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A Case Design on a Freely Movable Steel Non-Roller Track between Sliding Slots for Decreasing Impact

Mustafa Murat YAVUZ[1*]
[1]Department of Industrial Engineering, Osmaniye Korkut Ata University, Osmaniye, TURKEY

***Sorumlu Yazar:**
E-mail: muratyavuz@osmaniye.edu.tr

Abstract

The usage of sliding doors has been widely seen in commercial and industrial applications. Their easy usage and manufacturing property provides its popularity. However, some failure conditions have been detected with respect to their basic and simple mechanism in all usage areas, because of most of them includes no failure prevention systems/mechanisms. Impact, inappropriate usage, unsymmetrical loading and other conditions are mostly dominant situations for failure. In this study, a case design is tried to be realized for decreasing impact condition when slot track move on slots end at undesirable speed. Finite element analysis (FEA) is used for the investigations. The slot geometry has been changed to protect the non-roller track and slider from the impact effect. Aluminum material properties are used as the definition of material properties. A basic case design has been examined and it is compared with modified condition. The results have shown that even if changing the geometry a little, it is critically affective for decreasing the impact speed. But this application causes to locally stress peak points that should be considered in another investigation. All result figures are explained in detail.
Keywords: Impact, stress, deformation, non-roller track

INTRODUCTION

Sliding doors are one of the most usage building parts in the commercial and industrial applications. The opening distance of sliding doors is very short and automated opening mechanisms are easily applied from front or back of the door, which provide effective and more suitable properties. However, they are not fixed with a solid hinge connection. The sliding slot and a track roller application are commonly used, which separates them from commonly known connection structure.

Some case applications are applied and mostly seen in patent processes, less literature studies are observed. Gunoz et al. [1] investigate an automatic sliding vehicle door rope mechanism that is able to use all car doors. The study includes door weight, diameter of rope, applied torque and opening time analysis. Yun et al. [2] study on optimizing sliding door to increase their efficiency and usability, especially for vans. Guven et al. [3] investigate a sliding door that is used in automotive industry by using finite element analysis. They also specify that a sliding door mechanism should include manual operating effort, high energy slam, door drop off, door and mechanism stiffness, durability and packaging. Saitou et al. [4] study and design a special sliding door, includes semiautomatic lifting equipment that can be able to open by using weak/less force. Different geometrical conditions are examined by using simulations. Lachheb et al. [5] study on linear motors for automatic sliding door applications by using numerical analysis. Je [6] adds power sliding door system into minivans/vehicles to optimize interior design. Muneer and Sharma [7] study on closing speed for a manually movable sliding door. When considering the literature, fewer case studies are applied, especially for non-roller track sliders in sliding doors.

In this study, a sliding door's non-Roller track slider is investigated in a slider slot and a geometrical change is applied into the slot for trying to decrease impact velocity by using finite element analysis.

MATERIALS AND METHODS

All the parts of the sliding systems are modelled and analyzed with computational methods. A slot, a non-roller track slider and a stopper are modelled and assembled. Their assembly is shown in Fig. 1 and all dimensions are given in S.I. metric (m) units. Slot has a length of 800 mm, a width of 50 mm and a height of 65 mm. There is a C shape rectangular channel for assembling non-roller track is present that has a width of 30 mm and a height of 45 mm. Width and height dimensions of non-roller track is also as similar as channel dimensions. Length of non-roller track is 80 mm and all corners are sharp, not rounded. A stopper is modelled as two stepped 10 mm thickness, is placed at the one end the slot. No friction is applied between track and slot surfaces. The stopper is bounded to the slot. An initial velocity is applied to the non-roller track to the stopper direction.

A case design is applied into the slot for preventing or decreasing direct impact of the track to the stopper. The modified case drawing of the system is shown in Fig. 2. The distance between tracker and stopper is 0.1 m and there is an elliptic fillet is applied into the near side of the stopper on the sliding slot. To prevent sharp edge interaction with fillet slot surface, the edges of track is rounded with 3 mm fillet radius.

Investigations are carried out with numerical analysis. Suitable finite element package software is used in all cases. Aluminium material properties are selected which has a density of 2770 kg/m^3, Modulus of Elasticity 71 GPa, Poisson's ratio 0.33, tensile yield strength of 280 MPa and ultimate strength of 310 MPa. The solution time is determined as 0.11 second that will provide interaction of track and stopper. Side/upper and lower length surfaces of slot are fixed for determination of boundary condition. Stress results are illustrated with Von-Mises Stresses that can be suitable for linear elastic isotropic material failure theories as aluminium material.

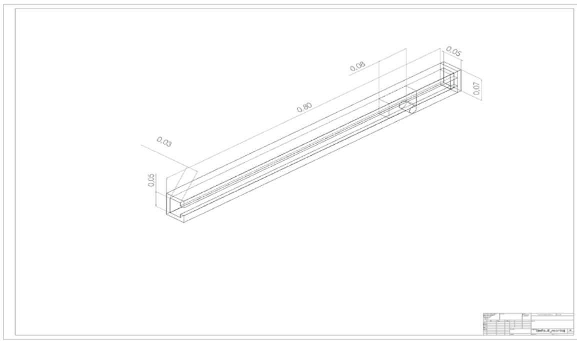

Figure 1. Assembly model of slot, non-roller track and stopper

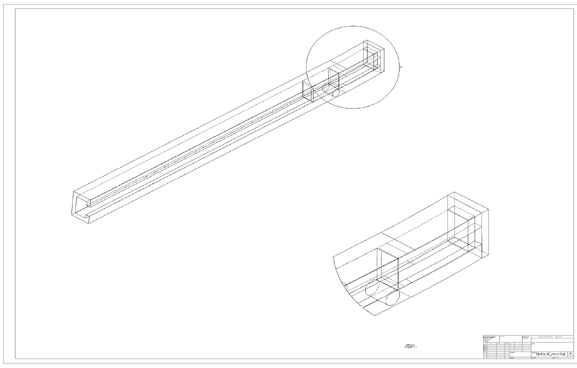

Figure 2. Modified case of the model of slot, non-roller track and stopper

RESULTS AND DISCUSSION

In Fig. 3, Von-Mises stress results of default slot geometry are given. Nearly whole stress contours occur at the passing and interaction locations of the track into the slot. The values of stresses are much less than yield strength of a standard aluminium material, which represent safety when only occurred stress and yield stress of material are compared between each other. Two high stress locations are detected that are the interaction edges of the track on the slot surface.

Deformation results are given for default models slot in Fig. 4. Maximum deformation occurs at the initial interaction locations of the track. This location is the beginning location of the movement of the track. The deformation results are small.

In Fig. 5, stress results of non-roller track are given for default case. Stress values are higher than slot results when it is compared with Fig. 3. The sharp edges include stress peak points.

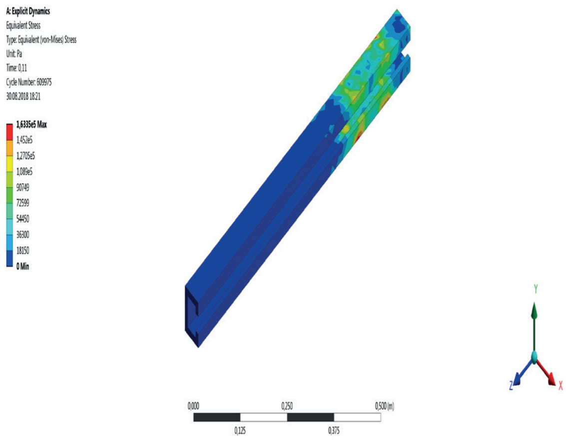

Figure 3. Von-Mises stresses on the slot without modification

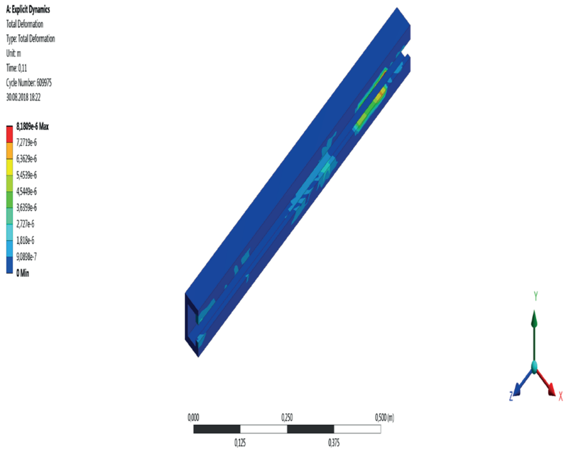

Figure 4. Total deformation of the slot without modification

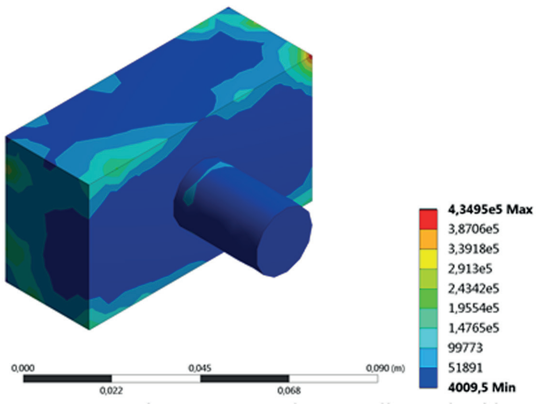

Figure 5. Von-Mises stresses on the non-roller track without modification

In Fig. 6, stress results of the stopper is given, which has the least maximum stress value. The interior contact area edges have the stress peak locations.

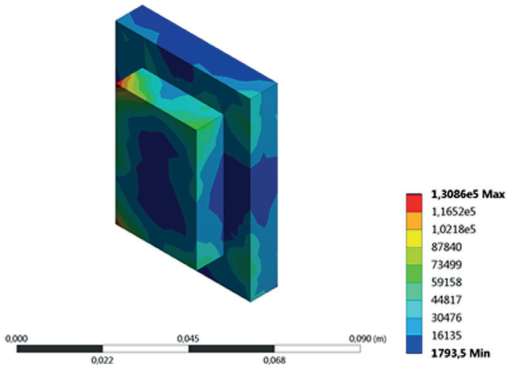

Figure 6. Von-Mises stresses on the stopper without modification

In Fig. 7, stress results of slot are given that includes a high stress peak location that is much higher than other stress locations. Hence stress contour are focused on that area. The modification and addition of a curve cause to more contact interaction at the edges of the track. That causes 17.4 MPa stress value.

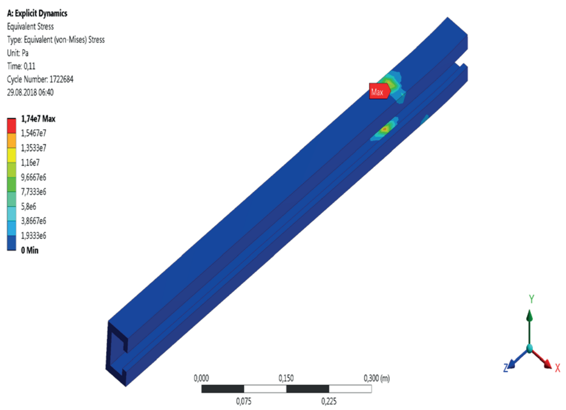

Figure 7. Von-Mises stresses on the slot with modification case

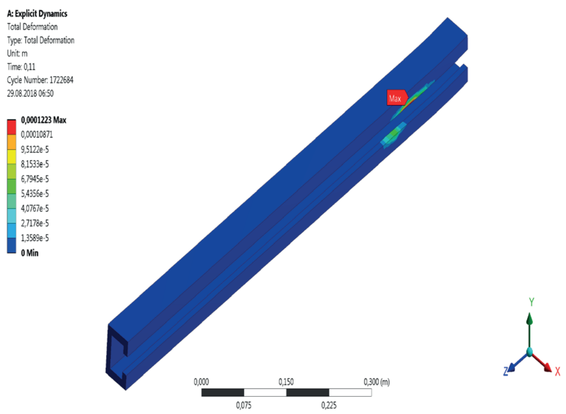

Figure 8. Total deformation of the slot with modification case

In Fig. 8, total deformation results are given. More deformation occurs in modified case rather than default case. Most of the deformation occurs at the edges when track edges and curved side of slot interact. In Fig. 9, track stress results are given. Nearly, 148 MPa stress value occur but a point interaction causes this value. Track is deformed more in the application of modification. In Fig. 10, stopper stress results are given. Its stress values are also higher than default case. But, the greatest values occur at the edges similarly.

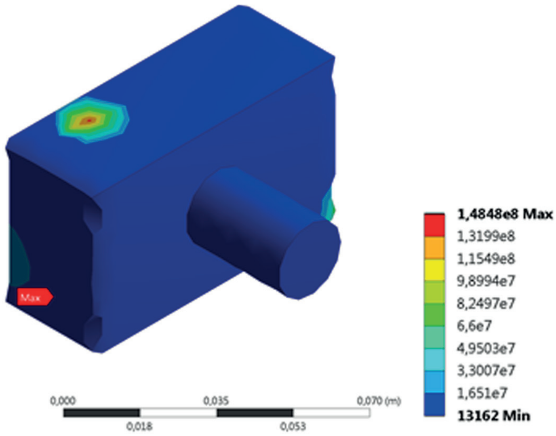

Figure 9. Von-Mises stresses on the non-roller track with modification case

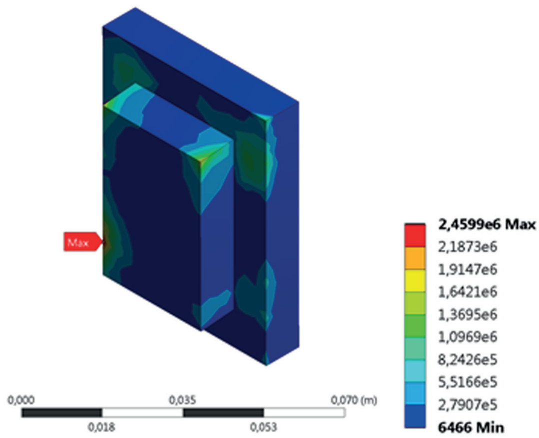

Figure 10. Von-Mises stresses on the stopper with modification case

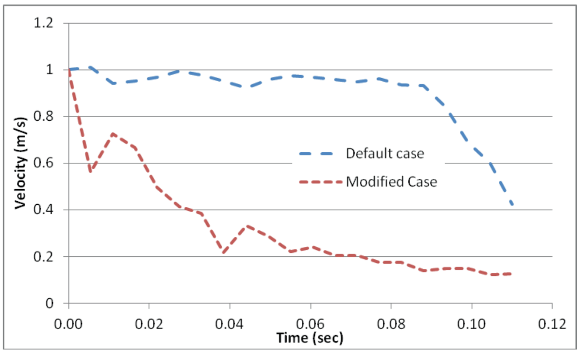

Figure 11. Velocity of the non-roller track with and without modification case

In Fig. 11, track roller speed is compared with default and modified case of slot. Even if stress values get higher when the slot modification is applied, it is seen that track velocity decreases at the beginning.

CONCLUSION

In this study, a slot, tracker and stopper system that is used for sliding doors, are investigated. Finite element analysis is applied in the analysis and time dependent case studies are examined. The results can be summarized as;

- maximum deformation occurs at the initial interaction locations of the track
- stress values of the track has the highest values
- sharp edges include stress peak points
- stress results of the stopper has the least maximum stress value
- interior contact area edges have the stress peak locations
- when geometrical modification is applied, all deformation and stress values of the components get much higher. most of them occur locally
- the velocity of the track get decreasing when modification on the slot is applied

The curve radius and more studies are carried on with considering the gained data from this study.

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