Application of Zero Turning Mechanism in Forklift using Mecanum Wheels

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Abstract – Forklift is an important part of industries where moving of objects within the industry compound is important. The aim of this paper is to analyze the optimum material for fork and minimize the space required for the movement of vehicle. The industries having less work space and more work volume requires forklift vehicle which can perform zero turn. In this paper we have studied the zero turn using Mecanum Wheels. No additional space is required to turn the vehicle. Various materials were studied and analyzed for the optimum choice to be used as fork material.

Index Terms – Boron Steel, Forklift, Mecanum Wheels, Stainless Steel S17400, Zero Degree Turning Radius.

1. INTRODUCTION

Stacking and emptying has dependably been an overwhelming procedure amid transportation due to the assortments, diverse shapes, distinctive bundling of the merchandise. Forklift was designed and turned into the answer for this issue, it spare time and space. A forklift or forklift truck is mainly utilized for stacking and emptying basic shaped products. It can likewise be utilized for non-bundled products or untraditional formed merchandise with exceptional attachments. Items like containers and boxes can utilize unique sort of attachments. Every single one of them can be requested with various limit and stacking extent to address distinctive issues. The stacking limit of a forklift truck is from 0.75T ~ 8.5T and greatest lifting stature can be up to 14.8 m. There are a few changes should be possible, and those are centered around in this study.

Ackerman or Davis steering geometry is engaged with conventional steering which has real impediment that it can't take minimum radius turn. Giving zero turn steering with no compromise in steer capacity and treatment of the vehicle is a noteworthy worry for automakers. In everyday life there are some difficult issues like vehicle moving on thin streets and amid stopping and to conquer this sort of issue this idea has been proposed. Zero turn steering gives much better mobility and control on the auto. Zero turning is finished by turning drive wheels at a similar rate in opposite direction. By controlling the back wheels toward the path opposite to the front wheels at low speeds, the vehicles turning radius is enormously diminished. Zero turn vehicle are now and then made by utilizing pneumatic actuators, DCV, engines etc [1]. Zero turning is additionally accomplished by omnidirectional Mecanum wheels. Exploratory and logically have given 12 distinct movements without changing the robot's orientation is accomplished [2]. The vehicle has a capability to move in a straight path as well as rotate arbitrarily around its center.

An ordinary Mecanum wheel comprises an arrangement of rollers orchestrated around a wheel hub [3]. Omni-directional mecanum wheel is utilized to move momentarily toward any path from any orientation. Omni directional robots have colossal favorable circumstances over a traditional plan as far as portability in congested situations which are ordinarily found in processing plant, workshops, warehouses etc. Omni-drive system work by having individual mecanum wheel apply torque one way similarly as a regular wheel, however can slide freely in other direction. The key preferred standpoint of mecanum wheel is that in view of their exceptional design they can acquire two various types of movements (translational and rotational) in the meantime. [4].

Prior, the issue of wheel positioning system being specifically associated with the steering system was settled by utilizing new idea of Zero turn vehicle with air operated circuit. It means that the positioning of the wheel will totally rely upon the compressor because of which it was anything but difficult to change orientation of wheel. The vehicle has an ability to pivot at its middle position in 360 degrees which can without much of a stretch take care of the parking issues in broad daylight places, shopping centers, multiplexes and etc [5]. We have contemplated an enhanced outline of mecanum wheel for omni directional robots. This plan enhances output of mobile robots by decreasing frictional force and consequently enhancing execution [6]. An automated vehicle was manufactured which rushes to convey material starting with one place then onto the next by utilizing radio frequency technology [7]. The mecanum wheel created comprises of nine rollers produced using delrin. Here four Mecanum wheels are used and the four mecanum wheels are autonomously powered utilizing four of DC motors and all the four wheels assembly were mounted specifically to the

frame of the vehicle [8,9].The most safety critical system on the fork lift truck is simply the fork arm, which must be fit for meeting the design specifications and the working conditions [10].

2. RELATED WORK

2.1 Zero turn Mechanism

Zero degree turning radius. The turning radius of the vehicle is a measurement portrayed by the outside wheels when turning with steering fully rotated. Zero degree turning radius of a vehicle suggests vehicle pivoting around an axis going through the center of gravity of the vehicle i.e. the vehicle turning at the same place where it is present.

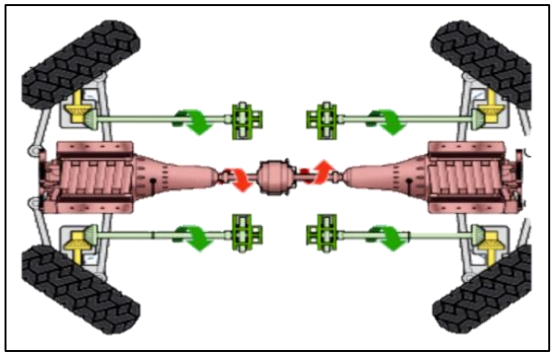

Figure 1 Zero Turning Mechanism In Jeep Hurricane

2.2 Steering Configurations

There are four steering configurations as follows:

- Two Wheel Steer: It is a type of a steering mechanism in which front wheels turn while the rear wheels are stationary and follow the front ones.
- Four wheel steer: It is a type of a steering mechanism in which front as well as rear wheels turn but in opposite direction.
- Crab steer: It is a type of a steering mechanism in which all the wheels turn in the same direction.
- Zero turn steer: It is a type of steering system in which the angle of wheel is so set that the vehicle rotates at the same place where it is standing.

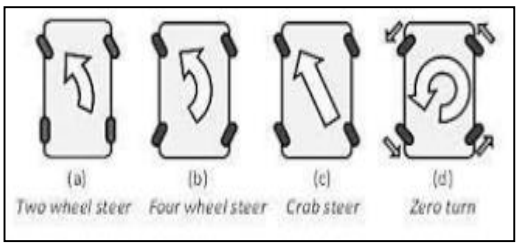

Figure 2 Steering Wheel Configurations

2.3 Zero turning mechanism using mecanum wheels

A Mecanum wheel is a specially designed wheel which has a capability to move a vehicle in any direction. It is a wheel with a number of rollers attached to its outer edge. The rollers have an axis of rotation at 45° to the plane of the wheel and to the axis of rotation of wheel. A mecanum wheel can be rotated such that each wheel applies force almost at right angles to the wheelbase diagonal. The vehicle can be made to move in 12 different directions and it can be turned by changing the speed and direction of rotation of individual wheel.

2.4 Zero turn vehicles with forklift

Now, most fork lift trucks have front wheel drive and use the rear wheels for turning but this one consists of new zero turning mechanism by using mecanum wheels. The full weight of the vehicle is placed on the drive axle for traction and braking (also known as counterweight). The wheelbase of the truck also affects its steering: the shorter the wheelbase, the easier to turn but in zero turn mechanism the only required area is the diagonal of the vehicle swinging and rotating to form circle.

3. MAJOR COMPONENT

Mecanum wheel

Mecanum wheel comprises of an arrangement of parallel rollers placed symmetrically around the wheel. The substance of each roller is a piece of a surface of revolution having its axis skew to the wheel hub. Each roller is driven by a different motor which provides vehicle with flexibility vital for an omnidirectional motion on ground. The advantage of mecanum wheels is that none of the wheels have to be turned. The wheel rollers rotate around their axes and move the vehicle in any desired direction. It is a simple but sophisticated concept of a wheel.

Figure 3 Mecanum Wheel

4. MATERIAL SELECTION

The most important component of the fork lift truck is the fork arm itself, which must be capable of meeting the design

requirements and the operating conditions at the place of operation. The technical characteristics required of a fork arm are described in ISO 2330, this requires;

- a minimum safety factor of 3 x safe working load
- Charpy V notch impact resistance of 27 J @ -20°C
- a type approval endurance test of one million cycles @ 1.25 x safe working load

The material properties of SAE 15B35H were reviewed, as the optimum material of choice for low cost and high volume manufacture with a discussion of what will be necessary in process terms, if this steel is to be replaced. The advancement of fork arms for exceptional applications is laid out, in precipitation solidifying stainless steel for corrosion resistance and in nickel aluminum bronze, for spark proofing.

When the manufacture of high volume production began in the late 60's, the product was characterised by high safety factors. The materials used were the traditional alloy steels, e.g. SAE 4340, SAE 4140, 42CrMo4, 817M40 etc. The essential process features were open die fully forged arms with integral forged heads; requiring machining or boring; a full heat treatment of harden, oil quench, and temper.

i. Boron Steel Fork Arms - During the 1990's the material analysis has been refined to lower the carbon content and redesignated SAE 15B35H Mod. The manufacturing processes have been modified to improve the product fatigue life. Steelmaking and casting developments are producing a cleaner and finer grained steel. The combination of increasing strength, from grain refining; the understanding of synthetic quenchants and cooling curve analysis; the understanding and use of rapid cooling have all contributed to the use of boron alloyed steel in the manufacture of fork arms in a wide range of section sizes; up to 300mm x150mm and capacities; up to 55 tonnes @ 1200mm load centre.

Name	SAE 15B35H	
General	Mass Density	7.8 g/cm^3
	Yield Strength	250 MPa
	Ultimate Tensile Strength	400 MPa
Stress	Young's Modulus	210 GPa
	Poisson's Ratio	0.3
	Shear Modulus	80.7692 GPa

Table 1 Mechanical properties for SAE 15B35H

ii. Stainless Steel Fork Arms - The common applications for stainless steel forks are port, harbour or coastal areas, food processing areas such as abattoirs and dairies where corrosive acids may be present, oil and petrochemical installations where corrosion and spark resistance are desirable. The strong steel fork arm is an other option to the standard boron steel fork arm with a surface cladding in either Grade 304 or Grade 316. S17400 is utilized broadly in the oil industry and related applications.

The choice of S17400 with controlled chemistry and heat treatment achieves the required mechanical and low temperature impact properties, with excellent fracture toughness from the martensitic microstructure. The mechanical properties allow section sizes to be offered similar to those for the standard boron steel grades.

Name	Stainless Steel S17400	
General	Mass Density	7.75 g/cm^3
	Yield Strength	1103.16 MPa
	Ultimate Tensile Strength	930.792 MPa
Stress	Young's Modulus	200 GPa
	Poisson's Ratio	0.3
	Shear Modulus	76.9231 GPa

Table 2 Mechanical properties S17400

Bronze Fork Arms - The fully forged solid nickel aluminium bronze fork arm was reviewed as a cost effective alternative to the brass clad steel fork arm. The primary application is the prerequisite for spark resistant fork arms for use in explosive places.

This particular alloy is spark resistant with strength, wear, abrasion resistance, and particular good resistance to sea water and other aggressive media, the inclusion of iron increases the tensile strength and the inclusion of nickel increases the proof stress; and both improve the corrosion resistance. The properties which are developed by this alloy are dependant on the chemical composition and the forging conditions.

The bronze fork arm is made with a minimum safety factor of 4:1, a minimum Izod impact value of 23 J with a sort endorsement dynamic endurance of 250,000 cycles @ 3 x safe working load and static test @ eight x safe working load.

Name	Nickel Aluminium Bronze	
General	Mass Density	7.59 g/cm^3
	Yield Strength	240 MPa
	Ultimate Tensile Strength	635 MPa
Stress	Young's Modulus	125 GPa
	Poisson's Ratio	0.32
	Shear Modulus	47.3485 GPa

Table 3 Mechanical Properties Nickel Aluminium Bronze

The materials discussed above are different from those conventionally used, these materials are improvised and better choice for the fork. Each have their own advantages when used under specific conditions and thus the right material can be selected accordingly.

5. RESULTS AND DISCUSSIONS

A forklift tuck was made by using mecanum wheel which had the ability to perform zero turning by the application of mecanum wheels. The direction and the velocity of all the wheels can be set independently with the help of four independent DC motors mounted with each wheel on the chassis of vehicle. An Arduino Uno board was used to give commands to control the direction and velocity of each and every DC motor. By setting the speed of each wheel at the same time during operation gave twelve directions of vehicle's motion without changing its orientation.

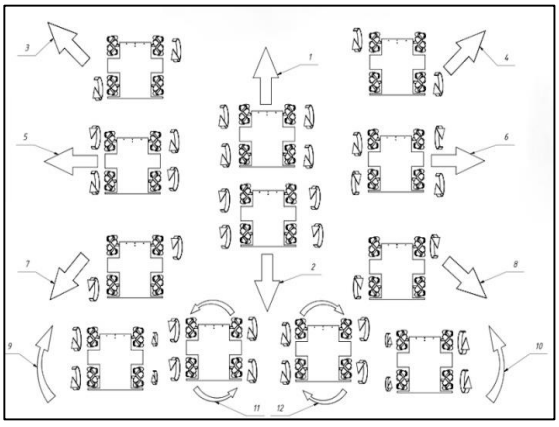

Figure 4 Obtained Motions Using Mecanum Wheels

Various unconventional materials were analyzed for stresses induced, load carrying capacity and other mechanical aspects so as to get their working under various conditions and loads. The forces following up on each wheel were acquired. The highlights that improved the model were the expansion in mobility in restricted space, and the parallel parking capacity. The proper selection of materials increased the load carrying capacity of the vehicle as compared to conventional materials used in fork.

6. CONCLUSION

This paper attempted to dissect, abridge, execute and consolidate the idea of zero turning system in a forklift with the assistance of mecanum wheels. The task is making a vehicle which has brilliant load conveying capacity and has zero turning, which can be utilized according to necessity in industrial applications. The materials discussed in the paper are unique in relation to those expectedly utilized, these materials are extemporized and better decision for the fork. Each have their own particular preferences when utilized under particular conditions and in this way the correct material can be chosen in like manner.

Hence, the aim is to make a vehicle inculcating the concept of zero turn in a forklift was fulfilled and a vehicle ergonomically safe, economically effective and mechanically efficient was produced. In view of the consequences of investigation following conclusions are drawn. The vehicle's turning behavior turns out to be more stable and controllable at low speed. The vehicles response becomes quicker and more precise. The vehicle's straight-line stability is improved during zero turning. The mecanum wheels of vehicle were rotated at a reasonable amount of low speed and by doing this the direction of movement of the vehicle became unrestricted. This system reduces parking and turning time as well as the turning space. Hence we achieved the zero turning without doing any compromise with the steering ability and handling of the vehicle.

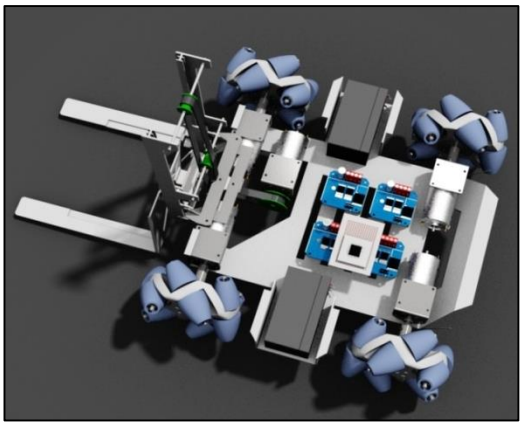

Figure 5 Final View Of The Vehicle

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