral control framework for UGVM control is presented in this paper. A cooperative motion controller makes up the second layer, and a three-level NSBC scheme is used in the upper layer. The algorithm's efficacy is verified through a simulation case. The findings show that vehicle-manipulator coordination can be effectively managed in complex tasks by creating a complete control system that incorporates behavioral control and a mission supervisor. Future research will concentrate on conducting experiments on actual UGVM systems and expanding the behavioral control from just transitioning from kinematic-level control to a combination of kinematic and dynamic-level control

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