ACCIDENT REDUCTION: A ROAD MARKING APPROACH

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Abstract

The absence of road mark on campus roads is a major factor for the occurrence and re- occurrence of Okada accidents within the campus roads most especially on some areas tagged as "Accident Prone Area" or sharp corners could be adduced to the absence of noticeable road marks and signs thus posing a great danger to the Okada rider or driver while driving as the driver tends to drive out of road range hence road marks as well as road signs are a good source of communication for the driver while driving. A portable cart wheel road marking machine measuring 50mm×100×80mm that houses vital components such as the pump, nozzle, hose, stirrer, paint tank, sprayer, brush etc was designed, constructed and its performance evaluated. The result of the pilot test carried out on a road stretch within the administrative block to the beautiful gate of the Polytechnic second gate shows a significant improvement in the effective area coverage and time taken when compared to hand- held manual road marking method. The machine is subjected to some level of road marking performance test and it is found to be adequate in terms of safety design and functionability hence it is recommended because of its positive impacts on Okada driver's behavior and road safety in reducing the number of Okada accidents on campus.

***Keywords**: Accident, Road marks, Okada- riders, Communication, Portable Machine.*

Introduction

Basically, a road marking machine is a portable machine used to mark broken thick lines on a bent road or long thick continuous line at the middle and both edges of the road kerbs. Road markings warn, guide and inform road users and regulate road traffic using and combining lines, signs and symbols. (Gibbon et al.2012) carried out a transportation research and concluded that road accidents are one of the leading causes of death globally and statistics show that, in 2018 alone, 2,047 people were killed on Lagos/ Ibadan expressway; (National Bureau of Statistics). Although road safety activity is improving across the states, the progress remains slow and misaligned with established targets. (Calson et al, 2011) carried out a traditional and innovative speed reducing measures for curves while investigating the behavior of the driver. It was observed that this slow progress is partially due to the dynamic and complex nature of road traffic, and safety performance depends on a number of interconnected factors related to the roadway environment, vehicle, and road users. Given the propensity for error, drivers have long been considered a major cause of road accidents, although external factors typically contribute to driver's error. (Gogly et al,1999)

According to (Graham, 1996), Roadway characteristics, as well as the vehicle itself, can provoke driver's error and thus be the primary cause of the accident. Accordingly, current road safety strategies clearly distinguish between the factors that truly cause road accidents (be it road user, environmental, road-related, etc.) and focus on a multidisciplinary and comprehensive approach to addressing this problem. According to (Lee, 1999), road marks are used to convey information about the upcoming situation to the drivers in an easy and intuitive way, using various measures, including the most cost-effective ones related to road markings and road signs. Generally, as part of the traffic control plan, road markings delineate the traffic surface by using lines, text, and symbols to provide visual guidance information for road users.

Past research studies reveal that there are several scholars who have worked and come up with different designs of road marking machine but further work is still on going to improve upon some performance characteristics of the existing ones. (Zhang Wu, 2006) opined that the markings must be visible in all traffic and weather conditions be it in the day or at night for perfect directionality for the driver. This visibility is linked to their retroreflective performance (night-time visibility) and visibility of markings' color used. (Babić *et al*, 2015) considered different

types of paint markings to which such as thermoplastic markings, preformed tapes and paint markings. He then remarked from an environmental point of view that the materials can be divided according to the presence and type of solvents used: solvent borne, waterborne, and solvent-free.

(Hamilton, 1999) carried out research on the impact of road markings width and configuration and road markings as a measure for speed reduction and speed limit compliance. The first subsection analyses studies which investigated how road marking geometry, i.e., width and spacing between dashed lines, affects driving speed, lateral position of the vehicle, and driver's manoeuvres. (Godley et al 1999) conducted a systematic evaluation of the effectiveness of perceptual countermeasures to speeding. Different treatments (narrower lane widths, inside hatching, centre line hatching, herringbone pattern, and reflector post positioning) were tested using a driving simulator. As for the impact of road marking measures, the report highlighted a significant reduction in speed, especially in case of full lane width and hatched median. (Charlton 2007) again used driving simulator to test two types of curve treatments: warning signs and road markings. Warning signs were placed before the curve in order to alert drivers and reduce the driving speed while approaching the curve. Road markings were designed to influence the speed and the drivers' lane position as they drove through curves.

2. Material and Methods

The full description of the various methods and manufacturing techniques employed in the design, material selection and fabrication of the various components that formed the road marking machine was described under the following sub- headings:

Material Selection

The knowledge of materials and their properties is of great significance for a design engineer. The machine elements should be made of such a material which has properties suitable for the conditions of operation. The selection of a proper material for engineering purposes, is one of the most difficult problem in any construction of fabrication work. It is widely believed that the best material is one which serve the desired objective at the minimum cost. The following factors were considered while selecting the material for the road marking machine:

i Availability of the materials
ii Suitability of the materials for the working conditions in service and
iii The cost of the material.

The important properties, which determine the utility of the material are physical, chemical and mechanical properties of the material. The physical properties include: color, size and shape, density, electric and thermal conductivity, and melting point. The mechanical properties of the materials are those which are associated with the ability of the material to resist mechanical forces and load. These mechanical properties of the material include strength, stiffness, elasticity, ductility, brittleness, malleability, toughness, resilience, creep and hardness. All these help to reduce vibration, frictional control and dynamic balance of the road marking machine constructed.

Design Analysis

Design is an iterative process that entails determination of correct input into a system so as to achieve the desired output. Specifications are those parameters we consider in value and magnitude which keeps a system running, based on these; it is pertinent to analyze some component parts so as to justify its selection for a particular task.

The Belt Drive

Belt drives is selected for this design and it runs from the driving pulley to driven pulley. Such drives are particularly well suited for use in transmission where the pulley centre distance is too short as in the case of the compressor to the gasoline driving shaft.

Pulley diameter

A pulley is a structural member which is long and slender and subjected to a torque (moment) acting about its long axis. Considering the circular section drive pulley needed for this design, the selected shaft is made from high carbon steel rod. Based on the design, the developed machine uses a horizontal shaft with a majority of its stresses being torsional and bending (Combined load). It is not vertical hence it has little or no load to cause buckling hence, the diameter of the shaft is calculated using the ASMEcode equation for a solid shaft having little or no axial loading thus (Lymon, 2001):

$$d^3 = \frac{16}{\pi S}\sqrt{(KbMb)^2 + (KtMt)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$d^3 = \frac{16}{3.142\times 40}\sqrt[3]{(1.5\times 324.4)^2 + (1.0\times 825)^2}$$

d = 33mm
Hence 30mm driven pulley was selected.

2.1.3 Power transmitted by the gasoline engine rotating driver pulley and compressor sub-assembly

The power P_T transmitted by the rotating gasoline engine and compressor sub- assembly is given by;

$P_T = 2\frac{\pi NT}{60}$ [Khurmi, 2001]……... (2)

Exit Nozzle

The exit nozzle for the discharge of the stirred paint is designed in such a way that it will increase the velocity or kinetic energy of the fluid at the expense of a decrease in pressure along the pipe collecting the paint and spraying on the roller brush. This flow occurs at a very high speed accordingly, heat transfer across the boundary is negligible, also there is no external work done hence the steady flow of the paint through the pipe nozzle is given by:

$$h_1 + \frac{1}{2}C^2 = h_2 + \frac{1}{2}C^2$$

Since $h_1 = 3_{mm}$ then h_2 = 6mm and $h_2 - h_1 = 3$mm

Component Parts of a Road Marking machine

A typical road marking machine is an assemblage of different mechanical parts. The component parts are fastened together using either permanent or temporary means; each parts are selected based on certain desirable properties and service requirements. The parts are:

Frames and Base plates

Road marking machine have a structural frame which is made of good material such as mild steel. It is often seen that the material which is used to make the frame define and determine the actual structural shape, weight and capacity as well as the strength of the road marking machine. The user can see a variety of frames that are welded together for rigidity purpose. Rigidity and weight are considered before the selection of materials for the frame.

Compressor

Compressor is a mechanical device that increases the pressure of a gas by reducing its volume. An air compressor is a specific type of gas compressor. There are different types of pumps such as reciprocating compressor, centrifugal compressor and rotary screw compressor etc but a reciprocating air compressor is considered for optimum performance because they increase the pressure of the air by reducing its volume.

Stirring Device

This is used to stir the paint inside the paint tank before supplying the stirred paint through the tap to the brush. It is a slender rudder that is incorporated through the top lid or cover into the paint mixture, it has a three blade at the bottom end that serves as the stirrer.

Paint Tank

This is a medium size receptacle tank used for holding, transporting or storing liquids such as paint. It is rectangular in shape and has an outlet with a regulated tap through which the paint is supplied unto the brush. The paint tank is mounted on the structural base designed to house some components parts that are connected side by side for ease of fabrication and assemblage.

Gasoline Engine

This is a typical type of heat engine, specifically an internal combustion engine that is powered by gasoline. It is a prime mover used for driving the compressor via a belt connection. The engine is bolted to the structural base in alignment with the pulley that drives the attached pump via a v- belt. The gasoline engine provides the required 5.5h.p needed to power the pump.

Wheels

These are the castor tyres attached to the base of the machine for easy of movement because the ease of movement from one location to another is of paramount importance when performing road marking that runs into kilometers hence the machine is equipped with castor tyres.

The hand Push Frame

The hand push frame controls the road marking machine developed being the primary control that was used in machine designs over the years in machine design. It still remains an easy and simple method to make a number of adjustments in machines, although its use today has been partly replaced by other types of controls.

The Brush

The brush is a roller type; it is adjustable and can be set to the required height from the paved road to be marked. It is designed in such a way that it could be replaced when it wears out due to continuous usage.

Determining the Location and Strategic Area to be marked

The determination of the area to be marked with broken thick lines on a bend road or long thick continuous line at the middle and both edges of the road kerbs, road markings warn, guide and inform road users and regulate road traffic using and combining lines, signs and symbols. The locator attached to the road marker helps to guide the brush in locating the strategic area to be marked, it serves as a navigating compass as it gives directional control. Though, Nigerian roads are considered to be death trap due to its dwindling, uneven and undulating topography hence road marks and signs are put in various points considered to be accident prone areas so as to caution the driver thus preventing some avoidable accidents and saves lives of passengers on board. Road marks may be continuous on a straight road that stretches to half of a kilometer or broken marks on a sharp bend thus warning the driver against overtaking.

3. Results

The Pilot Tests – Road Marking Machine

Pilot test is an operation carried out to establish whether the developed road marking machine could be produced in adequate quantities and yields at an acceptable price. The test reveals the performance characteristics and efficiency of the design concepts adopted.

A standard paved road that stretches from Polytechnic Administrative Car Park 2 to Beautiful Gate round about junction was used for the pilot test during the performance evaluation of the developed road marking machine.

The results obtained during the pilot test conducted to evaluate the performance of the developed road marking machine using 5.5h.p Gasoline Engine is shown in Table 1 as it presents the Marked Area against Time Taken and Energy Consumed.

Table 1: Values of 5.5h. p Gasoline Engine

Road Length (m)	Road Breadth (m)	Marked Area (m^2)	Time taken (s)	Energy Consumed (J) 5.5
1	0.6	0.6	3	1980
2	0.6	1.2	6	3960
3	0.6	1.8	9	5940
4	0.6	2.4	12	7920
5	0.6	3	16	9900
6	0.6	3.6	19	11880
7	0.6	4.2	21	13860
8	0.6	4.8	24	15840
9	0.6	5.4	28	17820
10	0.6	6	31	19800

Source: Pilot test along West Campus Road

4. Discussion

Table 1 depicted the relationship between yellow marked area and energy consumed when the machine developed was used. It was observed that as the marked area increases, the energy consumed by the machine also increases. This was also similar to the work of Parker et al, 2003 in which they developed and evaluate the performance of permanent pavement markings. This table also showed the relationship between the yellow marked area and time. As the marked area increases the time taken also increases- this could be likened to the work of Graham, 1996 on "Manual pavement markings and safety of the marker.

5. Conclusion

It is generally accepted that the absence of road marks on some roads with increasing road mishaps is a direct pointer that drivers tends to drive out of the road width or range as a result of over speeding hence design concept and fabrication of this machine is a necessity as the road marks helps to guide the driver along the road, stabilizes the vehicle, warns the driver on time ahead of any dangerous bends and caution the driver from unwarranted over speeding thus reducing road accidents on our campus.

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