SIMETRIKAL
Journal of Engineering and Technology

# Analysis Of Energy Absorption In Crash Box With Variation Of Trigger Hole Cyrcle Model Using Experimental Tests

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**Abstract.** Traffic accidents kill people every day and a large number of people are injured or killed in car accidents, safety in the automotive industry is being researched extensively. Every year, more than 1.2 million people are killed and ten million are injured in traffic accidents worldwide. Crash boxes as passive safety in vehicles continue to be modified to increase their ability to absorb energy. In this research, 3 crash box models were designed with a frusta model using Aluminum AA 6061-T4. Modeling was carried out using Solidwork software and testing using a Universal Testing Machine. From Experimental test results show that the Frusta 1 hole model crash box has the largest energy absorption capacity compared to other models, 1132.8 J with a force of 118 kN at a displacement of 28.32 mm. This shows that providing the Frusta model with a hole as a trigger provides an increase in the crash box's ability to absorb energy.

**Keyword:** Crash box, trigger holes, Solidwork,Aluminium, Universal Testing Machine.

***Abstrak.*** *Kecelakaan lalu lintas membunuh orang setiap hari dan sejumlah besar orang terluka atau tewas dalam kecelakaan mobil, keselamatan dalam industri otomotif sedang diteliti secara ekstensif. Setiap tahun, lebih dari 1,2 juta orang tewas dan sepuluh juta luka-luka dalam kecelakaan lalu lintas di seluruh dunia. Crash box sebagai pengaman pasif pada kendaraan terus di modifakasi untuk meningkatkan kemampuannya dalam menyerap energi.Pada penelitian ini di rancang 3 model crash box dengan model frusta menggunakan Aluminium AA 6061-T4.Pemodelan di lakukan menggunakan software Solidwork dan pengujian menggunakan Universal Testing Machine.Dari hasil pengujian eksperimental menunjukkan bahwa crash box model Frusta 1 hole mempunyai daya serap energi terbesar dibandingkan model lainnya 1132.8 J dengan gaya 118 kN pada displacement 28.32 mm.Hal ini menunjukkan bahwa pemberian model frusta dengan hole sebagai trigger nya memberikan peningkatan kemampuan crash box dalam menyerapenergi.*

**Kata Kunci:** *Crash box,* lubang pemicu, Solidwork, Aluminium, Mesin Uji Universal

Received 23 May 2024 | Revised 13 June 2024 | Accepted 31 July 2024

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Journal Homepage: https://talenta.usu.ac.id/index.php/jet

## 1 Introduction

In the midst of increasingly advanced developments in automotive technology, we are required to innovate, be creative and develop something new, especially the design of motorized vehicles (motorbikes, cars, etc.) which requires continuous innovation to create efficient security [1]. Because nowadays, traffic accidents kill people every day and a large number of people are injured or killed in car accidents, safety in the automotive industry is being researched extensively. Every year, more than 1.2 million people are killed and ten million are injured in traffic accidents worldwide. These numbers pose a significant problem for public health, trauma care, and traffic safety officials [2].

Many factors cause accidents, such as human factors, inappropriate speed, ignoring safety protective equipment such as seat belts, driving while drinking alcohol and drugs. All of these risks can create a brutal accident during a frontal collision. To protect passengers in the event of a collision several approaches were chosen to increase the level of safety by using more safety devices such as air bags and anti-lock brake systems (ABS) [3].

Several types of security have been created which are expected to minimize damage due to accidents, which are usually called passive security systems [4]. In the past, bumpers only functioned to absorb impacts [5].As technology advances, more functions have been developed for bumpers to absorb impacts.

The crash box is a deformation device that can be compressed while absorbing impact energy to protect other parts of the car body. The crash box is a structure that connects the front bumper of the vehicle to the front rail [6].

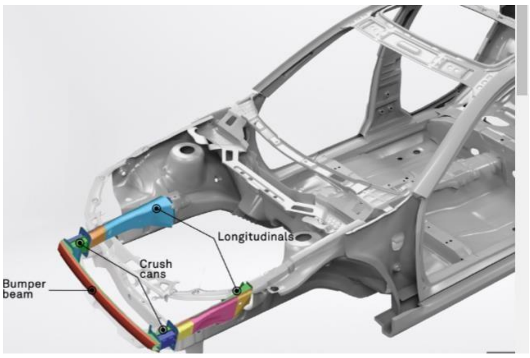


**Figure 1.** Crash Box on Car Frame [7].

This device was created to minimize damage to the vehicle's front frame and protect the passenger compartment from excessive deformation due to low-speed impacts [8]. During a high-speed crash, the crash box will crush first, reducing the impact of the impact, before the front rail absorbs most of the deformation energy [9].

Deformation is a common thing that occurs in metals, which usually occurs when metals are subjected to loading and experience changes in shape in their microstructure. In principle, the load on a deformable body is a force that acts on a solid object, causing Causative Influences which cause deformation [10]. If an object experiences deformation, analysis can be carried out in 2 ways, namely: Physical Interpretation and Geometric Analysis [11].

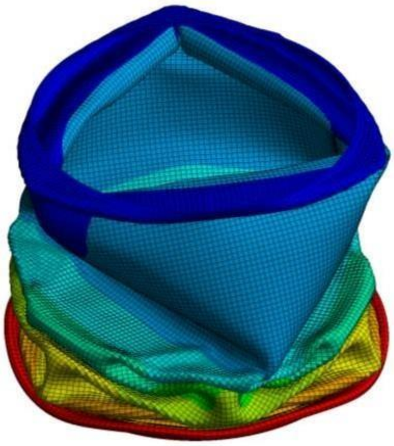

**Figure 2.** Deformation Pattern [12].

For geometric analysis, the emphasis is on determining deformation parameters by transforming changes in position into deformation parameters including translation, rotation and dilation [13]. Physical interpretation can be done using 2 types of methods, namely: Determination of Methods and Statistical Methods.

## 2 Material and Method

### 2.1 Aluminium AA 6061-T4

Aluminum is a chemical element metal with the symbol Al on the periodic table and the atomic number 13. Aluminum is not a type of heavy metal but is a third-order abundant metal with the element amounting to around 8% of the earth's surface [14]. According to observations throughout the world, aluminum is evenly used in a variety of products [15]. Aluminum is a good electrical conductor as well as a good heat conductor, because it is corrosion resistant, is a lightweight material, and is also strong. This makes it widely used as a material for high-voltagecables, aircraft bodies, and also various devices such as crash boxes in cars [16].
Aluminum is the third most abundant element in the earth's crust. This aluminum is located in aluminosilicate minerals which come from earth's crustal rocks. These rocks form clay due to natural changes and the clay contains aluminum.

**Table 1.** Mechanical characteristics AA 6061-T4 [17].

| Parameter | Value |
|---|---|
| Density | 2.7 kg/mm$^3$ |
| Poisson's ratio | 0.33 |
| Ultimate Stress | 171 MPa |
| Yield Stress | 82 MPa |
| Flow Stress | 126.5 MPa |
| Young's Modulus (E) | 68.2 GPa |

## 2.2 Crash box design

The design of the crash box that will be tested is a circular crash box with tapered corners with circular trigger variations on two sides.

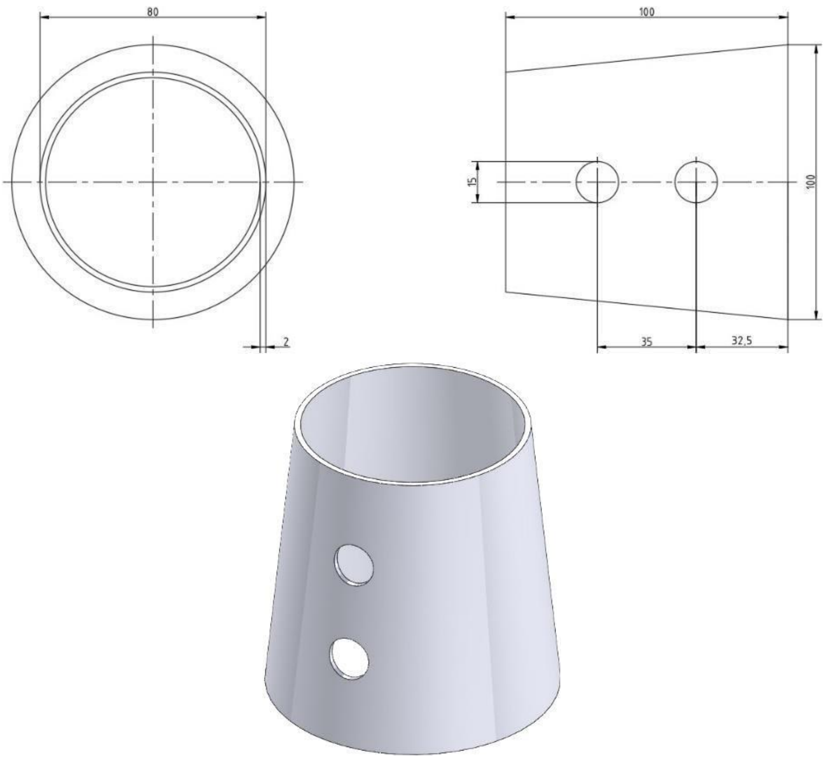


**Figure 3.** Crash box Design using SolidWork [18].

## 2.3 Experimental Test

Universal Testing Machine (UTM) is a testing tool that  functions to test the tensile stress (tensile test), compression test (compression test) and bending test (bending test) of a material inorder to determine the characteristics or how strong the material is. This tool is usually used in various industrial fields such as metal, automotive, research, plastics, rubber, composites, textiles, adhesives, petrochemicals, and others.

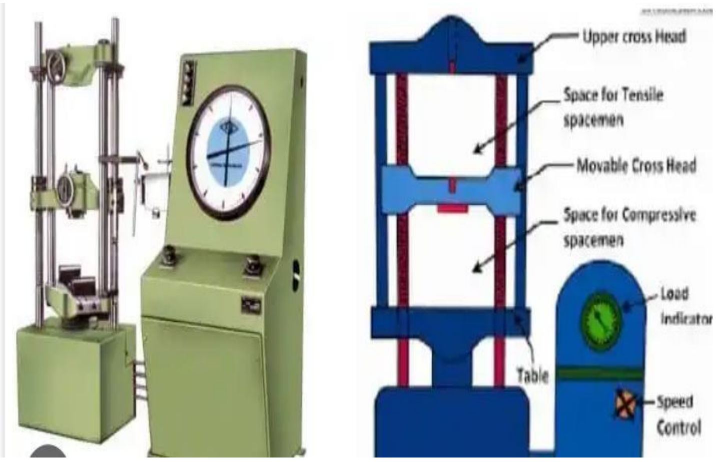


**Figure 4.** Universal Testing Machine [19].

## 3 Result and Discussion

The results of compression testing are used to identify the crash box's ability to absorb energy and resist deformation when compressive forces are applied. This experimental data is then compared with simulation results to validate the simulation model and understand how well the model represents the actual behavior of the crash box [20].

The following is a comparison chart between Force and Dispalcements Crash Boxes with trigger holes on both sides.

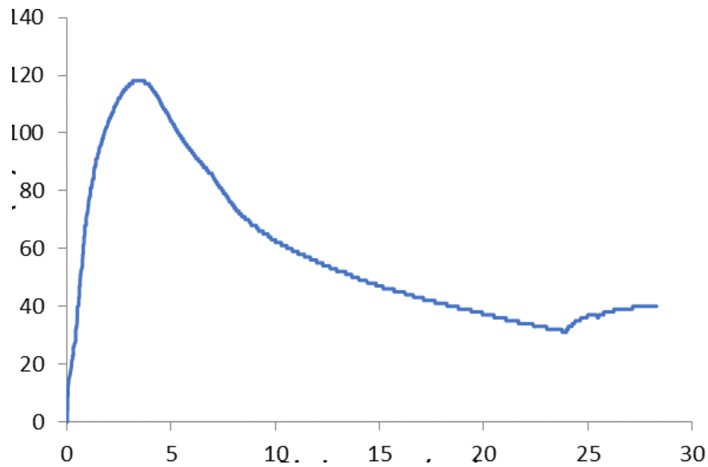


**Figure 5.** Graph of the relationship between force ratio and displacement

The picture above shows the strength of the crash box as the pressure applied increases. From this graph we can also see how the crash box experiences deformation as the pressure increases. The peak point on the graph shows the point where the crash box reaches its maximum strength,with the max force value reaching 118 kN and the maximum deformation value reaches 28.32mm.

From the results of this experiment we can find out how much energy can be absorbed by a crash box with 1 trigger hole, which is shown in the graphic image below.

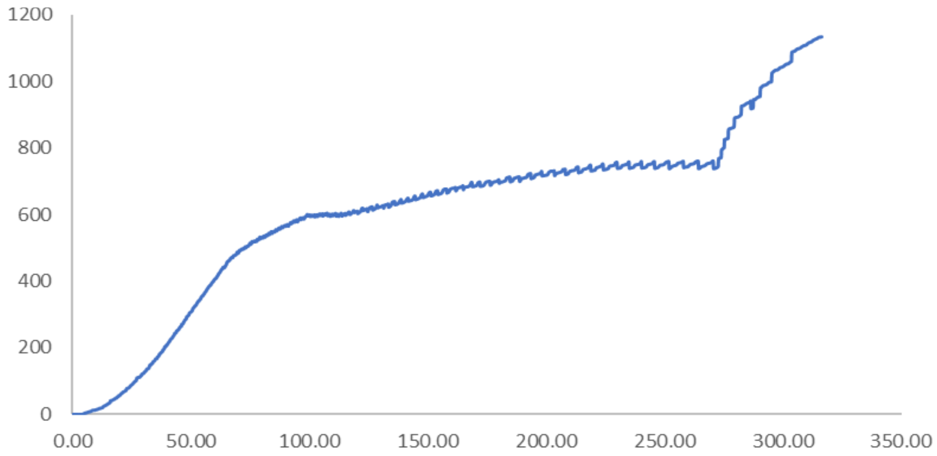


**Figure 6.** Arbsorption energy graph for crash box 1 hole

The peak point in the graph above shows the maximum energy that can be absorbed by the crash box with a value of 1132.8 J in 315 seconds.

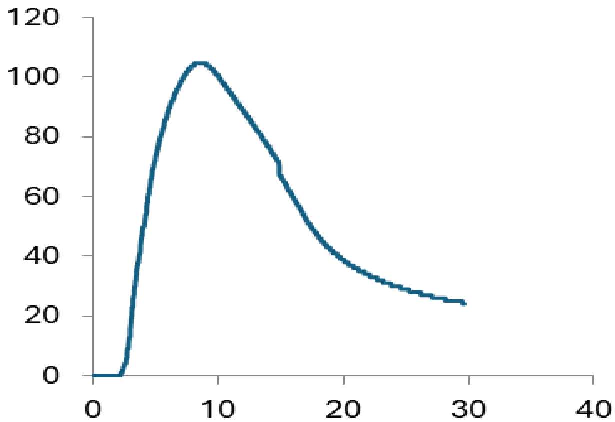


**Figure 7.** Graph of the relationship between force reaction and displacement of 2 holes

The peak point on this graph shows where the crash box reaches its strongest point or reaches its maximum strength. With a max force value reaching 105kN and a maximum deformation value reaching 29.61mm.

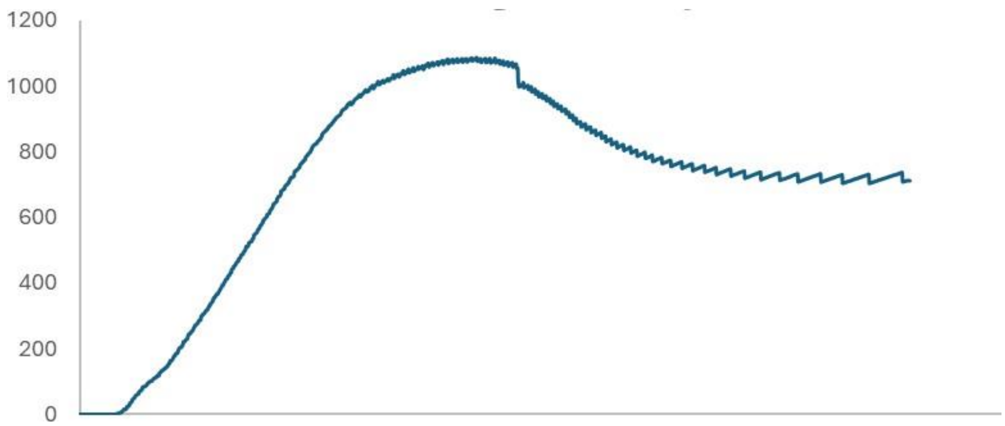


**Figure 8.** Crash box absorption energy graph with 2 holes

The peak point in the graph above shows the maximum energy that can be absorbed by the crash box with a value of 1085 J in 314.89 seconds. Next is a graph of a crash box with three trigger holes on both sides.

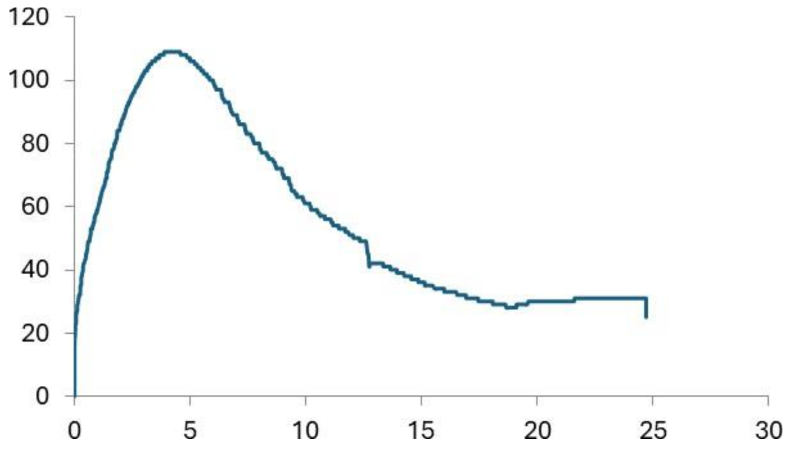


**Figure 9.** Graph of the relationship between force reaction and displacement for 3 holes

The peak point on this graph shows the maximum force of the crash box with three trigger holes on both sides, with a max force value of 109kN and a maximum value of 24.73mm.

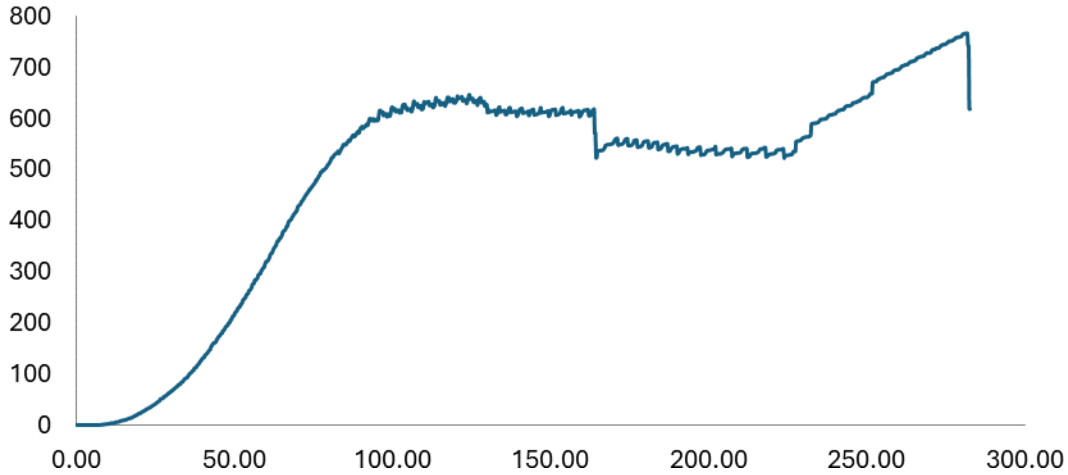


**Figure 10.** Crash box absorption energy graph with 3 trigger holes

The peak point in the graph above shows the maximum energy that can be absorbed by the crash box with a value of 766.63 j in 282.47 seconds .

## 4 Conclussion

The experimental method was used to evaluate crash box test items with various circular models, 1 hole, 2 holes and 3 holes. Modeling using Solidwork and Experimental Methods on equipment with a universal test capacity of 1000 kN and a speed of 5 mm/minute. The results ofthe two tests show that the circle model with holes has the highest energy absorption, namely 1132.8 J in 315 seconds.

Based on the values obtained, it can be seen that adding a hole to the crash box model as a trigger can increase the crash box's ability to absorb energy. The energy absorption value of the crash box is proportional to the maximum force value, namely 118 kN and the maximum deformation value reaches 28.32mm. Buckling can be triggered by the crash box holes, althoughthere is a limit of three holes.

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