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by Sumar Hadi Suryo

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Stress Analysis on the "C" 390F Excavator Link Bucket Using Finite Element Method

Sumar Hadi Suryo[a*], Raditya Irfan Ardiyanto[b], Ari Teliti Wilarsati[c], Bambang Yunianto[d]

[a,b,c,d]*Diponegoro University, Jl. Prof. Sudharto, S, 50275, Semarang, Indonesia*

[a]*Email: sumarhs.undip@gmail.com*

[b]*Email: radityairfn@students.undip.ac.id*

[c]*Email: ariyaelluciancain@gmail.com*

[d]*Email: b_yunianto@undip.ac.id*

Abstract

As technology evolves, infrastructure technology is also an important part of the country's economic growth. Since 1925, "C" excavator has been assisting producers worldwide by making progress that drives positive change. Excavators are heavy equipment and are usually used for excavationsThe commonly used operation Excavator, all coordinated from the arm; boom cylinder and buckets. In this study discussing the excavator stress analysis of excavator bucket link to determine the safety factor, the excavator bucket link is a "C" 390F link bucket. The stress analysis process on excavator link buckets uses manual calculations. The method that involves determining the material type IS 2062 steel plate. A static linear calculation analysis using element method up to see the maximum stress occurring in the 5-point excavator link bucket style, acquired vonMises voltage value of 52.11 MPa. Maximum breakout force at the angle of 30 ° position style.

Keywords: Bucket link excavator; Finite Element Method.

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* Corresponding author.

1. Introduction

Hydraulic Excavator comes from the most widely used earthmoving equipment in the construction and mining industry, and they will continue to play an important role among highway vehicles in the coming year [1]. Excavators are heavy equipment and are usually used for excavationsThe commonly used operation Excavator, all coordinated from the arm; boom cylinder and buckets Due to the high level of skill required for coordinated operation of the manipulator system, an efficient excavator operation is not an easy task. The automated digging system can help less experienced operators to accomplish the tasks given in an efficient time with acceptable quality of work [2]. This section often has a deflection that results in direct alignment with different digging fields. Therefore the mechanical properties of the excavator link bucket must be strong, hard and wear-resistant. However, besides that, an excavator link bucket needs to be replaced after a certain working period that leads to increased operational costs [3].Therefore, the authors did a design optimization on the excavator link bucket to discuss one of the problems in the excavator bucket and analyze the reaction style at digging. In this research design designing using the approach of the original design. For material properties that will be input in the simulation, the authors refer to the research conducted by R.B. Sarode and S.S.Sarawade explained that the excavator link bucket material analyzed was 2062 [4].In this simulation used static linear method for FEM process.

2. Material and Methodology

2.1 dentification material

In this study, the determination of bucket link excavator material used refers to R.B. Sarode and S.S.Sarawade discussing the material characterization of excavator link buckets IS 2062 [4]. The data can be seen in table 1 as follows.

Table 1: Material characteristic data IS 2062 [4].

No.	Material characteristic data IS 2062	Value
1	Modulus Elactisity (E)	2000000 Pa
2	Poisson Ratio	0.30
3	Density	7850 Kg/m^3
4	Yield Tensile Strength	250 MPa
5	Ultimate Tensile Strength	410 MPa

2.1 Flowchart

In this study there were steps of static linear simulation and excavator link bucket optimization referring to Figure 1 flowchart.

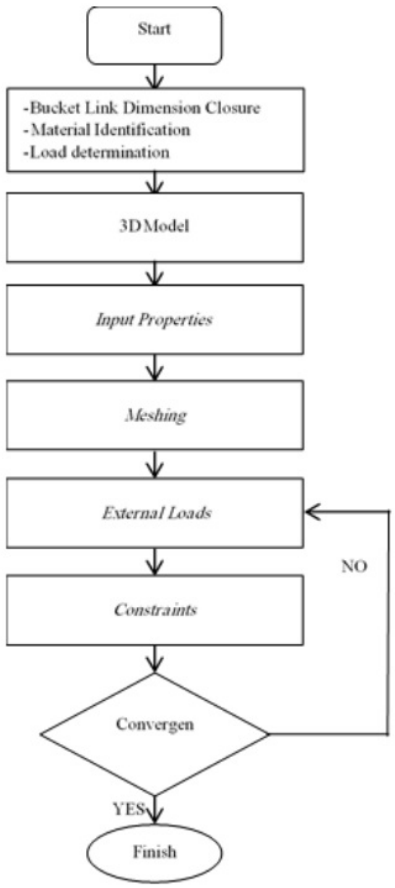

Figure 1: Flowchart

2.2 Modelling 3D Bucket Link Excavator

In this research the object used to be analyzed is the “C” 390F excavator bucket link. The CAD software used to model is Solidworks 2016. The design result using Solidworks 2016 can be seen in Figure 2 below.

Figure 2: Design bucket link excavator

2.3 Modelling linear static

Simulation of static structure loading analysis on bucket link excavator is done to know the maximum stress and deflection that is owned by a model of the bucket link excavator in certain conditions. In this research, using software finite element analysis (FEA) Altair Hyperworks 2019 to conduct analysis simulation of static-loading (static structural analysis).Static linear modeling is described in Figure 3.

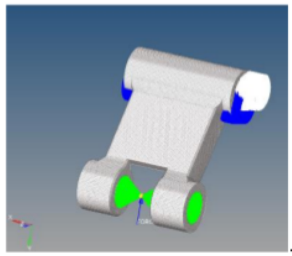

Figure 3: Modelling linear static on bucket link excavator

3. Result and Discussion

3.1 Calculation manual of linear static

Style calculations on 0° breakout force configuration are shown in Table 2.

Table 2: Static force on bucket link 0° breakout force configuration

Force	Value(kN)	Angle	SIN	COS	X	Y
BA4	364,8	25,28	0,43	0,90	329,86	155,79
BA11	1630,73	109,97	0,94	-0,34	-556,94	1532,68

Style calculations on 30° breakout force configuration are shown in Table 3.

Table 3: Static force on bucket link 30° breakout force configuration

Force	Value(kN)	Angle	SIN	COS	X	Y
BA4	364,80	38,23	0,62	0,79	286,56	225,75
BA11	1623,62	72,12	0,95	0,31	498,49	1545,21

Style calculations on 45° breakout force configuration are shown in Table 4.

Table 4: Static force on bucket link 45° breakout force configuration

Force	Value(kN)	Angle	SIN	COS	X	Y
BA4	364,80	69,10	0,93	0,36	130,14	340,80
BA11	1636,33	49,48	0,76	0,65	1063,14	1243,90

Style calculations on 60° breakout force configuration are shown in Table 5.

Table 5: Static force on bucket link 60° Breakout force configuration

Force	Value(kN)	Angle	SIN	COS	X	Y
BA4	364,80	75,20	0,97	0,26	93,19	352,70
BA11	1637,59	22,58	0,38	0,92	1512,06	628,79

Style calculations on 80° breakout force configuration are shown in Table 6.

Table 6: Static force on bucket link 90° breakout force configuration

Force	Value(kN)	Angle	SIN	COS	X	Y
BA4	364,80	45,83	0,72	0,70	254,19	261,66
BA11	1636,32	17,72	0,30	0,95	1558,68	498,04

3.2 Result Simulation Linear Static

To find out if the material used does not suffer failure and can be optimized to do static linear analysis to obtain the value of von Mises from a design with material obtained from the identification results. Table 7 shows the results of the vonMises of five position variations based on the FEM analysis with a maximum element size of 10mm each bucket link excavator, following the results of the von Mises of every variation of the position.

Table 7: Result Analyzed FEM

Derajat	von Mises [MPa]
0	51,28
30	52,11
45	50,16
60	49,2
90	48,48

3.3 Result Converged Test

To determine the appropriate number of elements to be continued with the optimization process is carried out the convergence test in advance which can be seen in table 8 until the results are converging on each increment of the element by performing a mesh repair gradually and in certain areas.

Table 8: Value maximum stress von Mises each element

No	Maximum Stress (MPa)	Maximum Element Size (mm)
1	51,94	2
2	51.97	4
3	52,04	6
4	52,28	8
5	52,11	10

Based on the variation in table 3 element increase, the more elements increase, the stress that occurs also increases, so that it can be concluded that the elements show already convergent. The study used the most elements in the 4th convergence test result of 52.28 Mpa. The following are the stress distribution images that occur on the bucket link excavator.

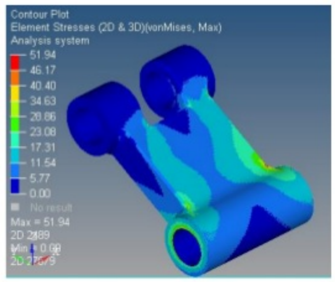

Figure 4: Value von Mises converged test 1

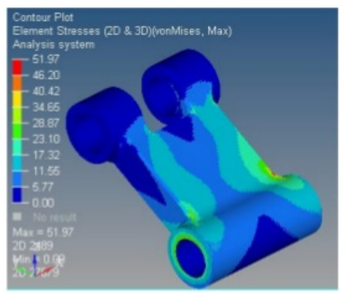

Figure 5: Value von Mises converged test 2

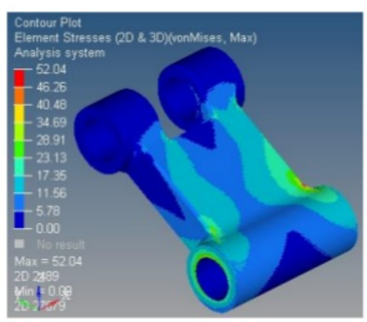

Figure 6: Value von Mises converged test 3

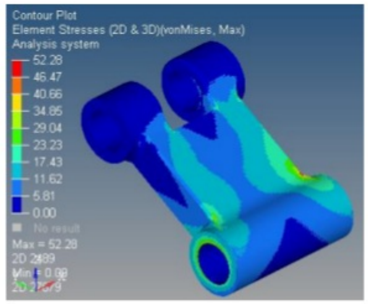

Figure 7: Value von Mises converged test 4

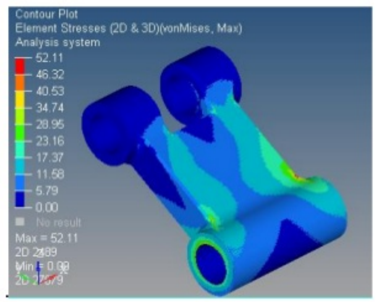

Figure 8: Value von Mises converged test 5

3.4 Calculation of Safety Factor

The results of the stress von Mises of five position variations based on FEM analysis with a maximum element size of 10 mm each bucket link excavator get the highest number in the position 30^0 is 52.11 MPa is still below the yield strength value of 2062 is 250 MPa.Then the safety factor bucket link as follows:

$$\text{Factor of safety} = \frac{250\ \text{MPa}}{52{,}11\ \text{MPa}}$$

Safety factor bucket link obtained at 4.7 which is still in safe range number so there is no material failure [4].

4. Conclusion

After the static linear simulation is performed using the element method until the maximum stress value is von Misses at a position of 30° to 52.28 Mpa. Load determination as a limit condition of maximum breakout force configuration is at 30° to 52.28 Mpa. The safety factor is obtained at 4.7 which can be said the value of the stress that occurs in both designs, although it tends to rise but is still declared safe.If compared between five variations of the configuration position with the maximum yield of 52.11 Mpa at 30° while the minimum is

49.48 MPA at 90°.

5. Limitations of the study

Although the current study uses design approaches from original design, simulations using Static linear modeling, standard-based style configurations with five position variations, the Bucket link excavator manufacturing production process uses Las for its connectors but for the FEM analysis is isotropic.In the current results, it is expected that it will be possible to conduct further studies.

6. Recommendations

Currently recommended for the importance of regularly research. The result of this study can also be used a reference for stress analysis excavator bucket link.

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