# Analysis of impact duration from Charpy impact signal

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**ABSTRACT** – This paper presents the reviews on impact duration from impact signal due to Charpy test. Charpy impact test is conducted at different material with different thickness but at the same of striker velocity. Impact signal is obtained from strain gauge that has been installed to striker and connected to high frequency data acquisition system. The signal is then analyzed by using software of SoMat eDaQ to identify the time period during impact occurs on materials before fractured. The impact duration from experiment is correlated and compared to the theory or previous study. The result from experiment indicates that Aluminium 6061-T6 has higher impact duration compared to Carbon steel 1050 and it was increased with thickness.

## 1. INTRODUCTION

Impact on a body is happens in very short period of time with large force is imposed. In impact case, crashworthiness an aspect is always becomes major attention in automotive industry because its ability to protect passengers from harmful during crash event. Vehicle that made from material with high impact duration is safer since there are an extended crush space for car protection which can reduce the damage effect to car structure and occupant.

Some ways may be apply in improving the safety condition of vehicles. Samer et. al [1] recommends that improvements on the security level of vehicle structure need to be achieved in order to enhanced the energy absorption capabilities of vehicles. A good and high quality of energy absorber should be designed to dissipate the impact energy irreversibly via plastic deformation of metallic structure. Most of the energy absorbers were developed using metallic thin-walled structure since they tends to deform plastically due to elasticplastic behavior [2].

Charpy impact test is widely applied for many years in engineering field since it is easy to conduct, reliability and low cost. This test usually implemented to study the failure behaviour and investigate the toughness of a material. Some aspects may influence the failure behaviour of Charpy impact such as temperature, notch position, material properties, impact velocity and others.

According to Jang et al. [3], experimental and numerical studies were performed to examine the effects of notch position on the failure behaviour and energy absorption when the Charpy V-notch impact test is made at 1ºC. Studied by Shende et al. [4] claims ductile-to-brittle transition curves may be obtained when the results of a number of tests presented in different temperatures are plotted. When the temperature is reduced through the transition range, the fracture surface changes from one having a 'fibrous' or 'silky' appearance with much distortion at the sides, to one of completely crystalline appearance with negligible distortion.

The main purpose of this study is to compare the impact duration obtained from Charpy impact strain signal with theory. Based on Ali et al. [5], the total impact duration, $t_0$ can be calculated from the formula shown as follow.

$$t_o = 2.94\left(\frac{5}{4Mn^1 v^{1/2}}\right)^{2/5} \quad (1)$$

Where total mass, $M = \frac{1}{m_1} + \frac{1}{m_2}$

$m_1$ = mass of impactor and $m_2$ = mass of specimen

$v$ = velocity during impact

and $n^1 = \frac{4\sqrt{R_1}}{3\pi(k_1 + k_2)}$

Where $k_1 = \frac{1-v_1{}^2}{\pi E_1}$ and $k_2 = \frac{1-v_2{}^2}{\pi E_2}$

$v_1$ *and* $v_2$ = poisson ratio of striker and specimen, respectively. $E_1$ *and* $E_2$ = Young Modulus for striker and specimen, respectively.

$R_1$ = radius of a spherical impactor

## 2. METHODOLOGY

The geometry of Charpy specimen is prepared according to standard in ASTM E23. In this study, the materials that have been used for Charpy impact test are Aluminium 6061-T6 and Carbon steel 1050. Table 1 shows the material properties for both specimens. The impactor of machine is made from steel and assumed to be rigid body since it is not deformable. Material properties for the impactor are 210 GPa (Young modulus), 7.86x10$^3$ kg/m$^3$ (density) and 0.32 (Poisson's ratio). Other equipment such as strain gauge and data acquisition system are used in order to collect the impact signal. V-notch Charpy impact test is conducted at 5.18 m/s of striker velocity with different thickness of material (5 mm and 10 mm).

Table 1 Properties of specimens[6].

| Properties | Aluminium 6061-T6 | Carbon steel 1050 |
|---|---|---|
| Density (kg/m$^3$) | 2700 | 7860 |
| Young's Modulus (GPa) | 70 | 210 |
| Poisson's Ratio | 0.35 | 0.32 |
| Yield strength (MPa) | 292 | 660 |
| Ultimate strength (MPa) | 328 | 675 |

## 3. RESULT AND DISCUSSION

Obtained signal from Charpy test is analyzed by plotting a graph of strain versus time. The graphs are shown as below.

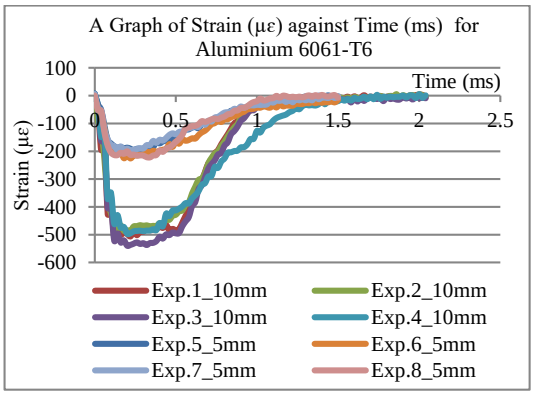


Figure 1: Distribution of strain (με) against time (ms) for Aluminium 6061-T6 at different thickness.

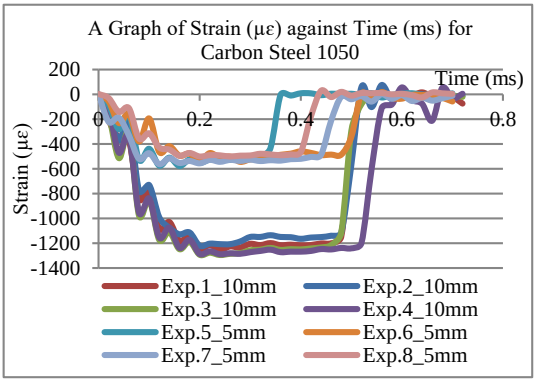


Figure 2: Distribution of strain (με) against time (ms) for Carbon Steel 1050 at different thickness.

Based on the graphs above, the range of impact duration for Aluminium 6061-T6 occurs between 1.1 ms to 1.5 ms and 0.38 ms to 0.60 ms for Carbon steel 1050. For both materials, the highest impact duration was found at the thicker specimen which is at 10 mm. The average impact duration for these specimens is shown in Table 2.

Aluminium 6061-T6 has higher average impact duration compared to Carbon steel 1050. It is because aluminium is more ductile than steel thus it has more elastic and plastic region in stress-strain curve before fracture. Impact duration from theory is calculated by using equation (1) and the comparison of impact duration between experiment and theory is summarized in Table 3.

Table 2 Average impact duration with different thickness (experiment).

| Thickness (mm) | Impact Duration (ms) | |
|---|---|---|
| | Aluminium 6061-T6 | Carbon Steel 1050 |
| 5 | 1.15 | 0.49 |
| 10 | 1.43 | 0.55 |

Table 3 Impact duration for experiment and theory.

| Material | Impact Duration (ms) | | | |
|---|---|---|---|---|
| | Experiment | | Theory | |
| | 5mm | 10mm | 5mm | 10mm |
| Aluminium 6061-T6 | 1.15 | 1.43 | 0.0496 | 0.0654 |
| Carbon Steel 1050 | 0.49 | 0.55 | 0.0597 | 0.0764 |

## 4. CONCLUSION

The impact duration for Aluminium 6061-T6 and Carbon steel 1050 were identified from both experiment and theory. Experimental result shows that impact duration increased with the increased of specimen thickness. Aluminium 6061-T6 exhibits large impact duration compared to Carbon steel 1050.

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