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FINITE ELEMENT MODELING OF REINFORCED BEAM COMPLEX LOADING

The features of deformation of reinforced joist beam when bending combined with torsion are being examined. The reinforcement and the composite matrix friction – the stress-strain state of the structure and generated inside gaps parameters effect has been analysed.

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AN APPROACH TO IMPROVEMENT IN THE FRAME DESIGN OF GO-KART CHASSIS

In this study, the frame design of Go-kart chassis was analysed and improved using CAD/CAE system. The Go-kart chassis frame was modelled and analysed using Pro-Engineer and ANSYS code. Frames with different sizes were analysed and an optimum dimensions were estimated. Finally an improvement in the frame existing design was carried out to reach higher strengthened chassis. Furthermore different cross- section style frames were also investigated and compared. The results showed that the circular cross section frame is the optimum from point view of cost, strength and reliability. A high increase in load carrying capacity is reached with 0,5 % increase in weight of the frame.

Introduction. Go-kart is a racing machine with lowest centre of gravity, wide track width and no true suspension system. Its wheels spin at the same time and with the same rate. In fact Go-kart has to use its tires and chassis flex to act as its suspension system. It is the cheapest existing motor sport, which attracts the attention of youths. This sport hobby became popular in the mid fifties. In 1970 having placed motor unit behind the driver carried out a large improvement in this area. In 1990 motor companies subsidized this sport and its racing field was spreaded around the country. Frame chassis is the carrying structure for all internal and external loads of the vehicle. In general chassis from the point of structure could be divided into different types. These types are ladder, X, fork and platform types. Each of these types or systems has its advantage and its application field, see figure 1, *a–d*. Types a, b have the advantage of minimum weight/ strength ratio. Generally the ladder type chassis is the most popular type used in Go-kart vehicle because of simplicity and low production cost [1, 2].

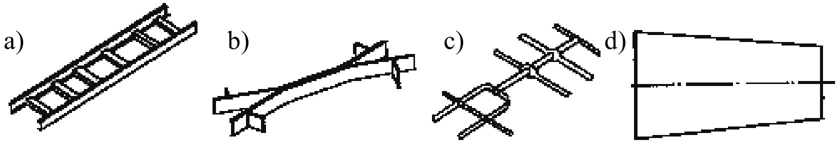


Figure 1 – Chassis type

In this study the CAD/CAE system was employed to the improvement in the design of the Go-kart vehicle frame chassis. The design was improved and analysed using CAD/CAE system. Go-kart pipe frame was modelled and analysed using Pro-Engineer and ANSYS code. The Pipe frame with 22–32 mm in diameter and 1–2 mm in thickness sizes and square, hexagonal and octagonal cross-section was modelled, analysed and an optimum cross section shape and dimension were pointed out. Finally an improvement in the frame chassis design was carried out to increase the carrying load capacity of the frame. The results showed that the circular cross section with the improved design was the optimum design from point view of cost, strength and reliability

Modelling and analysis. Modelling consists of the following steps: point definition, element generation, boundary conditions, constraint, loading and solution [3, 4]. An existing ladder type chassis was modelled using 124-beam element (Beam 189) for the frame and 14-shell elements type (shell 93) for the floor base. The model was constraint at the wheels bearing contact points. 100 kg driver dead weight was applied plus 30 kg for motor and all attached mechanisms were also considered. As materials St 42,2 steel material for beam frame and 1,25 mm thickness St10 steel sheet metal for base plate was used. Using the above modelling steps a 1,5–2,5 m length, 22–32 mm diameter and 1–2 mm thickness pipe frame chassis were modelled, see figure 2.

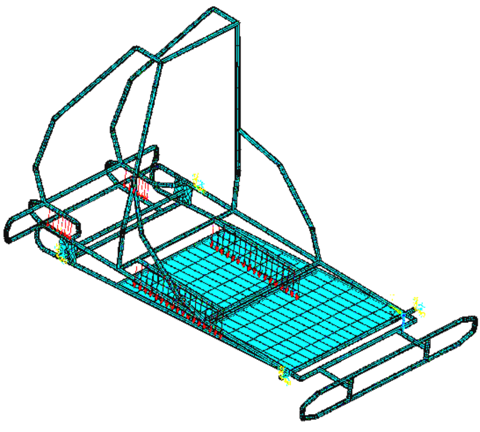


Figure 2 – Model and loading for existing Go-kart

Improvement in design was carried out by adding strengthen bar and triangle plates at the recognized week point of the existing design. Finally the improved chassis was also modelled and analysed. See figure 3. Furthermore frames with 22 mm size and 1 mm in thickness as square, hexagon and octagonal cross-sections were also modelled and investigated. All these models were analysed using ANSYS code with static structure solution.

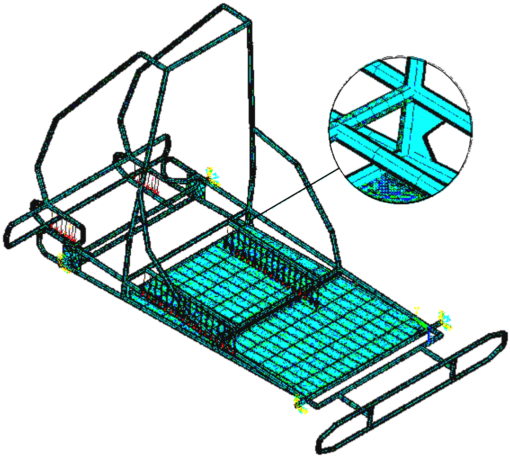
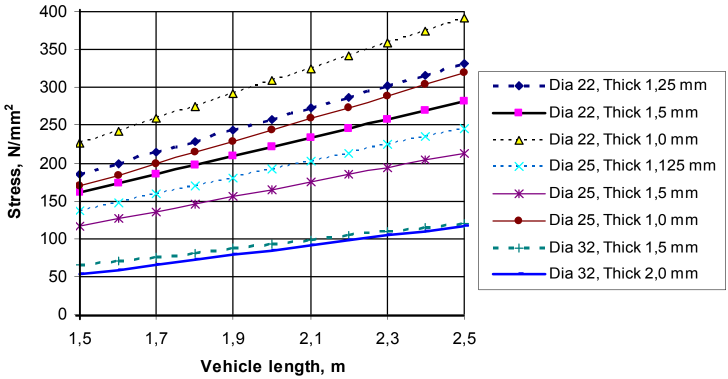


Figure 3 – Improved model of Go-kart

Results and Discussions. Figure 4, *a*, *b* presents the maximum Von-Mises stress – maximum displacement curves for Go-kart frame with length varying between 1,5–2,5 mm, beam size from 22–32 mm in diameter and 1–2 mm in thickness. It is clear from figure 4, *a* that the stress level changes with the change in vehicle length, frame beam diameter and thickness. The stress increases linearly with the decrease in beam section diameter and thickness and increases with the increase in length of the vehicle. The lowest stress level is for the frame with 32 mm diameter and 2 mm thickness and the highest level is for the frame with 22 mm diameter and 1mm thickness. As examining the strength from point of weight it is clear that the frame with 22 mm diameter and 1mm in thickness has the highest strength to weight ratio.

Figure 4, *b* presents the variation in maximum displacement with the vehicle length for frames with diameter varying from 22–32 mm and thickness 1 to 2 mm. It is clear from this figure that the displacement increases with increase in vehicle length and decreases with the increase in diameter and thickness of the frame beam. The highest level of displacement is for 22 mm diameter and 1 mm thickness frame. In fact the stress and displacement increase with the increase in length and in diameter to thickness ratio.

a)



б)

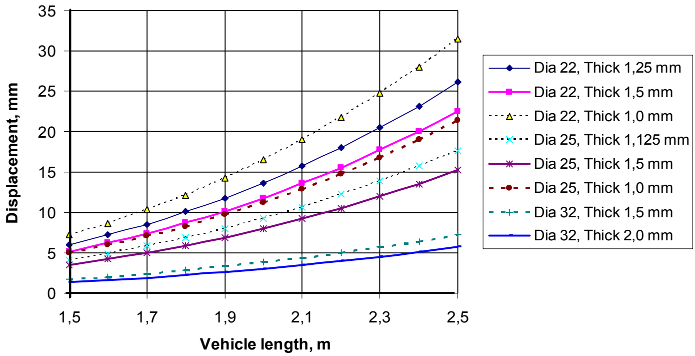
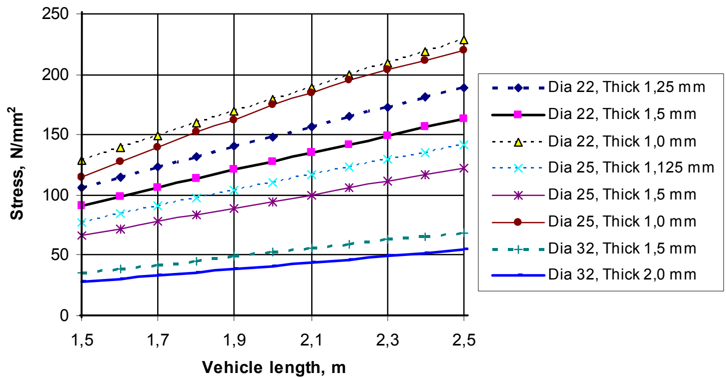


Figure 4 – Stress (*a*) and displacement (*b*) level in existing Go-kart

A modification in the design was carried out by adding the supporting elements in the regions shown in figure 3. The modified chassis analysis results showed that the modification resulted at the change in the level of the developed stresses and displacements see figure 5, *a*, *b*.

In this figure the stress increases with the decrease in diameter and thickness of the frame beam. On the other hand the displacement decreases with the increase in diameter and thickness of the pipe frame. Figure 5, *a* and *b* shows that the strength to weight ratio of the frame with 22 mm diameter and 1mm thickness is the highest. It is clear from figure 4, *a*, *b* that the highest stress and displacement levels for existing Go-kart are 300 N/mm^2 and 21 mm respectively. After the modification in design these values dropped to 150 N/mm^2 stress and 7 mm thickness respectively.

a)



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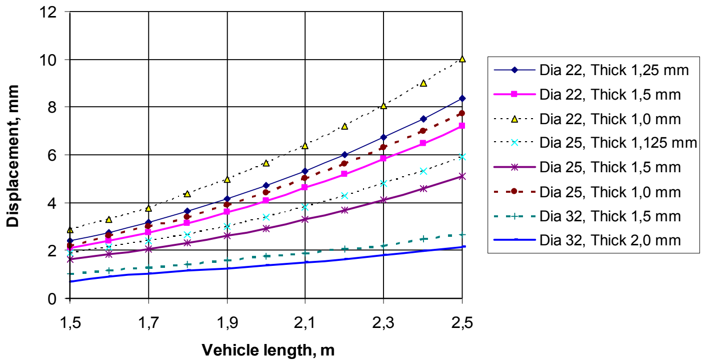

Figure 5 – Stress (*a*) and displacement (*b*) level in improved Go-kart design

Furthermore, the location of maximum stress and displacement were also changed. See figure 6, *a*, *b*. This result presents a 100 and 200 % drop in stress and displacement levels respectively. On the other hand the improvement in the chassis design results in 0,5 % increase in weight. Further drop in stress level was reached by adding plate angles at the sensitive locations, the maximum stress and maximum displacement dropped to 70 N/mm^2 and 2,2 mm respectively. This is a drop of 328 and 850 % in stress and displacement levels respectively. On the other hand the analysis results of 22 mm size and 1mm in thickness circular, square, hexagonal and octagonal frames showed that the minimum stress level was in the circular cross-section.

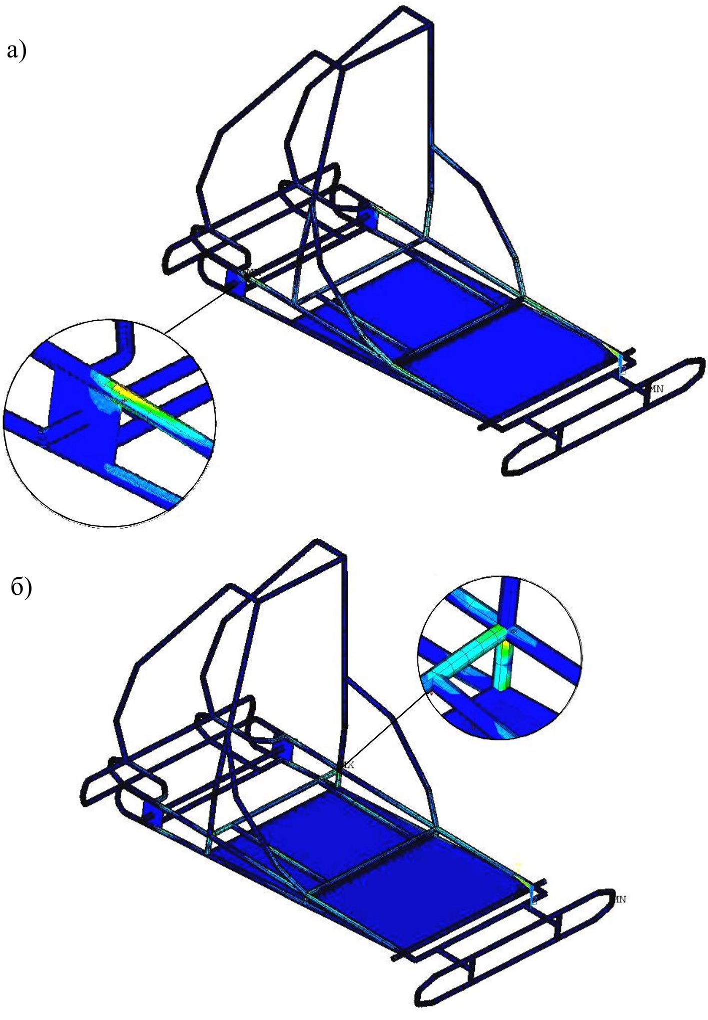

Figure 6 – Stress counter in existing (*a*) and in the improved (*b*) Go-kart

In comparison to circular section the values are 94, 52 and 22 % higher for square, hexagonal and octagonal respectively see table 1. This indicates that among all these different cross-section shapes, the circular section has the highest strength. Finally the overall analysis results indicate that the optimum strength, cost and simplicity in production are reached with the improvement in the design of the chassis for the frame made of 22 mm in diameter and 1 mm in thickness beams. Furthermore, improvements in the design result, in large drops in the level of stresses in the chassis system, which suggests the use of lighter materials with lower strength than steel.

Table 1 – **The max. stress and max. displacement developed in frames with different cross-sections**

Cross-sections	Stress (Von Misses), N/mm^2	Displacement, mm
Circle	104	2,8
Octagonal	127	3,3
Hexagonal	158	3,6
Square	202	5,5

Conclusions.

1 The circular section is the optimum design shape.

2 Improvement in design results in 330 % increase in strength for 0,5 % increase in weight.

3 For the sizes of Go-kart vehicles considered in this investigation the optimum chassis is of the improved design with 22 mm diameter and 1mm in thickness beam frame.

4 Use of lighter and low strength materials than steel.

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ПОДХОД К УСОВЕРШЕНСТВОВАНИЮ КОНСТРУКЦИИ РАМЫ ШАССИ КАРТА

Выполнен анализ конструкции спортивного автомобиля – карта с применением CAD/CAE систем. Рама шасси карта моделировалась с применением систем ProEngineer и ANSYS. На основе анализа рам с различными размерами были установлены оптимальные их параметры. Рассмотрен вариант усовершенствования конструкции, позволяющий значительно усилить конструкцию шасси. Сравнение различных вариантов поперечных сечений рамы показало, что наивысшие прочность, надежность и экономичность достигаются при использовании круглого сечения. Значительное увеличение несущей способности конструкции сопровождается увеличением веса рамы только на 0,5 %.

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