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Design of Transmission System for Mini-Train

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Abstract: The mini train rides are commonly seen rides in amusement parks. The study is based on a mini train operating at Vismaya amusement park, Kannur. During its operation, the mini train had frequent problems related to power transmission system and power consumption of the prime mover. So the design was modified many times. The main reasons for those problems were found out to be due to the faulty design of the wheel assembly and the presence of steep curves in the travelling path of mini train. These cause serious problems such as excessive wearing in wheels and track, over loading of prime mover and subsequent increase in power consumption. These problems can even effect the life of the prime mover and other mechanical parts of the mini train. For rectifying these problems, it is necessary to analyze the wheel assembly and track and then to design a new power transmission system which can improve the performance of the mini train. The first step is the force analysis and modeling of the wheel and track assembly. It is done in powerful analysis tool, SOLIDWORKS. By this analysis, I came to the conclusion that the design of the wheel assembly and track are safe in operating at the required load and speeds. The banking of the curve in the path and the maximum speed for mini train are also determined. Then the solution for the problems is to design a transmission system that is less affected by the curves and varying loads. While observing the operation of mini train, it is found that the power transmission system is through a single axle between the wheels. That transmits power equally to wheels on both sides. The speed of both wheels remains the same during the operation. This is found to be the primary problem. By considering the differential mechanism in the design, we can rectify those problems effectively so that the overall performance of the prime mover and mini train is improved. Also, the existing design uses a couple of belts for power transmission at each wheel that can be simplified to a single belt drive transmission. This makes the power transmission simpler and economical.
Keywords: FEA, Knematics, Solidworks.

I. INTRODUCTION

The increase of the world population, the growing energy prices and several environmental factors has promoted the expansion and development of railway transport in the last few decades. Nowadays, passenger trains have to travel faster, with improved safety and comfort conditions. Furthermore, the competition with other transportation systems has increased greatly. For short and medium distances, modern high speed trains are able to compete with air transportation, having the advantage of presenting better energy efficiency and causing less pollution. For larger distances, the railway system is still the most economical means for transportation of goods and starts to have some competitive edge in the passenger transportation. On the other hand, the railway operators are demanding reductions in the overall operational costs. In this regard, they put particular attention to the railway vehicles maintenance costs and to the aggressiveness of rolling stocks on the infrastructures, i.e., the track damage. The mini train rides are now common in all amusement parks. These rides are attractive for both children and grownups. The project is the design of new transmission system for mini train rides in amusement parks. Project is based on the mini train ride at Vismaya amusement park, Kannur, Kerala. The existing mini train is designed to carry 25 people to travel 500 meters. The existing power transmission system connects directly both right and left wheels with a prime mover, so that they rotate at same speed throughout the travel. This design raises many problems related to the operation and efficiency of the mini train as the travelling path has many steep curves. As the rotation of wheels are same, there arises problems related to excessive wear and tear for both wheels and tracks, overloading of the prime mover, more power consumption for prime mover etc.

The project is done in two stages. In the first stage, the force analysis and modeling of wheel assembly and track are done using Solidworks. From this, it is concluded that the design of track and wheel assembly are safe. In the second stage, the new design of transmission system with differential mechanism is done.

II. DESIGN METHODOLOGY

A. Maximum Load Carried by Rail

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Assume Factor of safety F.S = 4

$$\sigma_{ut} = 250 \text{ Mpa}$$

Max. Shear stress in the rail (at neutral axis) = σ_{ut} / (F.S)

$$\frac{S * aY}{I * b} = \sigma ut/(F.S)$$

$$S = 16357.51 \text{ N}$$

B. Banking of Rail

Forces Considered for Dynamic Equilibrium at this stage are, Self-Weight W acting vertically downwards, Centrifugal force mv^2/r acting radially outward (horizontal) & Reactions R1&R2 acting normal to the rail surface. For designed speed there will not be any lateral force (frictional) & wheel reactions are normal to rail.

Σ forces to inclined plane = 0

$$tan \propto = \frac{V^2}{(g \times R)}$$

V=2.22 m/sec

R=12 m

$\alpha = 2.39^o$

Result: It is better to provide banking by an angle of 2.39^o, to make sure the stability of bogie at the curvature.

C. Maximum Speed of Train

$$V_{max} = \sqrt[2]{\frac{Ea+3}{.0007D}}$$

Where,

V_{max} = max. allowable operating speed

Ea = Avg. Elevation of outside rail

D = Degree of curvature (degrees).

Here,

Ea = 0 (They have not provided any elevation)

D = 24°

V_{max} = 13.36mph

=21.376 kmph

III. COST ESTIMATION

Table 1

Sl No	Item	Description	Quantity	Cost (Rs)
1	Differential		1	5000
2	Housing		1	2500
3	C.I Pulley (V-Groove)	90 mm	1	300
4	C.I Pulley (V-Groove)	110 mm	1	350
5	V- Belt	B-Grade 17mm	1	290
6	Taper Roller Bearing	Bearing no:30.205	6	1758
7	Taper Roller Bearing	Bearing no:30.207	2	814
8	Hexagonal bolt and nut	M16	27	1890
9	Mild steel sheet	320 x 16 mm	36 kg	1792
10	Mild steel sheet	90 x 15 mm	23 kg	1145
11	Mild steel sheet	60 x 16 mm	10 kg	498
12	Mild steel sheet	36 mm dia	10 kg	498
13	Mild steel sheet	26 mm dia	4 kg	200
14	Mild steel sheet	50 x 50 x 5 mm	3 kg	165
	LABOUR COST			6000

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Miscellaneous Expenses= 2500
Overall Cost for this Project = Rs 25700/-

IV. OBSERVATIONS

The study is part of the main project which consists of static and dynamic analysis of the rail track. But the analysis, I have conducted here, is only static one. The results show that

A. Track will not fail under the given load conditions.
B. It is better to provide banking at an angle 2.390
C. The train can move with a max speed of 21.376 kmph

Dynamic analysis is yet to be conducted and the dynamic response is to be recorded. Only then, I can make a final conclusion as to whether the track will fail or not under the given load conditions.

Result: max. allowable operating speed =21.376 kmph

V. MODELLING & ANALYSIS USING SOLIDWORKS

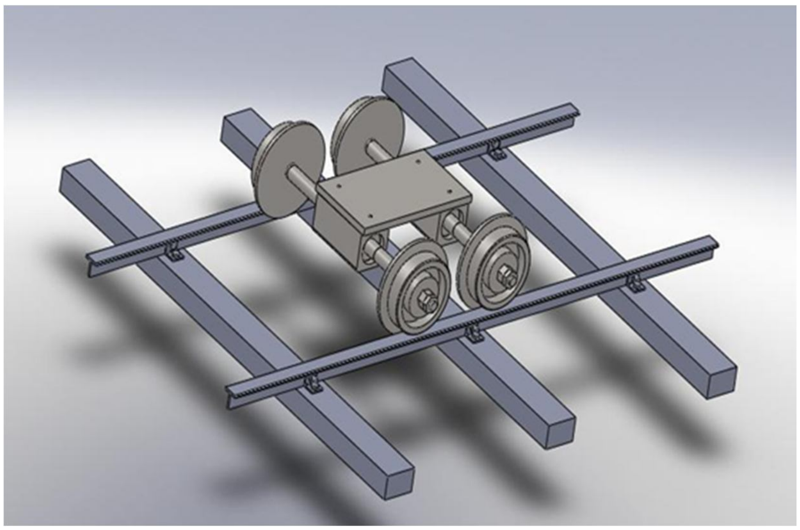

Fig 1 Track & Wheel Assembly

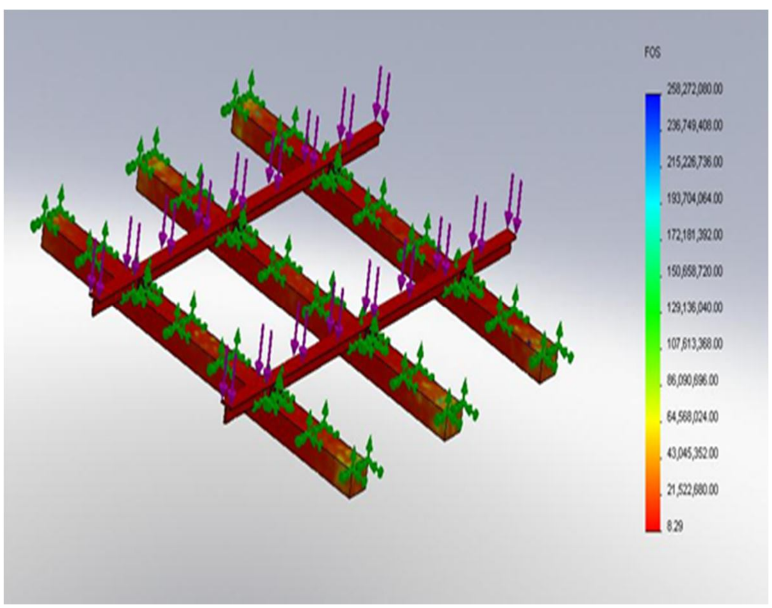

Fig 2 Analysis Using Solidworks

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Fig 3 Project Site: Mini-Train

VI. CONCLUSION

The new power transmission system with differential mechanism for the mini train is designed. For the operating load and speed conditions, the design is found to be safe.

The drawings of all the components are prepared and the dimensions are selected as per standards. By the implementation of the new design, the problems related to wearing of track and wheel can be eliminated. The overloading of the prime mover is reduced to get low power consumption. The overall design is made to be simpler and economical.

The various design parameters obtained are

A. Diameter of pulley on motor, D1 = 90 mm
B. Diameter of pulley on pinion shaft, D2 =110 mm
C. Velocity of train, v =10.9km/hr
D. No. of teeth on pinion, Z1 = 9
E. No. of teeth on gear, Z2 = 39
F. Normal module, mn = 5 mm
G. Face width, b = 33 mm
H. Pitch diameter, D1 = 54 mm
I. Diameter of pinion shaft, dp = 20 mm
J. Diameter of shaft for back wheel = 30 mm

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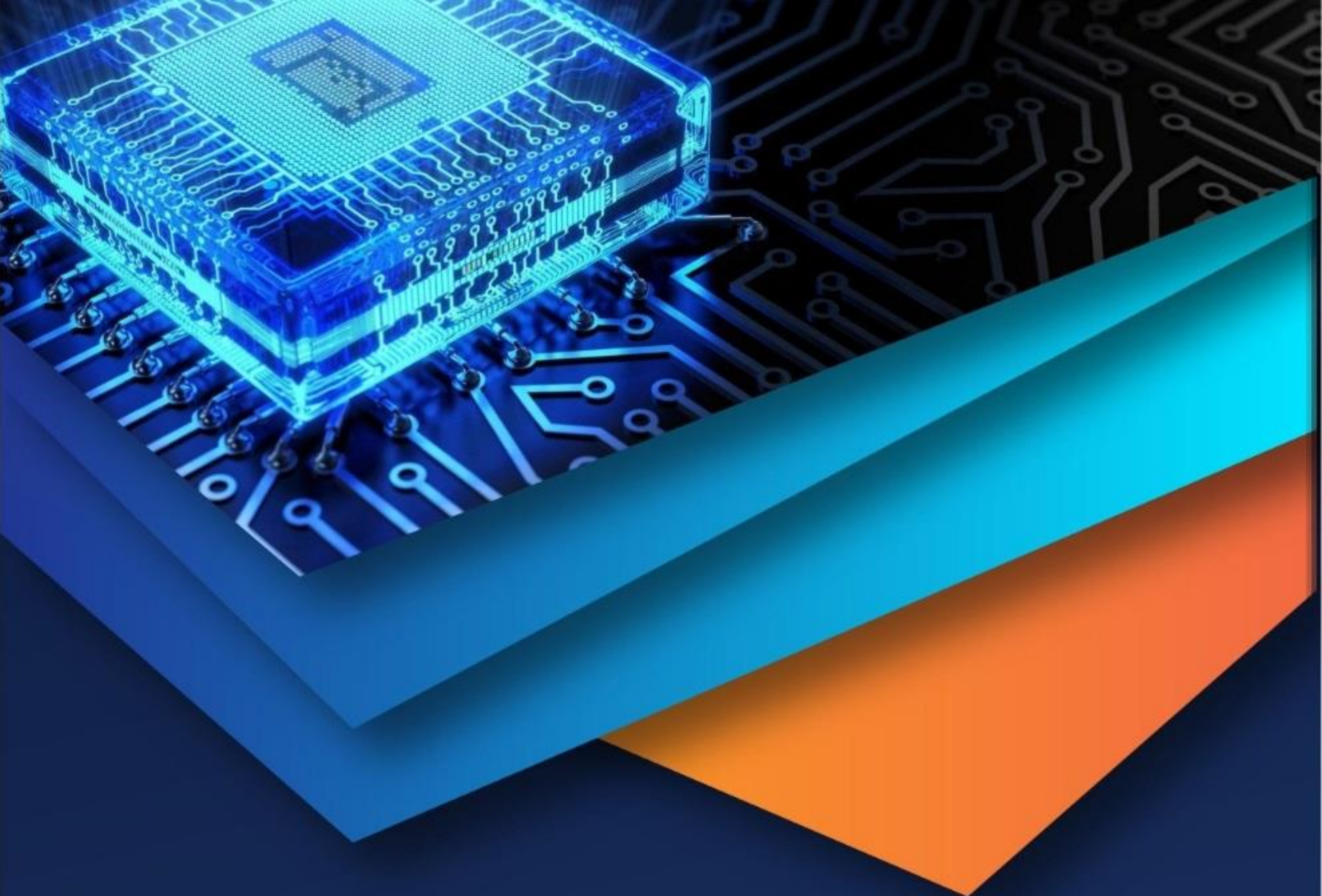

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