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Main Frame Structure Exploration of Sliding Tandem Bike as the Effort to Enhance Product Feature

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Abstract: Tandem bikes have been produced, since, several years ago as the choosing of costumer besides single/solo bikes alternatives. However, the numbers of their selling were not considerable contrast to that of single bikes. One of the difficulties is their dimensions which are longer, especially when they are operated or carried out. On the other hand, their existences are demanded adequate for the people who would like to ride not alone other than in couple. Within the facility to reduce the dimension of tandem bike, therefore, it is expected the innovation could respond the obstacle above. Currently, the technology development or improvement of bicycle industry also has come near or parallel to the innovation. That is which is created the folding bike, however, in the implementation of it is only featuring in the single bike rather than tandem bike. Besides, the dimension reductions by means of sliding system also still carry out rarely. The improvement of sliding tandem bike, especially, its main frame could increase the degree of comfort for the rider. Finite element simulation will be applied to examine the performance of each alternative of main frame. Stress and deformation analysis will be evaluated moreover the variation of frame material and wall thickness will be taken out for the particular main frame alternatives. Main frame structure investigation could be obtained. The result of structure analysis could be used to determine of main frame design for sliding tandem bike as the one of consideration.

Key words: Main frame, structure exploration, sliding tandem bike, effort, product feature, implementation

INTRODUCTION

The function of bike has been improved it could not only be used as the tandem bike but also could be used as the single bike. The creators name it tandem bike (Iskandriawan and Jatmiko, 2014). Another version of tandem bike but still could be transformed to single bike is siding tandem bike (Iskandriawan *et al*., 2017). In the sliding tandem bike, how to transform tandem bike to single bike or vice versa only reposition front frame and back frame on the main frame. Figure 1 shows both of them.

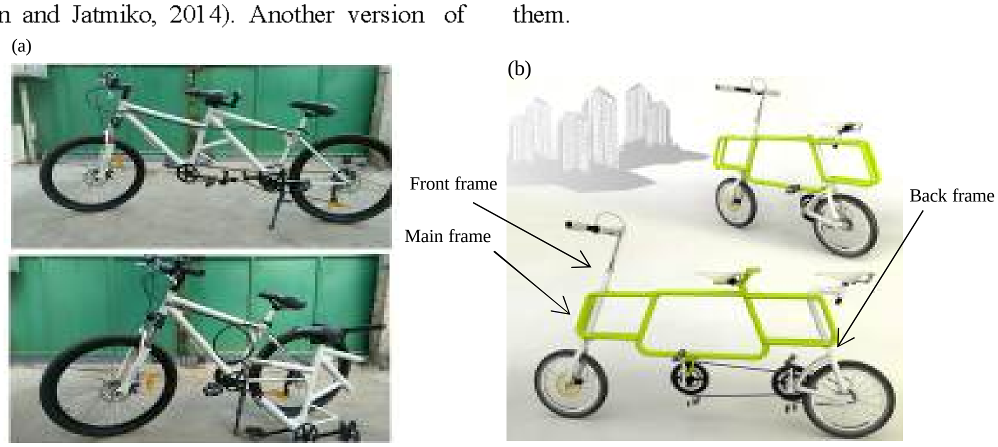

Fig. 1: a) Trandem bike, the bike could be used as the tandem bike or the single bike based on the need and b) The sliding tandem bike again it could be transformed to the tandem or single bike with only reposition of front and back frame on the main frame (Iskandriawan and Jatmiko, 2014; Iskandriawan *et al*., 2017)

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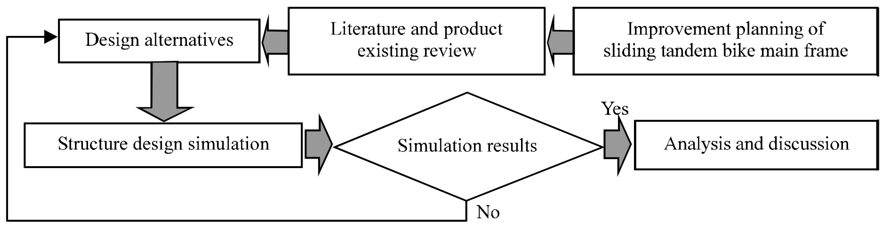

Fig. 2: Structure analysis research flow of sliding tandem bike main frame

In the past, some of bike designs variant have been produced (Embacher, 2011). People known very well some of them, unfortunately people also didn't know partly of them. They inspire the researchers to create the variant of main frame design. The principles of design methods and material selection are implemented to analyse the main frame design of sliding tandem bike (Cross, 1994; Ashby and Johnson, 2007). Ergonomics approach is fundamental to the main frame design. They could determine the bikes are suit to the rider or still could be improved more (Grandjean, 1986; Christiaans and Bremner, 1998; Donkers *et al*., 1993). Science and technical aspects constitute the essential matter which are could not be ignored for the bike main frame design consideration (Chen *et al*., 2015; Mott, 2009).

This study will explore the variation of sliding tandem bike main frame design. It is discussed the structure aspects which are became one of contemplation to select the main frame of sliding tandem bike (Fig. 2).

MATERIALS AND METHODS

Structure analysis research flow of sliding tandem bike main frame was established (Fig. 2) (Cross, 1994). It is started with the improvement preparation of sliding tandem bike main frame. Truthful observation of product existing is the important phase besides literature study. Based on main frame design of existing bike furthermore was developed design alternatives of them. Simulation researches was implemented by means of finite element practice. Analysis and discussion of sliding tandem bike main frame was realised to select the best design alternatives.

RESULTS AND DISCUSSION

Based on the existing design of sliding tandem bike main frame furthermore was improved 8 (eight) new design of them even though still in 2D Model (Fig. 3). Then, it was accomplished simulation researches within the finite element software. Two essential elements of material properties that are stress and deformation features of main

Existing design			
1	2	3	4
5	6	7	8

Fig. 3: Main frame of sliding tandem bike existing and eight new alternatives 2D design

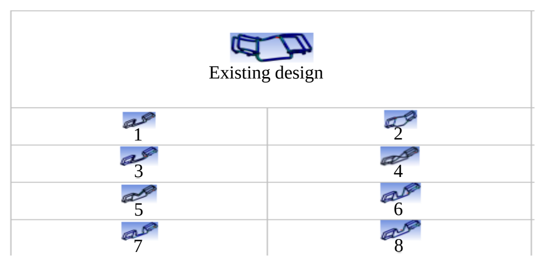

Fig. 4: Stress simulation results of main frame existing and eight alternatives design besides the maximum stress could be detected (red arrow sign)

frame will be argued. Moreover, the variation of material and pipe frame wall thickness will be implemented for certain main frame.

Previously, researchers performed the improvement of sliding tandem bike concerning to the increasing of comfort and operational easiness for the rider based on ergonomics study. The team determined the material of main frame is aluminium rather than iron in order to the weight of bike could be reduced. In order to increase the effortlessness, especially at the time of the rider run the bike, therefore, alternative 8 of main frame was chosen. Actually, alternative 8 is the improvement of alternative 6 where the centre top pipe was moved up slightly.

In this case, there are two kinds of loads: front and back rider, Fig. 4 shows us the stress intensity of main frame for all alternatives and existing design based on the finite element simulation results. The location where the maximum stress occurred moreover could be detected (red arrow sign). Five of them occur at the corner of pipe frame where another four are chanced at the bottom pipe under the load.

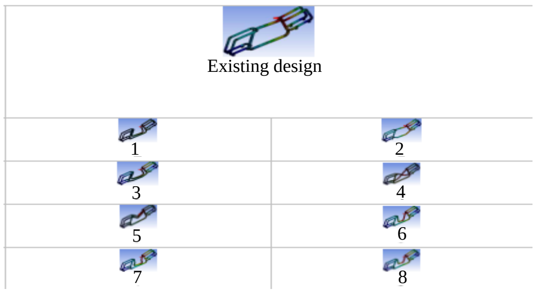

Fig. 5: Deformation simulation results of main frame existing and eight alternatives design moreover maximum deformation could be detected (red arrow sign)

It can be seen at Fig. 5, the deformation degree of main frame of existing design and all alternatives. It was so surprise that the location of maximum deformation is different with that of maximum stress.

Figure 6 presents us the graph of maximum stress of existing main frame and eight new alternatives design as the function of vertical load. From the stress aspect point of view the best four are 4, 5, 2 and existing main frame. The worst four are frame 3, 1, 7 and 6 where frame 8 is the intermediate amongst them.

The deformation aspect is very critical especially for the transportation product such as sliding tandem bike (Fig. 7). Similar situation are happened in the deformation aspect where if the stress is high accordingly the

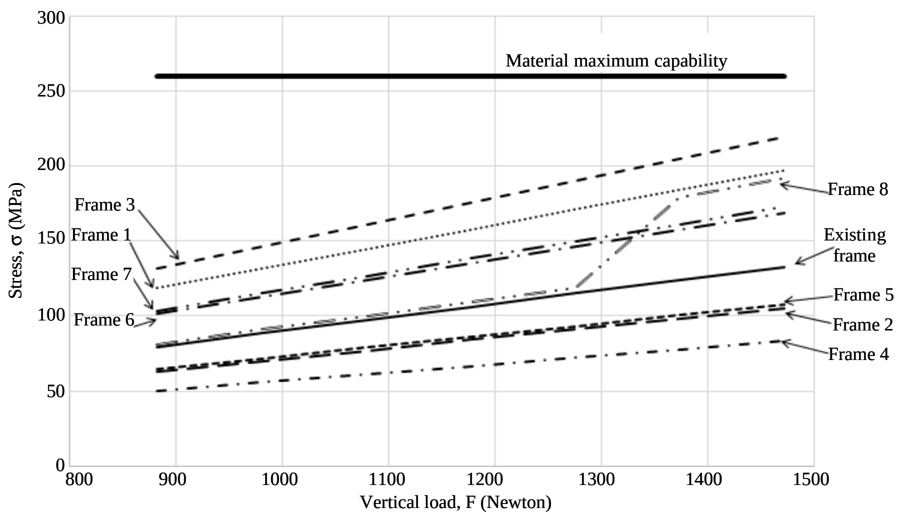

Fig. 6: Maximum stress of existing main frame and eight alternatives design as the function of vertical load

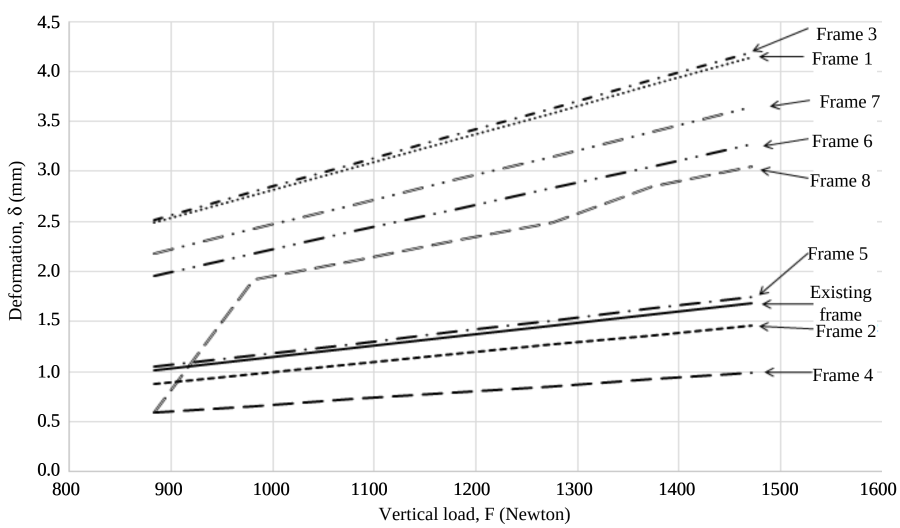

Fig. 7: Maximum deformation of existing main frame and eight alternatives design as the function of vertical load

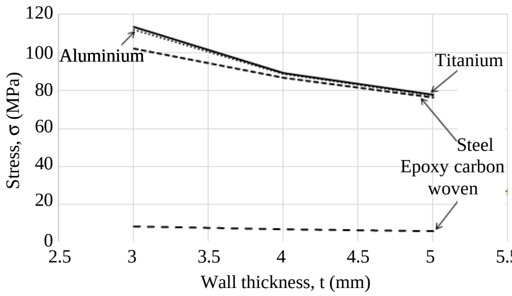

Fig. 8: Maximum stress of existing main frame as the function of pipe wall thickness for selected material

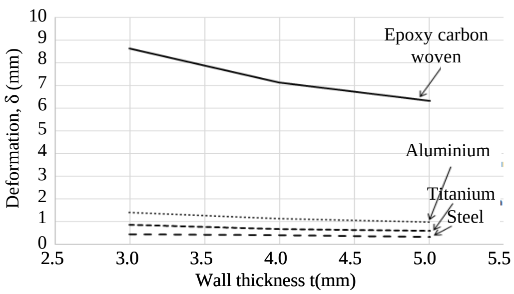

Fig. 9: Maximum deformation of existing main frame as the function of pipe wall thickness for selected material

deformation correspondingly high. Again the position of frame 8 is somewhere between the others. One another interesting is there is a fractures line at frame 8 both in stress and deformation graphs.

Especially, for existing and 8 main frame, it would be implemented the variation of material will be used. There are four materials will be practiced: steel (Structural steel UT460 MPa), Aluminium (Al 6061 T6), Titanium (Ti 6AI4V) and carbon (Epoxy carbon woven 395 GPa). The magnitude of load was 1,471.5 Newton.

It could be seen at Fig. 8-11 that stress and deformation will decrease when the wall thickness of pipe grow. Especially for existing main frame (Fig. 8 and 9), carbon is excellent from the maximum stress point of view compare to steel, aluminium and titanium. Its stress is very low, σ under 20 MPa. Unfortunately, its deformation δ is highest more than 6 mm. The deformation of steel is the best. Titanium and steel have deformation not more than 1 mm.

Similar condition are occurred for main frame 8 (Fig. 11) where carbon is the worst compare to the others from maximum deformation point of view, δ = more than 10 mm. Its maximum stress also highest (Fig. 10) where this situation is different compare to what happened in the existing main frame.

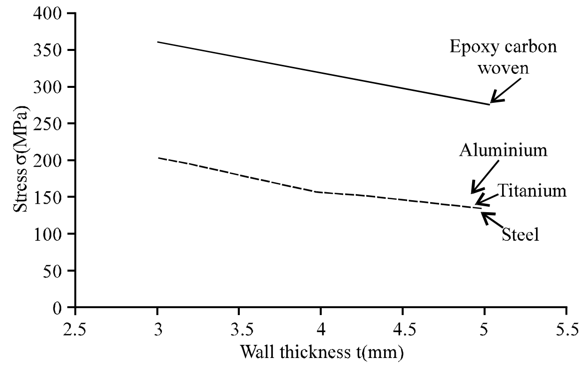

Fig. 10: Maximum stress of main frame eight as the function of pipe wall thickness for selected material

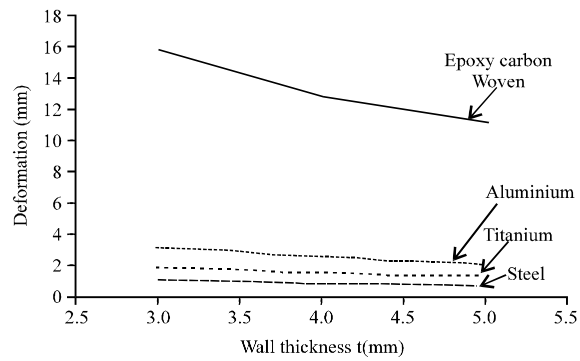

Fig. 11: Maximum deformation of main frame eight as the function of pipe wall thickness for selected material

CONCLUSION

The problem of existing sliding tandem bike are how it could be downgraded the bike weight and could be increase the effortlessness of bike operational.

Hopefully, the replacement of material to aluminium rather than iron could bring into reality the reduction of bicycle weight. However, the effort to increase the easiness of operational is answered with new main frame design of sliding tandem bike. The existing main frame design and the new alternatives design should be checked their structure.

Main frame structure exploration gave idea to the bike designer to select the best design of main frame as evidence besides the other contemplation such as visual aspect. The inspection was only implemented static loading rather than dynamic due to the bike is only personal transportation where high-speed train maybe reveive more excessive load (Abebe and Qiu, 2016).

It could be determined the best main frame design based on their maximum stress which is happened at the specific location of main frame. There is a linier correlation between stress and deformation aspects due to a particular load.

Material selection of main frame was important aspect which is controlled the bike performance. The higher the wall thickness, the poorer the stress and deformation. Unfortunately, the correspondence between stress and deformation is conflicting for some material. Possibly the stress is good but the deformation is horrible. But for the particular main frame design, it was not occur.

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