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Design and Analysis of Utility Vehicle for Industries

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***Abstract*— In this competitive world, work with more efficiency and less time consumption is the need of the hour. For an industry which performs manufacturing in a large scale, the operations must be carried in such a way that it causes minimum fatigue to the operators and can be easily performed. To satisfy this purpose, the utility vehicle is designed and analyzed. This machine can perform many operations which include lifting, gripping and movement. The vehicle is designed in such a way that it can also be controlled easily by less skilled persons. This utility vehicle consists of 4 wheels of which two are at the front and two are at the rear. The rear wheels are the driving wheels connected to a 24V DC motor and the front wheels are driven. The motors are powered by lithium ion batteries. This vehicle can be controlled either by joystick or mobile phones. In general, machines in industries are used only for the purpose of material handling, leading to high cost and more time consumption. In order to minimize this, it is designed in such a way that the forklift is attached to a base that can carry loads up to 200 kg. Forklift is operated by the hydraulic mechanism. The second operation that can be performed by the vehicle is gripping. The materials and machined components are gripped by two fingers which are operated by using gears. This utility vehicle's operations are performed by conventional forklift and gripping machines, which leads to increases in the rate of production. It also increase the effectiveness of the material handling operations performed in the industries.**

***Keywords*— gripper – DC motor – Battery**

1. INTRODUCTION

Material handling is defined as the function of preparation and positioning of materials to facilitate their storage or movement. It involves the handling, movement and storage of materials during different stages of manufacturing. In Indian industries, material handling accounts for about 40% of the total cost of production. Out of standard time 20% time is spent on processing of materials and the remaining is spent on the movement of materials from one place to another. Considerable reduction in cost and cycle time can be achieved through scientific material handling. Poor material handling may result in delays leading to idling of equipment. There are many papers regarding material handling. Das and Pasan (2016), has reviewed that the first big development for the AGV industry was the introduction of a unit load vehicle in the mid-1970s. This unit load AGVs gained widespread acceptance in the material handling marketplace because of their ability to serve several functions; a work platform, a transportation device and a link in the control and information system for the factory. Deros (2015), studied about Manual Material Handling (MMH) is the most common cause of Musculo Skeletal Disorders (MSDs) and Low Back Pain (LBP). It involves manual lifting, lowering, carrying, pushing and pulling loads. Allwyn et al. (2018), the development of Mechanical forklift assures the ergonomically comfort to the operator or worker and to reduces time required for manual lifting and handling. It lifts the maximum load of 200 kg at maximum height 1250mm.Bilge et al. (1997), has discussed the potential issues and benefits of AGVs related to multiple-load AGV systems and demonstrates the potential benefits of using them. Panara et al. (2015), aimed to control forklift through wired communication. The main advantage of using this technology is to increase the safety of operator by operating the forklift from certain distance. Sharnangat et al. (2013), reports on an approach for integrating low cost, power efficient sensors, probabilistic localization, and stochastic learning in a wireless sensor network-based system applied to warehouse management. Schulze et al. (2008), has discussed about the business benefits of automatic guided vehicles and gives an overview on AGVS technology, points out recent technological developments and describes results of research performed by the Department of Planning and Controlling of Warehouse and Transport Systems. Aggarwal et al. (2017), has studied, analyzed and reviewed the evolution and industrial grippers including Servo Grippers, Universal Grippers and Pneumatic Grippers have made headlines today for their breathtakingly innovative applications in areas like prosthetics, high risk medical surgeries, automobile industry and space travel. Nishimura et al. (2018), presents a gripper whose design is inspired by chuck clamping devices, for transferring heavy objects and assembling parts precisely in industrial applications. The gripper is light in weight and used in manipulation of heavy loads and can automatically align to its position and posture, using fingertip.

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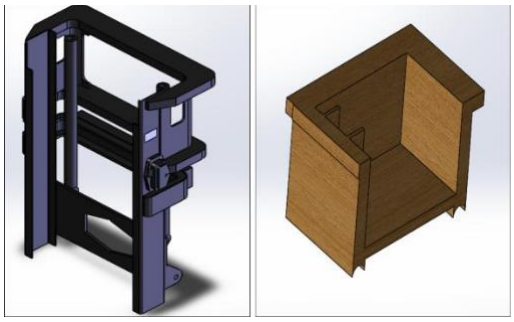
2. COMPONENTS

2.1 CHASSIS

The chassis of the vehicle is designed in such a way that it has sufficient space for the operator to sit and freely operate the vehicle without any fatigue. The dimensions of the body are 1500 x 914 x 1000 mm.

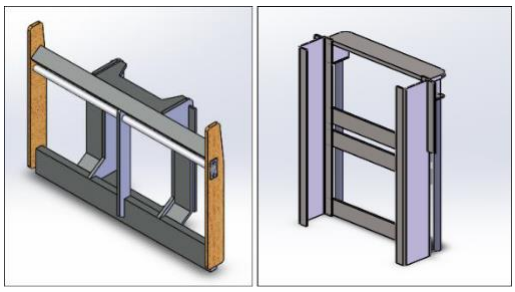


2.2 Uppermast

Upper mast is the support frame which is used for lifting the carriage up and down. The dimensions of the upper mast are 1150 x 610 x 1600 mm.

2.3 Lower mast

The lower mast is the moving frame to which the carriage is attached. The lower mast moves up and down using the hydraulic mechanism. The dimensions of the lower mast are 914 x 350 x 1600 mm.

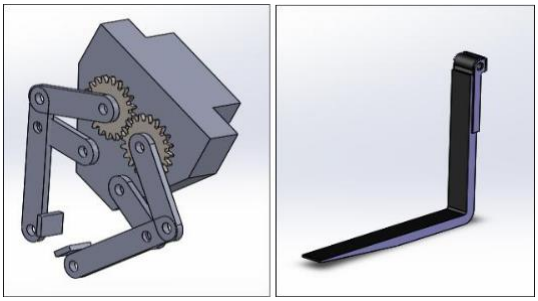


2.4 Carriage

The carriage is the support frame to which the forks are attached. The carriage is attached to the lower mast. The dimensions of the carriage are 1000 x 350 x 800 mm.

2.5 Fork

The fork is load bearing link that is attached to the carriage. The fork must be always parallel to the carriage so that the load will not fall down due to the weight distribution. The dimensions of the fork are 800 x 150 x 900 mm.

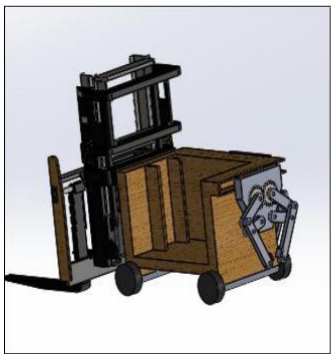


3 Final Assembly

All the above components are assembled together as shown.

4. Design Calculation

The design calculation of the utility vehicle consists of determination of torque required per wheel for movement, lifting motor power.



4.1 Specifications 0f Utility Vehicle

1. Total weight of the vehicle (M_R) = 890 Kg
2. Maximum load weight (M_L) = 200 Kg
3. Nominal speed of vehicle (V_N) = 3m/s
4. Load lifting speed (c) = 0.5 m/s
5. Acceleration time (T_A) = 1 s
6. Diameter of wheel (D_W) = 0.3 m
7. Weight of fork ($_{MF}$) = 55 Kg

4.2 Traction Wheel Rotation Speed (N_T)

$$N_T = \frac{V_N}{\pi \cdot 0.3}$$

4.3 Thrust Force (F_T)

F_T = g*k (M_R + M_L)

F_T =9.8 * 0.15 * (890 +200)

F_T = 1602 N

4.4 Power Required For Uphill Movement

P_U =F_T*V_N

P_U =1602*3

P_U = 4806 W

4.5 Torque Per Wheel

T_T = $\frac{1}{2}$ * $\frac{0.3}{2\pi}$

T_T = 1/2 * 0.3/21602

T_T = 120.15 Nm

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4.6 Lifting Motor Speed

N_T =

N_T =

N_T = 63.66 rpm

4.7 Thrust Required To Lift Weight

F_L = g (M_F + M_L)

F_L = 9.81(55 + 200)

F_L = 2500 N

4.8 Torque Required To Lift

T_L = * F_L

T_L = * 2500

T_L = 187 Nm

4.9 Power Required To Lift

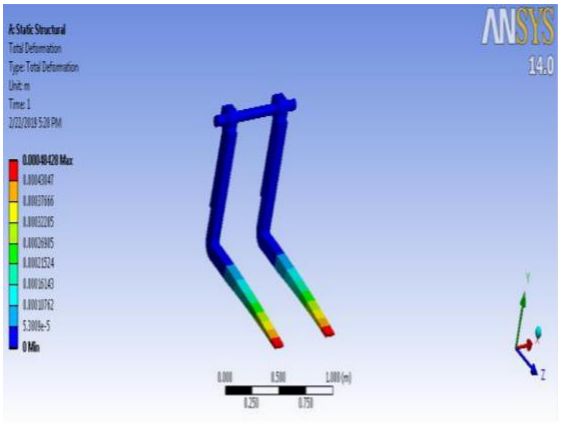
P_L = F_L*V_L

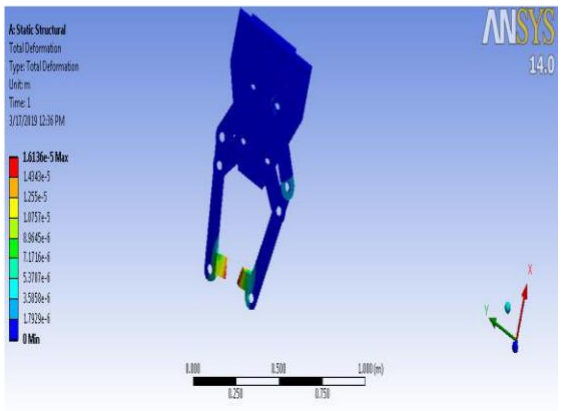
P_L = 2500 * 0.5

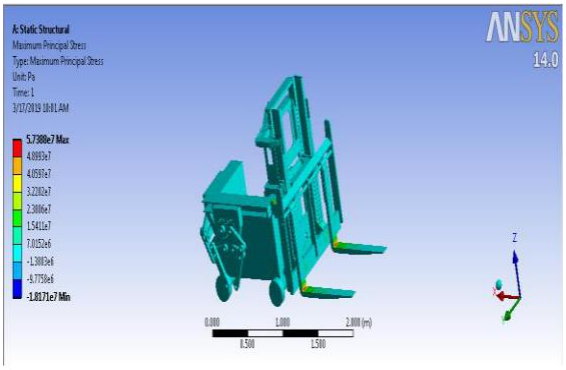
P_L = 1250 W

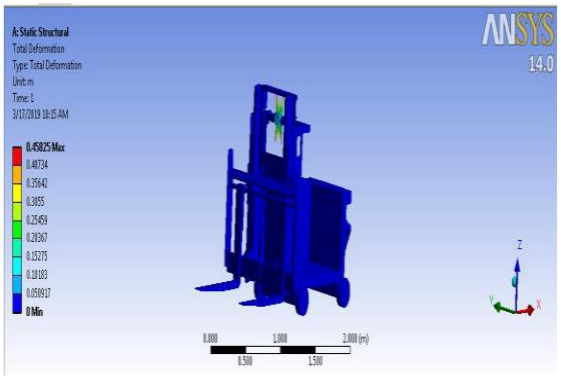
5. Analysis of utility vehicle

The analysis is done for the forks since it is the main load bearing components in this vehicle. The support rod is kept as fixed and the forks are given a vertical force of 2000N acting downwards. The gripper is designed in such a fashion that is can carry a load of 1500N. Here the opposite of the load carrying side is fixed to one side and the other side load is acted. The gear is then given with a moment of 2500N. Frictional support on the center.



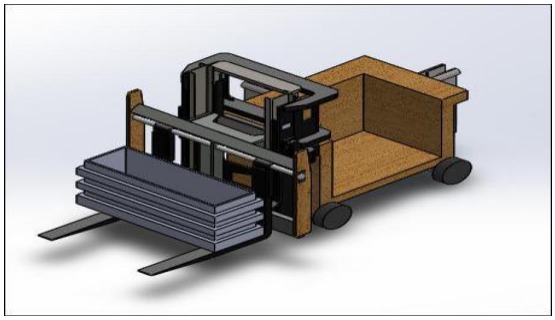






6. Working

This utility vehicle consists of four wheels which are driven by 24V DC motors which is powered by 24V 70KWh battery. The rear wheels are driving wheels and the front wheels are the driven. The whole vehicle is controlled by the mobile or any remote control devices through Wi-Fi technology. For this purpose a PLC is installed in the vehicle. It is coded to control all the functions performed by the utility vehicle and also the movements of the vehicle. The vehicle can also be controlled manually using the joystick control systems provided in it. A user interface display screen is provided in order to know the real time working conditions. It displays the data regarding the charge of the battery, load being lifted by the fork using the load cell, the obstacles in the way of the vehicle using the obstacle detection sensor. The fork is being lift up using the hydraulic mechanism for which the lift cylinder is used. The gripper is used to place the components of the engines in the required place using the position sensor. This eliminates the movement time and increases the efficiency of the work being done. This utility vehicle is very much useful in the flexible manufacturing system.



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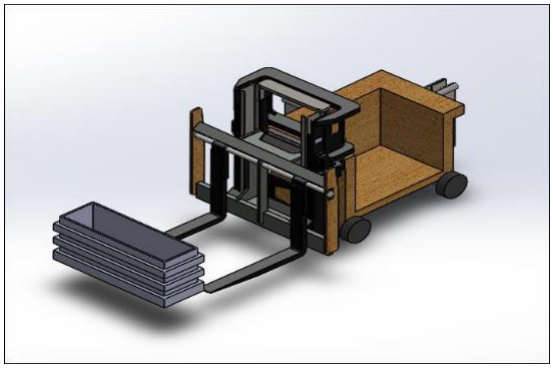

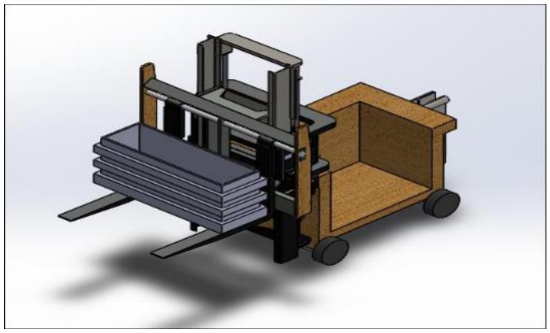

7. Conclusion

The activities of both forklift and gripper are performed by the same machine the operations performed using this utility vehicle are very efficient. This utility vehicle is very useful in Flexible manufacturing systems since it is automated machine which can be controlled by workers. Since it is electrically operated the maneuverability of the vehicle is simple. The weight of the utility is low as compared to the traditional forklift machines used in the industries. The cost of this vehicle is very much less as compared to the forklift used in industries. This utility vehicle reduces the fatigue of the workers which in turn increases the rate of work. The design is also compact and weightless compared to normal forklifts so the utility vehicle is very much helpful in industries. From the results of the analysis done with help of ANSYS software, it is suitable to say that that mild steel material is suited for the forks as the maximum stress on the forks is very small compared to its yield strength. It can also be viewed that the gripper material can be suited is EN8 with maximum stress values of $1.6136x10^{-5}$ and EN8 capable of withstanding a yield stress of 280MPa.
Under a loading condition of 2000N, the maximum stress inflicted is $5.7388x10^{7}$Mpa. Hence it is safe to use EN8 for the fork. Also the total deformation is negligible and hence the utility is safe to use.

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