Maglev Train a Competitive Technology for Rail Transportation

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ABSTRACT: Use of lightweight composite always benefits any application in various ways. So this was an attempt to design and fabricate a bogie frame using lightweight composite. Further a combined mold was developed and a multi-cavity composite casting block was manufactured. Result of the experiments performed showed that glass fiber reinforced can be used as load bearing element which will reduce the weight up to 30.9% as compared to other metal materials [4].High speed of maglev trains may lead to vibrations in certain cases. Thus commercial Maglev line in Shanghai was chosen to study Maglev train induced vibrations including seven test sections with speed ranging from 150-430km/h. The analysis was done in both time and frequency domain. The results showed that not only vertical vibrations are dominant but effect of transverse and longitudinal vibration is also needs to be considered especially near turns. When compared with traditional high speed trains one thing is for sure that Maglev train generates considerably different vibrations [2].In order to obtain correct propulsive positioning and levitated balancing an observer based adaptive fuzzy neural network control was designed. The ultimate aim is to achieve smooth and easy control over transformation and requirement of different signal and parameters [3].

Keywords: *Maglev, levitation, Lightweight composites, guideway.*

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I. INTRODUCTION

Using lightweight composites improves properties such as corrosion resistance, specific strength. With lightweight composites weight can be reduced along with increased fuel efficiency which will reduce overall cost significantly. There is transformation of lightweight composites from being used as secondary load bearing structure to being used as main material in train as well as railway infrastructure constructions. Even a glass fiber and foam was used by a Dutch company to fabricate a new nose, lighter and cheaper than conventional steel noses. But complex manufacturing process and extreme loading condition make it difficult for lightweight composite to be used as primary load carrying structure. The experimental results showed that weight reduction of approximately 25% could be achieved with composite element for bogie frame [4]. Maglev trains work on the principle of levitation, propulsion, guidance which is frictionless making it possible to reach to high speed. It has advantages like high riding comfort, high speed, low noise, less energy consumption, lower risk of derailment over conventional train. Electromagnetic suspension system (EMS) and Electro-dynamic suspension system (EDS) are the two types of maglev train. In past few years many experiments were done to obtain various characteristics like vertical motion and levitation stability, vehicle response and ride comfort, which gave rise to medium and low speed maglev train. Thus research focuses on principles, dynamics of car body and bogie and design and analysis of guideway [3]. A 3D multi body vehicle guideway soil finite element model was use to study vibrations induced by maglev trains which showed that ground vibration induced by high speed railway trains are different from that induced by high speed maglev trains. The study of vibrations induced by maglev trains is of great importance because it has raised certain concerns to public in its surrounding. Thus experiments were performed to study effects of maglev train speed on vibrations of bridge piers and ground [2]. The Maglev train is a new way of transportation where a vehicle is lifted at a short distance away from tracks using magnets [1]. Maglev train has propulsion and levitation as its basic principle. Maglev trains are used due to their abilities like elimination of friction due to mechanical contact, lower maintenance cost, accurate positioning, etc. EMS and EDS are two main types of maglev trains. EDS is also called as 'repulsive levitation' which uses permanent magnets or superconductive magnets. Repulsive magnetic poles of superconductivity magnets are useful only at high speed for long distance. Levitation force in this case is more stable. On the other hand, EMS is attractive levitation. When compared with EDS, EMS has advantages like low cost and simple manufacturing process but high suspension power loss is a serious problem in EMS. This suspension power loss can be reduced by permanent magnet to the electromagnet.Electric power is also required in addition with electromagnets to provide suspension as well as specific levitation height. Thus both these type goes hand by hand with each other [3].

II. MATERIAL CHARACTERIZATION OF A MULTI CAVITY COMPOSITE FOR BOGIE

1. Design Background

Commercial maglev train in China had capacity of 363 persons and maximum speed of 100 km/h with five 5 metal bogies per car. So weight reduction was a serious issue. Bogie frame of maglev train was equipped with 4 casting blocks, 4 anti-rolling sills, 2 side beams and electromagnet. The framework of hybrid maglev train is a linear motor via hybrid electromagnetic suspension technique to reduce suspension power loss and friction forces for simplifying mechanical design procedure [3]. The casting block made of aluminum material was weighing approximately 60% of total weight of bogie frame. Thus a new lightweight composite casting block was designed considering assembly relationship with other components as shown in fig. 1[4].

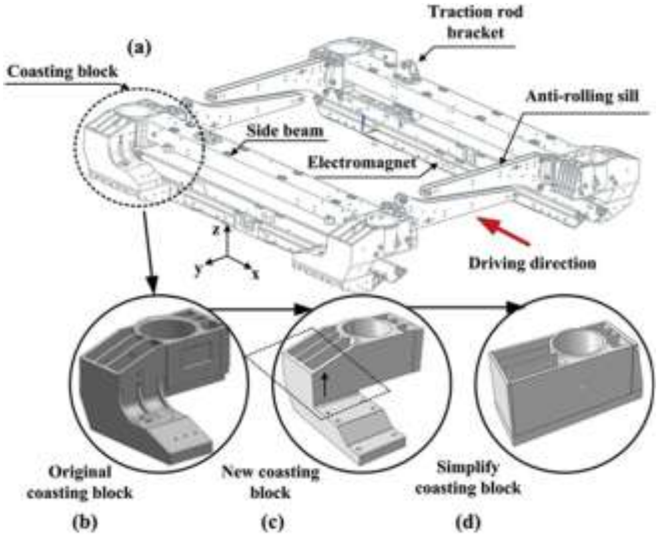

Fig-1: Configuration of bogie frame and casting block [4]

III. EXPERIMENTAL DETAILS

1. Design of mold

The component was successfully manufactured after choosing proper mold and different processes as per the requirement. Autoclave molding process was used as it can be useful method in fabricating high performance composite structure. The desired mold was designed by using material like red oak and different characteristics like simulation in CATIA, thermal coefficient of expansion, auto ignition temperature and other mechanical properties. The reduction in cost was an added advantages to those listed above.The size and geometrical complexity of bogie, was important factor in designing mold core, outer mold and substructure as shown in fig.2. The mold was composed with 7 components (No. 1 to 7), the outer mold was comprised of 4 components (No.8 to 11), and 12th component was substructure with 7 slots which can be used to fix other components. After machining, the base mold was sealed by release cloth for easy demolding and preventing shape changes caused by varying humidity [4].

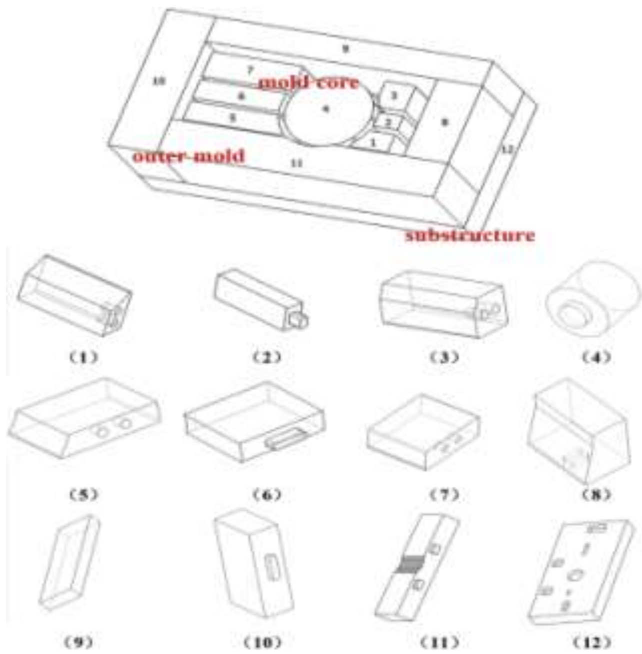

Fig-2: Components of the designed mold [4]

2. Manufacturing

The plain weave glass fiber pre-pegs was utilized as reinforced material in present study. The layer thickness was 0.27mm and areal weight was 300 g/m2. Type of matrix was epoxy resin (E-6509) with glass transition temp.of 137deg.C. The minimum cure temperature is 110deg.C and resin content was 40+-3% in weight [4].

3.Static Test

Fig.3 shows corresponding positions of bogie, like weight of car-body(A), electromagnetic attractive force(B), orbit support force(C), traction(T) and twist. Here traction and twist is zero. The width, height and length of casting block were measured to as 255mm, 224mm and 610mm, respectively. Depth was 190mm. Thickness of side wall were 10mm and 15mm with span of 400mm. Also significant efficiencies of pier vibrations in three directions increase with train speed [2]. A universal testing machine was used for the experiment.The load was applied at a stroke controlled rate of 0.2mm/min until 80 kN. To control strain of blocking 60 electrical-resistance strain gauges were mounted on surfaces. An automatic data acquisition system connected to computer was used to monitor loading, deflections and strains in structure. The main aim was to evaluate static strength of composite casting block and not fatigue strength and reliability [4].

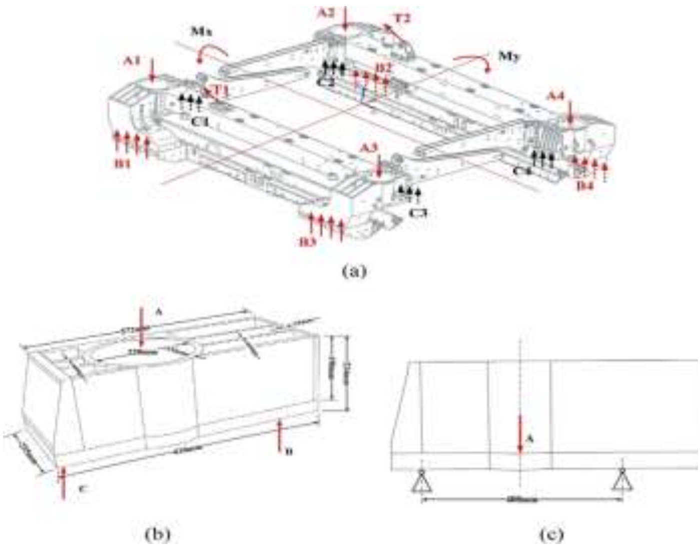

Fig-3: The equivalent relation of load along the vertical direction [4]

IV. RESULT

1. Static Test Results

The experimental response curve of casting block was as shown in fig.4. Maximum load of 80kN was applied. It was revealed that the overall structure did not fail under this condition and still had enough bearing capacity. The response curve exhibited a linear elastic behavior during the loading process. The result indicated that the static strength of fabricated composite bogie frame element could satisfy the load bearing requirement of application (20kN). The maximum vertical displacement obtained by experimental was 0.58 mm, which was less than the maximum allowable deformation (0.8 mm). According to the results of experiments, composite bogie frame has rather surplus strength and stiffness, while making the bogie frame lighter and safer [4].

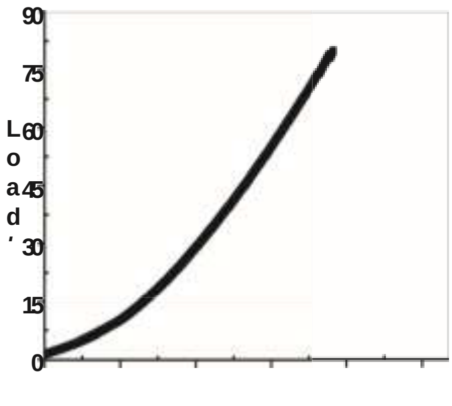

Fig.4: Load-displacement curve of casting block subjected to three-point bending [4]

2. Weight evaluation and prospect

The weight of fabricated glass fiber reinforced composite casting block was measured to be 27.9 kg (61.5 pounds). The reduction of weight was approximately 30.9% compared to the traditional aluminum structure, which achieved the design aim. It is necessary to emphasize that the applied ultimate load during the three-point bending test was almost four times than the actual load, whereas the overall structure still did not fail [4]. The local strain and stress of block obtained by FEA (1241 mε, and 32.16 MPa) were far less than the material allowable strain and stress (3000 mε, and 90 MPa). There was a larger safety redundancy in the composite casting block [2]. Thus, it indicated that the glass fiber reinforced plastic composite has a great potential in the lightweight transformation of rail transit industry [4]. Guideway configurations affect transverse ground vibrations, whereas effects on vertical and longitudinal ground vibrations are weak [2].

V. CONCLUSION

Developed mold can fabricate multi cavity structure and process can be used for manufacturing of complex structure. Glass fiber reinforced casting block can be fit as load carrying element. Weight reduction up to 30.9% can be achieved. Thus, results showed that composite bogie frame has more strength and stiffness.

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