CFRP 갠트리 보의 에너지와 하중 저감 효과

CFRP composite gantry beams for energy and weight saving

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1. Introduction

Majority of precision manufacturing machine tools are made of rigid conventional material for increased stiffness and narrow deflection limit making the overall system bulky. The operational cost for bulky moving parts is high because of the requirement of bigger capacity motor, while the motion of the moving components are slow reducing the efficiency of the system. Hence mass reduction of the component is advantageous without the compromise of the stiffness of the structural member. In this paper we present a parametric study of four hollow gantry beams (G1 ~ G4) designed and developed for 11th generation Liquid Crystal Display (LCD) panels manufacturing. The 11th generation LCD panel measures 3200mm in length and 3600 in the width which will be used for the manufacture of LCD screens more than 70 inches wide. In order to make system energy efficient, a lighter beam is desired for rapid motion. The beams were made of carbon fiber reinforced plastics (CFRP). CFRP is lighter yet stiffer material compared to other conventional material like steel making it a good candidate for the high stiffness beam. The use of CFRP composites to upgrade structures and, in particular, to construct lighter but stiffer beams has wide applications[1].

Table 1 summarizes the history of upsizing of LCD glass substrate sizes. It can be seen from the table that generation 11 glass substrate is nearly one-third times larger than the previous generation glass substrate.

Table 1 Comparison of LCD glass substrate size for some earlier generation [2]

Generation	LCD glass substrate size		Year
	Length(mm)	Breadth(mm)	
8	1870	2200	2005
9	2160	2460	2006
10	2850	3050	2009
11	3200	3600	-

2. Model Description

The assembled CFRP beam consists of three linear motor(LM) guides, two support bases at each ends of beam, and an aluminum carriage. Aluminum carriage holds the optical module. The aluminum carriage travels along the length of beam on the LM guide with 1G acceleration. Figure 1 shows the cross-sectional view of all the four beam models. The beams were 4 m long (z-axis) and cross-section of 300mm and 400mm in breadth (x-axis) and height(y-axis) respectively. Two linear guides were attached to the right-end of the beam while single guide is placed on the top of the beam. LM guides are immediately supported on aluminum base before it is attached to the CFRP beam as shown in figure 2.

Two base plates with cross-section of 300mm length 200mm width and 10 mm thick were attached on the lower part of the beam for the support. The beams were made of laminated unidirectional and woven CFRP. The wall thicknesses of the beams were 8mm.

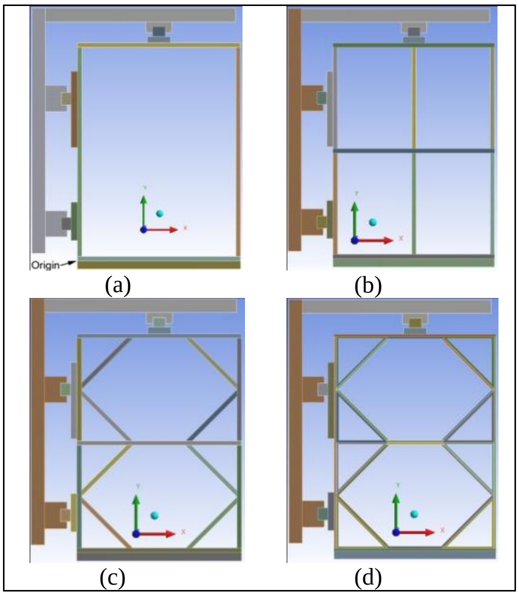

Fig. 1. Four models for analysis (a) G1, (b) G2 (c) G3 and (d) G4.

Optical module which rests on the carriage has a mass of 150kg. The mass was replaced by the corresponding force of 1500N (750 N on the top of carriage and 750N on the side of the carriage) which was applied on the top and side faces of the aluminum carriage. During the horizontal movement of beam (1G), horizontal forces along with vertical forces comes into action, the horizontal forces equals in magnitude to the vertical forces and act in the direction opposite to the movement of the beam (not shown in the figure).

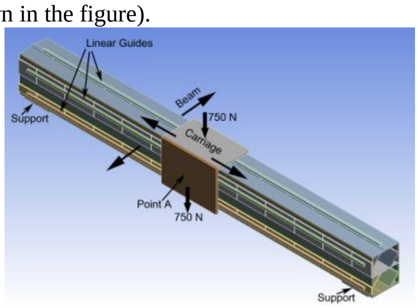

Fig. 2. Gantry stage system showing the carriage and LM guides

3. Result and Discussion

The deformation results were measured at the point, -85mm (x-axis), 200 mm (y-axis) and 2000mm (z-axis) (mid span of the beam) which lies at the center of the hanging carriage surface. The deflections of the beam under loading conditions were calculated taking un-deformed beam as a reference. The experimental results were compared with the numerical analysis. The test results agreed well with the numerical results validating the design.

In table 1, weight comparison of aluminum and CFRP beams (8mm thick wall) is shown, it can be seen that CFRP beams are lighter compared to aluminum beam. Reduction of weight ranged from 16%~27% for all the models with 8mm thickness. The total deformation in case of G1 is highest among the beams, with slight improvement in G2 followed by G4 and G3.

Table 1: Weight comparison of aluminum and CFRP beams (8mm)

Material of Beam	Weight (Kg)			
	G1	G2	G3	G4
Al	249	308	363	363
CFRP	196	229	266	307
Wt. ratio	0.786	0.743	0.731	0.846

4. Conclusion

The CFRP beam designed and manufactured is better than the corresponding aluminum beam in terms of deflection and weight. Both of which directly governs the performance of LCD manufacturing equipment. This finding will be important in the race of upsizing and achieving higher precision in the LCD manufacturing industry which otherwise is increasingly complex to meet the specification for the LCD manufacturing equipment.

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References

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