Design and Finite Element Analysis of Pallet for Automated Car Parking System

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Abstract— Now a days with rapidly rise in number of vehicles; it is really hard to find out adequate land space to park the vehicles. In metropolitan cities, availability of land is varying scare and which matches to demand of driver and car size. To cope with this problem, pallet for automatic parking system is designed considering various parameters like car size, kerb weight and loaded weight of car etc. It also presents Finite Element Analysis of pallet to analyze the displacement and stresses on the pallet strips. Use of single pallet in automatic parking system drops material cost and also in number of moving parts, which reduces the complexity of parking system, making it more user-friendly and easy to handle and also reduces human interception.

Key words: Automatic Car Parking, Design, Displacement, Finite Element Analysis, Stress, Traffic

I. INTRODUCTION

The advancement and progress of nations is measured by the possibility of their use and application of latest invented technologies in all aspects of life. Control engineering is one of the aspects which have been given a great deal by many researchers. It became to a great concerns in many areas such as industry, agriculture, medicine, education and infrastructure. Automatic control systems have emerged as an integrated part in telecommunications, electricity, fuel and other applications. The driver will park his vehicle on a pallet at the platform of the car park. Then the sensor will detect the available empty parking spaces and the machine will transport the vehicle to a space on its own. Conveyer belts will be used to reduce the noise and vibrations in the system. The driver will get registered using mobile number and a unique verification code will be provided. In order to retrieve the vehicle, the driver has to enter his registered number and the verification code provided. Once the verification is done the system will retrieve the vehicle from the parking space and send it back to the original position where the driver is waiting. Programmable Logic Controller (PLC) will be used in the design of the prototype of the automated parking system. The PLC is used to control the movement needed to transport and retrieve the vehicle to and from the available parking space based on the signal from the driver. Power window motor and direct current (DC) motor would be used to provide movements to transport the vehicle in the parking system. The control system will play a major role in organizing the entry to and exit from the parking lots. It also presents the design of multi-level parking lots which occupies less need on the ground and contains the large number of cars. Therefore, the need of using technologies became inevitable. In the modern world, where parking-space has become a very big problem, it has become very important to avoid the wastage of space in modern big Automatic multi-level car parking system helps to minimize the car parking area companies and apartments etc.

A. Problem Statement

As it is known, the land is becoming less but the population of human is growing day by day. This scenario is very obvious in modern developed cities. Therefore, land is very limited and spaces need to be saved in every aspect of life. By building an automated parking system which allows high space utilization, less space is needed compared to the conventional car park. This is because in the automated car park, the parking space can be more compact by having vehicles parked nearer to each other and also less space is required for runways or paths in the parking space as vehicles are transferred to parking spaces using elevators and conveyers. Thus, optimized usage of spaces can be achieved. Considering this there is need of designing and implementation of automated car parking system. The aim of this project is to design and make a prototype of automatic car parking system.

B. Objective

1) To survey existing parking system
2) Select suitable mechanism for vertical transportation of vehicles
3) Pallet designing
4) Manufacturing of Prototype
5) Analysis of components by FEA

C. Scope of Project

The scope of this project is to develop a prototype of an automated parking system which is able to park and retrieve the vehicle by itself even without the driver. All the movements needed to transport a vehicle in the automated parking system are controlled using Programmable Logic Controller (PLC) as it is the controller in this system. For lifting the car we design the hydraulic mechanism and for transverse and longitudinal motion we design the rack and pinion mechanism. This will help in reducing the traffic and car parking related problems.

II. DESIGN OF MECHANISM FOR AUTOMATIC CAR PARKING

A. Specification of Car

- Length – 500mm = 5 m
- Width – 2100mm = 2.1 m
- Height – 2800mm = 2.8 m
- Weight – 3000kg = 3 Tons
- Total height of building = 18 m approx.
- Total car parking – 33
- Entrance condition – Ground level entrance[3]

B. Design of Pallet

The first component of lift is the pallet on which vehicle is placed. The design of pallet is done by referring following procedure.

Consider the weight uniformly distributed at 4 wheels

Total weight = $m \times g$ [9]
Factor of safety = 1.5
Material for pallet – C40
Sut = 600 N/mm^2 [8]
Syt = 380 N/mm^2 [8]
Total weight = 4500×9.81
Load on each wheel = $\frac{4500 \times 9.81}{4}$ = 11036.25 N
Max. wheel base = 3000 mm (Endeavour)
Max. Wheel track = 1600 mm
Min. wheel base = 2200 mm (Nano)
Min. wheel track = 1300 mm
Max. Wheel size = 265/70/R16
Min. wheel size = 135/70/R12
Max. Moment = M = $Force \times Distance$
Using bending formula – [8] [9]

$$\frac{M}{I} = \frac{E}{R}$$

Deflection at car wheel for cantilever beam – [3]

$$\delta = \frac{WL^3}{3EI}$$

$$\delta_{max} = 14.18\ mm$$

$$\delta = 7.35\ mm$$

Pallet – Length = 3600 mm
Width = 2000 mm
Height = 40 mm
Mass = 1281.1 kg
Strips – Length = 600 mm
Width = 50 mm
Height = 40 mm

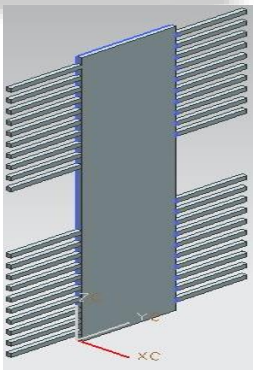

Fig. 1: Pallet Design

C. Design of Cell

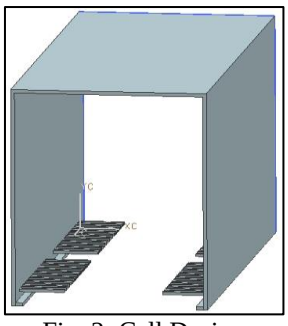

Fig. 2: Cell Design

We design cell for parking the car. Design is based on the dimensions of pallet. Wall is made from concrete material and for strip we use C40 material.
Length – 6000mm
Width- 2600mm
Height- 3250mm

III. FINITE ELEMENT ANALYSIS OF PALLET USING HYPERMESH

The three dimensional model of pallet prepared in solid edge modeling software is imported in HYPERWORKS workbench and load is applied at the wheel resting portion and results are obtained[10].
Deformation in pallet: Maximum Deformation = 4 mm

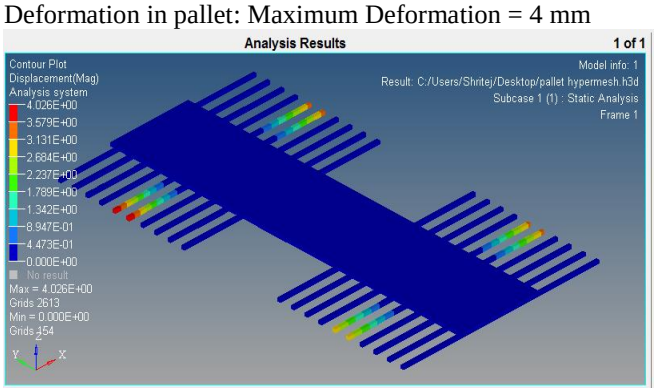

Fig. 3: Displacement in pallet

Stress in pallet
Maximum stress in pallet- 243.6 N/mm^2

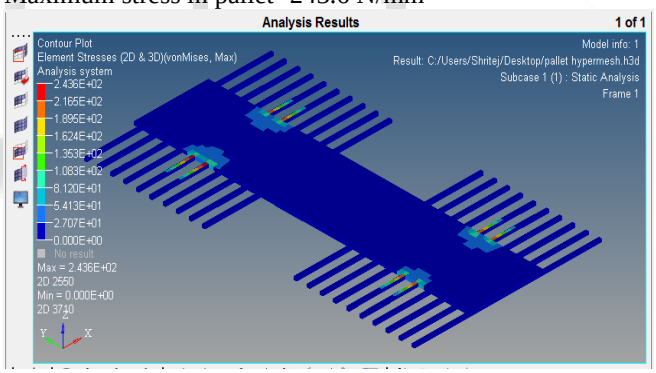

Fig. 4: Maximum stress in Pallet

IV. RESULT

A. Testing Results

Sr. No.	Points to be checked	Target	Remark
Functional testing for Parking system and Pallet:			
1	Pallet Transfer with/without Car from ground to particular cell and vice versa	Smooth transfer, vibrations, accuracy	Ok
2	Car transfer from ground to parking		Ok
3	Car transfer from parking to ground		Ok
Technical testing for Mechanism			
1	Lift speed	100mm/sec	Ok
2	Horizontal speed travel speed	80mm/sec	Ok
3	Pallet function time	40 sec	Ok

Accuracy			
1	Lift at max speed, with full load	+/- 5mm	-4mm
2	Lift at max speed with no load	+/-2mm	0mm

Table 5: Testing Results

V. CONCLUSION

In this paper we calculate the Dimensions of pallet and model is created. The model is created using UGI is Imported to Hyperworks. By Static Analysis Deformation and stresses are calculated. The calculated Von Misses stresses are less than yield stress of material so our design is safe and should go for optimization cost and material. The scaled prototype is manufactured and result is observed. It is observed that movement of elevator is smooth and continues.

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