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Research article

Simulation of Static Loading on the Automatic Folding Clothes Hanger by Using Autodesk Fusion 360

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A B S T R A C T

Simulation of the static loading to the folding frame of the clothes hanger investigated by using Software Autodesk Fusion 360. The strength of the folding frame is important during hanging the clothes weight. The simulation of loading of wet clothes was by Autodesk Fusion 360 and performed in real life. The loads spread to three positions, which those locations investigated as critical locations. The locations are at short distance X_1, medium X_2, and far X_3; the zeroing is from the wall. The simulation performs Von Misses procedure for the loading analysis. Thus, the result of the analysis responds to the external load at the joints of the structure. The loads are the weight of the wet clothes during drying time. The bar aluminum structure connects its parts using hinges. Simulation result obtains data of loading. Further, displacement analysis completes those data. The safety factor was at the frame loading simulation. That is, those data are in by Von Misses stress-strain analysis. The result reveals the effect of the frame loading. The process of loading 12 kg induces a safety factor 3.746, normal stress 73.42 Mpa, and a displacement of structure bar 6.452 mm. At loading 22 kg obtains the safety factor 2.038, maximum stress 134.9 Mpa, and the displacement 9.86 mm. Furthermore, loading 37 kg-load, the safety factor 1.21, prime stress enlarges 61.48 Mpa, and the displacement was larger by 10.97 mm. Therefore, the simulation result concludes the weight of clothes trends a linear effect on the loading of part joints. The frame structure is tough to the weight of dry clothes and safe, deformation of the bar is less than 10 % of normalizing for 37 kg-loading.

1. INTRODUCTION

Technology transformation has shown its development. They expands resulted in innovative technology and was more dynamic. The new technology assists easy the people to work, i.e. clothes hanging clothes and drying. Hanging clothes is a common activity of people and it finds weeks. Thus, it becomes a culture to a region as people habits. Therefore, technology is needed to easy it. The traditional hanger just constructs plastic rope. Thus, its structure is not strong enough to hang a lot of clothes and needs more area. It device has constraints when at early rain [1-3]. Where people exert more effort to move the wet clothes to avoid rain. Therefore, its traditional structure needs improvement in its design. The new design helps people when the rain starts. It could fold shorten when no clothes hanging and rain-drop come.

The portable hanging structure has protruded some advantages [1,3]. Its design helps people during the clothes hanging. The folding frame could be short to close the wall. Therefore, the reservation needs a short length. It also has advantages because attaches near the house. Therefore, wet clothes are safe from

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rain and be convince for user. Its design appears in people's homes but it installed a simple structure. The conventional clothes hanger coincides with a wall clothes hanger. Its structure applies plastic rope and folds. Especially, it also saves the clothes from rain. Recently, the folding frame has improved its structure by applying a hollow frame [2]. Thus, sensors help it moving. The frame could be folded shorter [2-4]. The reserving area is not large. That is, its design is compatible with small houses or apartments. The strength of the frame structure is important. Because it needs to be safe when holding wet clothes during the drying process. Due to it reason, the materials of the frame are strong i.e. steel or aluminum series 6. The aluminum series 6 chosen for many reasons. It has apparent good physics properties i.e. light material. Sensors installed to the frame and a small electrical motor. Those parts applies the driving of the automatic fold. Thus, the frame is able to be shorten when the rain comes. However, the structure of the frame performs a rigid structure when holding the wet clothes. The folding step shows a flexible structure close to the wall during rainy That is, the hanger is semi-automatic. It combines mechanical and electrical driving. Thus, the weight of wet clothes is limited and still under the yield strength of aluminum. It makes sense to not bend the structure during drying wet clothes. Sensors drive the frame mechanically. Those instruments combine sensor Light Dependent Resistor and Rain Drop. That is, the electricity current controlling of the electrical motor is by sensors. Figure 1 shows Light Dependent Resistor (light intensity sensor). Its sensor can perform when detect light intensity [4]. The area covers a meter area. Further, electric current intensity relates to light intensity at its area. Strong light intensity creates a powerful current. Low light intensity reduces the power of electric current.

Fig 1. Light Dependent Resistor/light sensor.

The raindrop sensor is a humidity sensor. It functions to detect a rainwater bubble. It works as an activating panel at an electrical motor [3,4]. Position "on" is to activate a servo motor. The "Off" signal is zeroing the electric current of an electric motor. Thus, the raindrop is the activator. Due to the physical properties of the rain drop is a good conductor. It makes sense to activate an actuator. Figure 2 illustrates a raindrop sensor.

Fig 2. Raindrop sensor.

Bending stress to a structure is always due to an effect of external stress that applies to its frame. It works on the body due to external loading [4,5]. For instance, stress is the ratio of internal force over an area. Normal stress σ_n is the internal effect in which a force acts in a normal direction and perpendicular to the normal area. Empirically, the stress is at equation 1 below,

$$\sigma_n = \frac{P}{A} \quad (1)$$

Thus, normal stress σ_n demonstrates its effect at normal direction N/m^2. P is an external load N. A is active area m^2. Shear stress τ is stress in the direction in which it attaches to a normal area. It works coincided as a pairing of normal stress. It is apparent as loading equilibrium. Loading equilibrium is a pair in which external loading is proportional to internal force at a rigid body [5,6]. Equation 2 shows shear stress,

$$\tau = \frac{F}{A} \quad [2]$$

Thus, the τ represents shear stress. P is external load. Then, A is an effective area.

The frame design applies safety factors. It step to ensure size and its structure are safe.

Safety factor (SF) are values that important for evaluation to parts or structure of the engine. It show depend on loading types and its direction as well as material [5-9]: refers to yield stress 1.25–1.5 (under control), 1.5–2.0 are to kinds of material. The normal to specific loads is at range of 2.0–2.5. Thus, the range 2.5–3.0 is for un-specific material and non-testing material as well as its application to average loading. Range 3.0–4.5 is unspecific. Dynamic loading applies 1-5, 3-5 (shock loading) dan loading to fracture (2-5). Those criteria have also been studied by previous researchers [7,8].

2. METHODOLOGY

Figure 3 illustrates the investigation method.

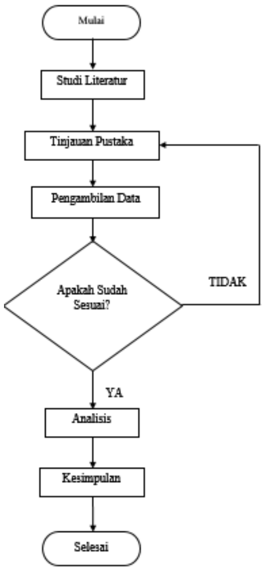
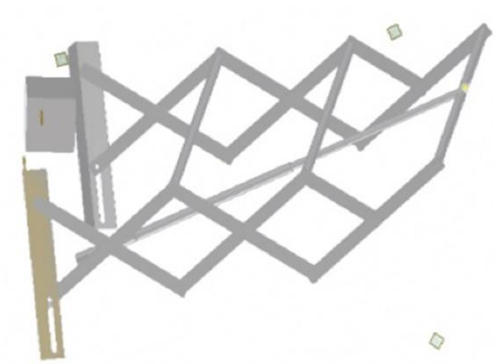
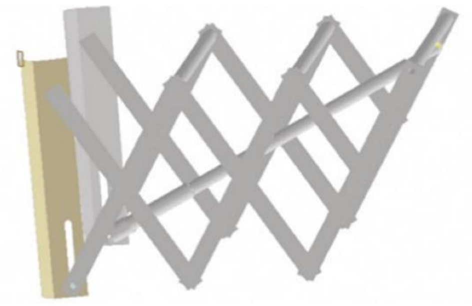


Fig 3. Investigation method.

The frame strength simulates strong enough from the loading and pursue alike normal condition. Loads simulation applies Software Autodesk Fusion 360 deploys to obtain the strength of the frame by investigation under static loads. Figure 4 demonstrates the frame design of the folding hanger. In which, those parts support 15 aluminum hollow bars. The pinion hinges frame to the fifteen aluminum bars.



a. An expanded stage of frame visually.



b. Folding stage of frame visually.

Fig 4. A folding frame at different positions: (a) an expanded frame visual and (b) a folding frame visual.

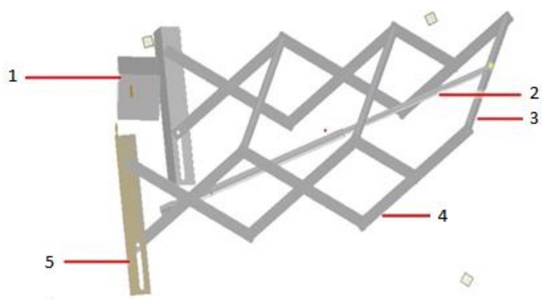


Fig 5. Design of folding hanger.

The hanger design is illustrated in Figure 5. Those parts apply sensors module (1), linear actuator (2), hollow pipe (3), aluminum bar (4), and Carnal *L*. The connecting bars are still hinges. The joining type is to support the expansion-folding. The frame load is overall to 12 kg (117N). Further, the hanger frame made from aluminum and steel. Both materials are pick up for strong frame. It step is illustrated in Figure 6.

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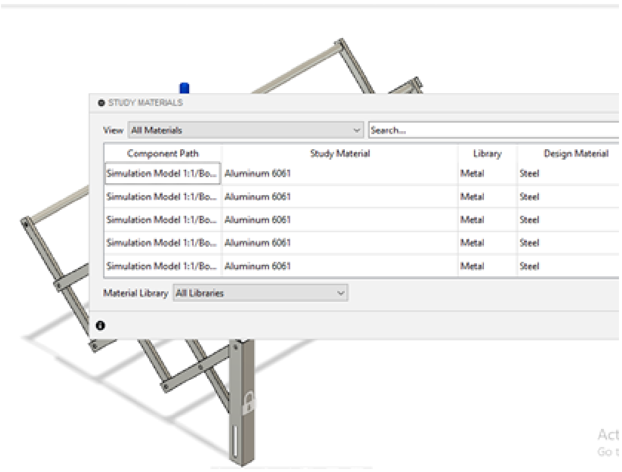

Figure 6. The step of the material chosen at software Autodesk Fusion 360.

The positions of loads give the load-impact to structure. The simulation of the loads of structure is shown on Figure 7.

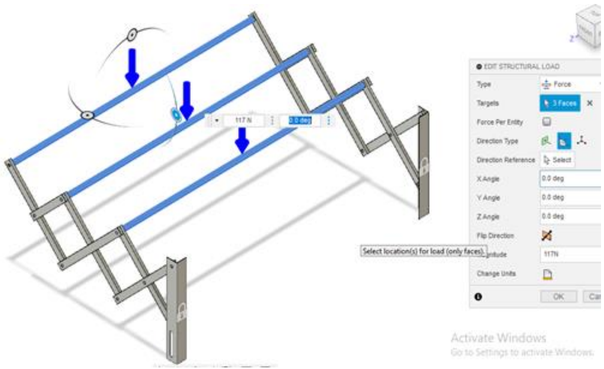

Figure 7. Simulation of loadings on a folding hanger.

Meshing is the next level in its simulation steps. It step arranges a lot of nodes which are the points of investigation. Those arrangements were similar by previous scholars [5-7]. In recent work, the meshing field expanded in more detail. Therefore, the larger area of the mesh may reveal result that is more accurate. Previous researchers use also a lot of nodes to provide the investigation more detail. Figure 8 illustrates the meshing plan for the study.

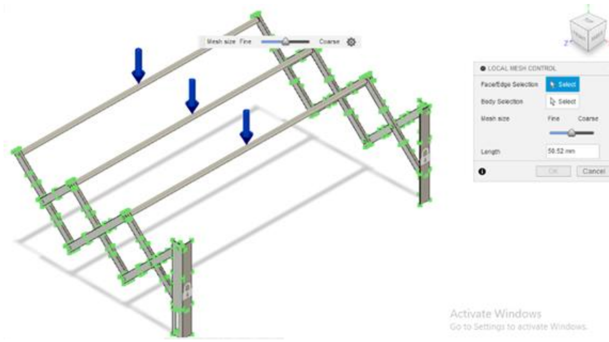

Figure 8. Meshing area to the frame of the folding hanger.

3. RESULT AND DISCUSSION

The loads simulation explains Safety Factor, Von Misses Stress, Strain, and Displacement, respectively. Then, those reveal the strength of the folding hanger structure.

3.1. Safety factor

Safety factors is as known as the values for checking the safety of the structure. It can explain that the structure frame can support the wet clothes. Figure 9 shows the results of the simulation. The bar at the wall reveals 2.038 and the farthest bar to 6. Those values show that the failure effect might appear to a bar at wall to be more at the next bar. Further, it method also demonstrated by previous scholars [7].

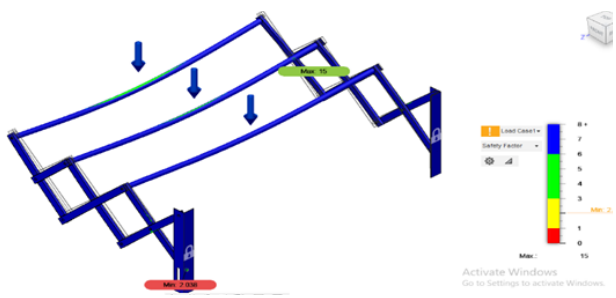

Figure 9. Safety factors of simulation.

3.2. Von Misses Stress

Stresses of the frame structure are as shown in Figure 10. Those distributions reveal some the potential loads at the folding hanger. The investigation applies the Von Messes Stress analysis procedure. That is, the zeroing is still at the wall as well as 134.9 Mpa to the farthest bar. The Von Misses method obtains the principal stresses. Further, the previous researchers also demonstrated it [6-8].

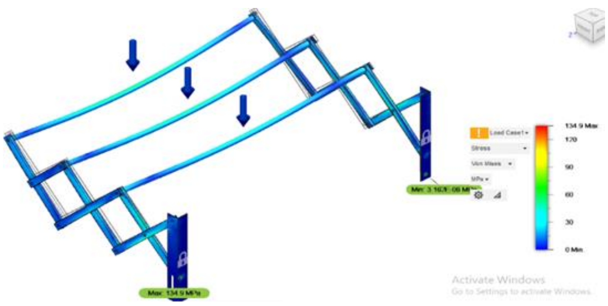

Fig 10. Stresses analyzed by applying Von Misses.

Normal stress performs principal stress in which it can reveal the primary stresses. Those stresses appears created the best impact to frame. Figure 11 shows normal stress σ_x at *x* direction about from minus 148.7 to 89.54 Mpa.

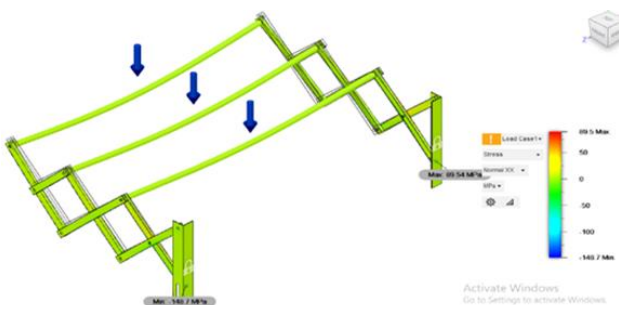

Fig 11. Normal stresses at *x* direction.

Figure 12 obtains the normal stresses in the *y* direction. Stress σ_y obtained from minus 54.2 Mpa and rose to 41.6 Mpa. Figure 13 reveals the normal stresses in *z* direction. Those stresses detect to -63.59 Mpa and increase to 57.87 Mpa.

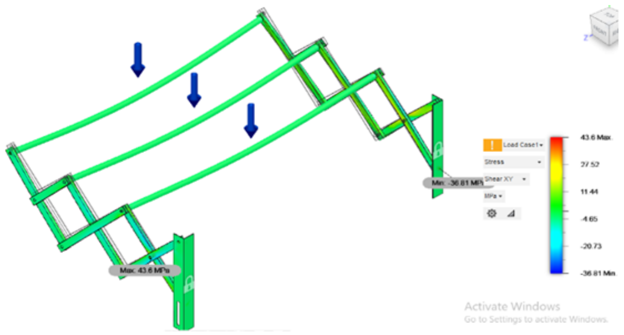

Figure 12. The normal stresses at *y* direction.

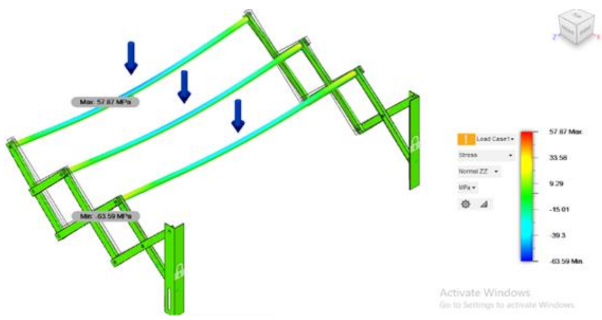

Figure 13. The normal stresses at y direction *z*.

3.3. Strain

Shear stresses can reveal the structure loading. It also assists in studying the structure during withstand from the external loading. The physic of strain is the ratio of expanded length to initial length. Figure 14 shows the strain investigation of the hanging frame. The zeroing is still at the wall and the maximum strain to 0.0021 Mpa. It is at the farthest bar. Those data explain that the bar deformation can be higher at the farthest bar.

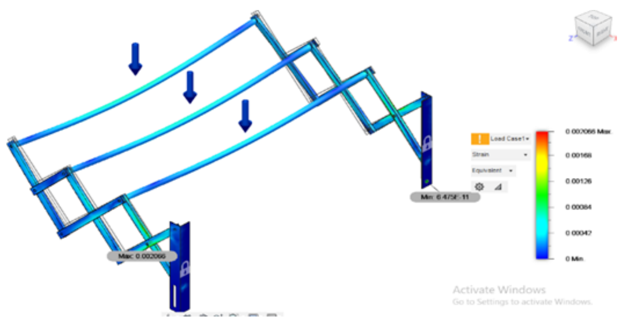

Figure 14. The strain distribution at *y* direction.

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3.4. Displacement

Displacement presents the plastic deformation phenomena at the frame structure due to external force. Thus, its degree shows that the level of deformation depends on force. In which its magnitude and direction deform the frame structure significantly. Further, the physics material contributes to the structure for survival from deformation. Figure 15 shows the displacement location at hanger frames. Thus, the *zeroing* still occurs near the wall and rises to the optimum 11.86 mm. The method has also been at previous studies [7-10].

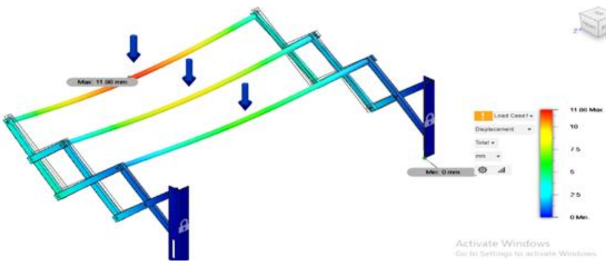

Figure 15. Displacements occur to the frame at the *x*-*y* plane.

Data summary are at Table 1. Accordingly, the risks reported details by the physic values. Then, the improvement of design can enhance the frame strength. Further, its location and dimension can obtain the failure risk at the frame structure.

Table 1. Data of simulation at the frame hanger.

Factors	Values
Safety Factor	2.038 - 6
Von Misses Stress	134.9 MPa
Normal stresses at x direction	Min -148.7 MPa Max 89.54 MPa
Normal stresses at y direction	Min -54.21 MPa Max 41.6 MPa
Normal stresses at z direction	Min -63.59 MPa Max 57.87 MPa
Shear stresses at xy-plane	Min -36.81 MPa Max 43.6 MPa
Strain	Max 0.002066
Displacement	Max 11.86 mm

CONCLUSION

The previous discussions can be concluded below, Simulation of loading to the folding hanger shows the values of safety number are low at the wall and rise at the next bar. Therefore, it will survive while hanging the wet clothes. Normal stress gives the best impact to the frame in *y* direction. Displacement occurs less than fifteen. Those data reveal the structure is safe at local load and no dynamic load.

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