Design and Analysis of Rotary Automated Car Parking System

Mr. Prasad Pashte[1] Mr. Vaibhav Narkhede[2] Mr. Shubham Nade[3] Mr. Sanket More[4] Mr. Yogesh L. Maske[5]

[1,2,3,4]Student [5]Assistant Professor

[1,2,3,4,5]RMD Sinhgad School of Engineering, Warje, Pune

Abstract— In metropolitan cities, parking of vehicles has become a major concern in crowded areas and to cope up with this problem, we need a good parking system. Different types of vehicle parking systems are implemented worldwide namely Multi-level Automated Car Parking, Automated Car Parking System, Volkswagen Car Parking, etc. The present project work is aimed to design and develop a working model of a Rotary Automated Car Parking System for parking 8 cars. This system has been implemented to reduce the excess use of land space which is already very scarce in metro cities. The chain and sprocket mechanism is used for driving the parking platform and a motor shall be implemented for powering the system and indexing the platform.

Key words: ANSYS, Chain and Sprocket Mechanism, Rotary Automated Car Parking System

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. For nearly one hundred years, planners, engineers and environmentalists have wrestled with the challenge presented by the increasing prevalence of the automobile where to put cars. Ranging from the earliest parking garages renovated horse barns to fully automatic parking structures, innovative thinkers have attempted to devise clever ways to park vehicles. The rapidly growing urban population of India is creating many problems for the cities, vehicle parking being one of the major problems faced almost every day. In many urban housing societies, the parking space ratio is 1:1. To avoid these problems, recently many new technologies have been developed that help in solving the parking problems to a great extent.

The Rotary Automated Car Parking System (RACPS) belongs to the class of smart car parking systems. The traditional parking systems such as multilevel or multi-story car parking systems (non-automated), robot car parking systems, automated multilevel car parking systems etc. have been implemented on a huge scale. But these systems have a major disadvantage of large space consumption which is successfully eliminated with the use of a Rotary Car Parking System. Moreover, the latter provides the added benefits of flexible operation without the need of an attendant and added security and least chances of vehicle damage. Since the model makes use of composite parts, it is easy to assemble and dismantle and is thus more convenient than the traditional car parking systems. The rotary model is specifically designed to accommodate multiple cars in the horizontal space of two cars. The structure can accommodate six cars in the space of two or can even be customized to hold a greater number depending upon the requirements of the user and can be efficiently put to use in much space crunched areas. Although automated parking like multilevel parking has made the condition a little better than the earlier situation, there is still scope for improvement. This is because people still face problems of space availability, searching time and waiting time in public places like malls, multiplexes, railway stations, shopping streets etc. With the new technology of smart parking, majority of these issues will be solved. The vehicles parked randomly cause major problem faced in most of the metropolitan cities and to deal with this problem, after studying all these systems we learnt that Rotary Car.

A. Objective

- To design and develop a safe and secured car parking system which will not damage the vehicle and the property.
- It should consume less time, money and fuel.
- To minimize pollution and to construct an eco-friendly system.
- Designing a systematic parking system which will accommodate to any building style and environment.
- By using modern technology, to design a system which will minimize land requirement, maximize efficiency and will be profitable in long term.

II. Design and Optimization

A. Operation Procedure

All pallets rotate in counter-clockwise direction. The chain and sprocket mechanism is used for driving the parking platform.

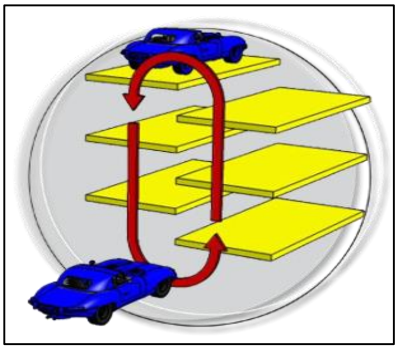

Fig. 1: Operation Procedure

B. Assumptions and Standard Details

- Capacity - 8 or more than 8 cars
- Car available dimensions

Types and Specifications	Sedan (Honda Accord)	Hatch Back (Maruti Swift)	SUV (Hummer)
Length	4900mm	3850 mm	5300 mm
Width	1800 mm	1695 mm	2100 mm
Height	1450 mm	1530 mm	1500 mm
Weight	1800 kg	1100 kg	3000 kg

Table 1: Car Dimensions

- Motor power – 14 kW.
- Rotating speed – 6 m/min.
- Rotating technology - Rotation by chain.
- Power - 400V tri-phase.

C. Mathematical Calculations of Component

- Motor Selection
- Considering Width & Height of pallet, Diameter of Sprocket is:
- D = 2400 mm

1) *Velocity (v):*

$$v = (\pi DN)/60$$

Assume,

- Chain velocity (V) = 6 m/min = 0.1 m/s

(It is the required speed of the pallet. One pallet is changing its position in 15 second)

So,

Speed of driven sprocket (N),

$$N = 0.796 \text{ rpm}$$

2) *Force (F)*

$$F = 134586.72 \text{ N}$$
$$\sim 140000 \text{ N}$$

3) *Torque (T)*

$$T = (F\times D)/2$$
$$=168000 \text{ Nm}$$

4) *Power*

$$P = (2\pi NT)/60$$
$$= 13996.864 \text{ W}$$
$$\sim 14 \text{ kW}$$

Power rating = 14 kW = 18.77 Hp

5) *Conveyor Chain*

Diameter of Sprocket (D),

$$D = 2400 \text{ mm}$$

Let, No. of teeth,

$$Z = 40 \text{ [20]}$$

Using formula,

$$D = p\sin(180/T)$$

So,

$$p = 188.3 \text{ mm}$$

As Centre Distance(C),

$$C = 4500 \text{ mm}$$

- Length of Chain(L),
- $L = 2C+(T1+T2)/2+(T1-T2)/(4\pi^2C)$
- L = 9040 mm

No. of Links (K),

$$K = L/P$$
$$K = 48$$

Power Transmitting Chain

We know,

Rated Power = 14 kW

Speed of driven sprocket, N_2 = 0.796 rpm

Let, No. of teeth on Drive Sprocket (Z_1),

$$Z_1 = 19$$

Speed ratio = 6

(Maximum permissible in Chain Drive)

So, Speed of drive sprocket is (N_1)

$$N_1 = 0.796\times 8 = 6.368 \text{ rpm}$$

No. of teeth on Driven Sprocket (Z_2),

$$Z_2 = 19\times 6 = 114$$

Design Power = Rated Power × Service Factor

Service Factor= load factor (K_1) ×lubrication factor (K_2) × rating factor (K_3)

{K_1 = 1.25 … for variable load with mild shock
K_2 = 1.5 … for periodic lubrication
K_3 = 1.25 … for 16 hours per day}

Therefore,

Service Factor = 2.34

So,

Design Power = 14×2.34 = 32.76 kW

Now,

Chain Selection on the basis of Design Power & RPM of smaller sprocket for 19 teeth pinion 48 A-1… American Standards

We get,

- Roller Diameter =47.625 mm
- Pitch (p) = 76.2 mm
- Minimum width of roller = 47.35 mm
- Breaking load = 629.32kN [22]

6) *Pitch circle diameter of small (pinion) sprocket*

$$D_1 = p \operatorname{cosec}(180)/T1$$
$$= 154.31\text{mm}$$

7) *Pitch line velocity of small (pinion) sprocket (v_1)*

$$= (\pi D_1N_1)/60$$
$$= 0.051 \text{ m/s}$$

8) *Pitch circle diameter of larger Sprocket (D_2)*

$$= p \operatorname{cosec}(180/2)$$
$$= 1034.62\text{mm}$$

9) *Pitch line velocity of larger Sprocket (v_2)*

$$= (\pi D_2N_2)/60$$
$$= 0.043 \text{ m/s}$$

10) *Load on the chain is (W)*

$$= 274.50\text{kN}$$

11) *Factor of Safety (n)*

= Breaking Load W
= 629.32325.58
= 2.29

12) *Length of Chain*

Assume:

Centre distance of Sprockets = 1393 mm

Then, Length of chain is

$$L = 2C+(T1+T2)/2+(T1-T2)/(4\pi^2C)$$
$$L = 2852.5 \text{ mm}$$

13) *Sprocket Shaft*

Diameter = 166.44 cm Length = 719.040 cm

III. Design of Component Based on Analysis

A. Pallet

The design of pallet is done by referring following procedure.

1) *Vehicle Specifications:*

- Vehicle size=4854mm*2197mm*1476mm
- Wheel base = 3000 mm, Wheel track = 1800 mm
- Max Weight of Vehicle= 1985 ~ 2500 kg

2) *Pallet Specifications:*

- Thickness = 5 mm…. (Considering the load of vehicle & Analysis is done)
- Length = 5000 mm
- Width = 2317.5 mm
- Height = 1650.7 mm
- Mass of a car is 2500 kg
- Total load on pallet = 2500*9.81 = 24500 N

Load is applied on four points on the pallet where tires of the vehicle are assumed to be resting.

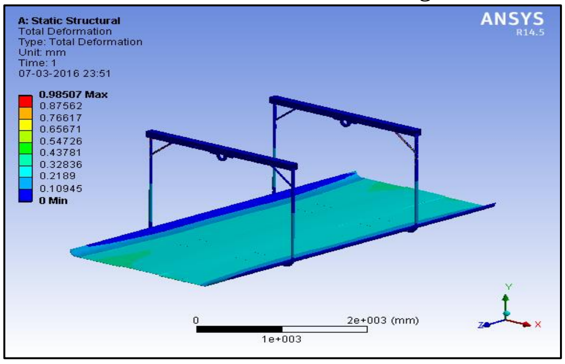

Fig. 2: Total Deformation of Pallet

B. *Hanging Rod*

Specifications and Calculation of Forces of Hanging Rod:

- Length = 5766 mm
- Diameter = 100mm
- Total load on the Rod = Weight of vehicle + weight of Pallet.
- Mass of the Pallet = 575kg (Calculated Using CREO Software)
  = 575×9.81 + 2500×9.81
  = 30165.75 N

Now,

Using weight distribution of 66% on front mounting point and 34% on rear mount point, we have applied following loads on two mounting points of the rod.

F_1 = 19909.395 N F_2 = 10256.355 N

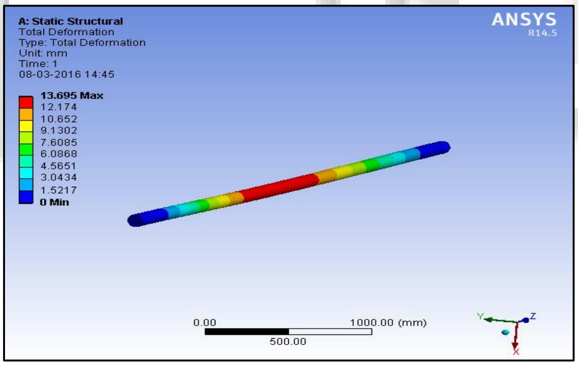

Fig. 3: Total Deformation of Hanging Rod

C. *Joint*

Total load on a joint = [Weight of vehicle + Weight of Pallet + Weight of Rod] /2
= [575×9.81 + 2500×9.81 + 353×9.81] / 2
= 16814.34 N

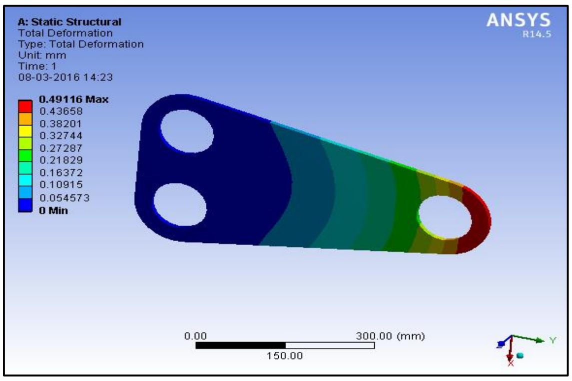

Fig. 3: Total Deformation of Joint

D. *Frame*

Dimensions of the Frame:

- Height: 10183.0 mm
- Width: 4364.04 mm
- Length: 7190.40 mm

Total load on the Frame = {Weight of vehicle × 8 + Weight of Pallet×8 +Weight of Rod×8 + Weight of Chain×2 + Weight of Rotor×4 + Weight of Joint×16 + Miscellaneous}

= 2500×9.81+ 4600×9.81+ 2824×.81+ 1242×9.81 + 12348×9.81 + 144 + 17915.02
= 232084.98N

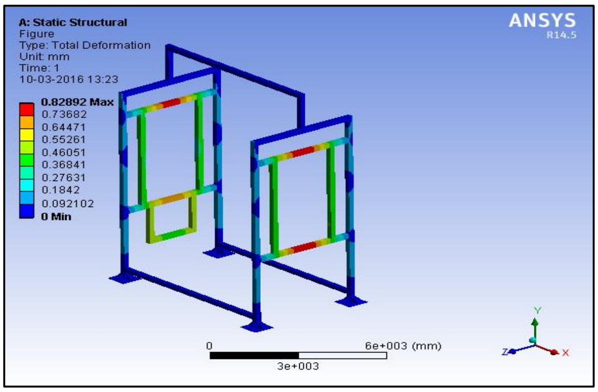

Fig. 4: Total Deformation of Frame

Since, it is very critical part, we have applied a load of 500000N

IV. CONCLUSION

The major enablers or drivers for smart parking essentially are the problems of urban liability, transportation mobility and environment sustainability. Some of the underlying benefits could be lowering operating costs, while building value for customer to drive occupancy, revenues and facility value. To solve this all issues we designed and analyzed Rotary Automated Car Parking System. The Rotary Automated Car Parking System has been designed considering the actual size, dimensions and weight of car up till sedan class. The scaled model has been prepared and all the composite parts in it have been manufactured and assembled. Analysis of important parts like pallet, joint, hanging rod and frame has been done at actual dimensions. Finally, in the long run, the rotary automated car parking system can actually transform the very makeup of our urban landscapes, making them more amenable to people rather than cars.

V. FUTURE WORK

This automated car parking system can be installed with safety installations such as, whenever there is human movement in the system, the rotation of the platforms should be immediately stopped and also the platforms can also be equipped with safety sensors guiding the movement of vehicles in the platforms. It can be fully automated by integrating it with a panel board, such that whenever a particular number is called on the panel board, the respective platform should appear at the ground level. This calling can also be made more secured by providing each platform a specific password, so that only whenever a particular password is typed the platform is retrieved. A turn table can be incorporated with the system in front of the ramp of platform so that cars can be easily turned and parked into the platform. This is very useful in the areas where cars cannot turn easily to get into the platform.

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