CORRELATION OF CHARPY IMPACT BETWEEN WELDED AND UNWELDED MATERIAL

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical And Manufacturing Engineering Technology (Automotive Technology) with Honours

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2022

DECLARATION

I declare that this Choose an item. entitled “Correlation Of Charpy Impact Between Welded And Unwelded Material” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : MUHAMMAD HAFIZIN ARIF BIN TAJUDIN

Date : 11th June 2023

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical and Manufacturing Engineering Technology (Automotive Technology) with Honours.

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DEDICATION

Every challenging work, needs self efforts, as well as guidannce of elders especially those who were very close to our heart. My humble effort I dedicated to my biggest supporter, my sweet, caring, loving parents,Mr. Tajudin bin Yusof & Mrs. Huzaimah binti Amirudin. Whose affection, love, encouragement and prays of day and night make me able to get success and honor. Not to forget my beloved siblings, Fatin Liyana, Amirah Fatanah, Idayu Farahin and Amirul Aiman for being helpful and supportive towards this journey, from start till end of this study. And finally, I would proudly dedicated to my life-sharing partner, Adibah Nur Athirah for expressing abundance of opinion and informative idea towards this thesis study.

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ABSTRACT

This thesis investigates the effects of different parameters which is type of materials and material thickness on the results of energy absorption and impact strain signal behaviours due to Charpy impact test. Findings from Charpy impact test was used to investigate the correlation of absorb energy between welded and unwelded (based) material. This thesis also analyze the the study of impact signal between the welded and unwelded material. Hence, covers the study of material thickness effect on energy absorbtion. Mild steel is the common type of steel that used in automotive industry because of its material characteristics and low-cost manufacturing production. Due to its massive usage in the automobile parts, this steel must be design in variety ways to meet both crash safety and performance needs. Recently, the number of accident on highway has been increased due to loss of structure integrity to withstand high impact load. On collision, one of the concertrates matter is the joint of automobile parts especially body chasis which joint together by the welding process. This give an idea on how weld zone has effect the base material after the application of welding process and what is the effect of impact energy on weld zone compared to the base material. To better understand about this phenomenon, this study has to be done between two types of specimens which is welded material and unwelded material. These specimens must be test with the Charpy impact test, also known as the Charpy V-notch test to measure the amount of energy absorbed by the specimen during fracture. By the additional application of strain gauge, we can correlate the energy absorbed with strain energy by installing strain gauge to striker hammer that connected to data acquisition system (SOMAT eDAQ). Through the test we can also visualize the difference of impact signal between the welded and the unwelded material. Besides that, mechanical testing of tensile test with the same material is carried out to obtain the material behavior and to identify the material properties for additional and supporting data purpose.

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ABSTRAK

Tesis ini bertujuan untuk menyiasat kesan parameter yang berbeza iaitu jenis bahan kajian dan ketebalan bahan kajian ke atas hasil penyerapan tenaga dan tindak balas isyarat terikan hentaman menggunakan ujian hentaman Charpy. Dapatan daripada kajian hentaman Charpy digunakan untuk menyiasat hubungkait serapan tenaga antara bahan yang dikimpal dan tidak dikimpal (bahan asas). Tesis ini juga menganalisis kajian isyarat hentaman antara bahan yang dikimpal dan tidak dikimpal. Justeru, mengkaji hubungan antara perbezaan ketebalan bahan terhadap penyerapan tenaga. Keluli lembut adalah jenis keluli yang biasa digunakan dalam sektor industri automotif kerana ciri-ciri bahan tersebut dan kos pengeluaran dan pembuatan yang rendah. Disebabkan penggunaannya secara meluas dalam pembinaan bahagian-bahagian kenderaan jalan raya, keluli ini mesti direka bentuk dalam pelbagai cara untuk memenuhi kedua-dua aspek dalam keperluan untuk keselamatan kemalangan dan prestasi memandu. Baru-baru ini, bilangan kemalangan di lebuh raya telah meningkat disebabkan kehilangan integriti struktur untuk menahan beban berimpak tinggi. Dalam perlanggaran, salah satu bahagian bahan yang difokuskan ialah sambungan bahagian-bahagian kereta terutamanya casis badan yang disambung menggunakan proses kimpalan. Ini memberi gambaran idea tentang bagaimana zon kimpalan memberi kesan terhadap bahan asas selepas aplikasi proses kimpalan dan apakah kesan tenaga hentaman ke atas zon kimpalan berbanding dengan bahan asas.Untuk lebih memahami fenomena ini, kajian ini perlu dilakukan antara dua jenis spesimen iaitu bahan yang dikimpal dan bahan tidak dikimpal. Spesimen ini mesti diuji dengan ujian hentaman Charpy, juga dikenali sebagai ujian takuk Charpy V untuk mengukur jumlah tenaga yang diserap oleh spesimen semasa patah. Dengan penggunaan tolok terikan, kita juga boleh menghubungkait tenaga yang diserap dengan tenaga terikan dengan memasang tolok terikan pada tukul hentaman dan disambungkan dengan sistem pemerolehan data (SOMAT eDAQ). Melalui ujian tersebut, kita juga boleh meneliti perbezaan isyarat hentaman antara bahan yang dikimpal dan yang tidak dikimpal. Selain itu, mekanikal ujian tegangan dengan bahan yang sama dijalankan untuk mendapatkan bacaan kebolehan bahan dan mengenal pasti sifat bahan untuk tujuan data tambahan dan sokongan.

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LIST OF SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS

CVN	-	Charpy V-notch
ASTM	-	American Society for Testing and Materials
SAE		Self-addressed Envelope
HAZ	-	Heat Affected Zone
ISO	-	International Organization for Standardization
PSD	-	Power Spectrum Density
PE	-	Potential Energy
KE	-	Kinetic Energy
KV		Notch Impact
SEB		Single Edge Bend
BH		Bake Hardening
IF		Interstitial Free
MA		Martensite Austenite
HSLA		High-strength Low-alloy Steel
HSS		High-strength Steel
AHSS		Advance High-strentgh Steel
TBF		TRIP Aided Banatic Ferrite
SMAW		Shielded Metal Arc Welding
FCAW		Flux Cored Arc Welding
GMAW		Gas Metal Arc Welding
GTAW		Gas Tungsten Arc Welding
MIG		Metal Inert Gas
TIG		Tungsten Inert Gas
PWHT		Post-weld Heat Treatment

SYMBOLS

A		Area
ε		Strain
E		Young Modulus

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F	Force
J	Impulse
k	Spring stiffness
M	Total mass
ms	miliseconds
v	Velocity
σ	Stress
r	Radius
m	Mass
h	Height
H	Total height
V	Knotch impact
L	Length
ΔL	Elongation
D	Diameter
c	Damper of viscous damping coefficient

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CHAPTER 1

INTRODUCTION

1.1 Background

The automotive sector is critical to the economies of developed countries. Due to the increasing worldwide rivalry, one of the primary goals in the automobile industry is low-cost manufacturing. As the least expensive of all steels and the most widely used, mild steel is the most optional alloy for an industry that's going to works with hefty amounts of metal. This is why it's so commonly used by the automotive business for chassis and body panels in every road-worthy vehicle. Mild steel has advantages over other metals and materials in the automobile industry, and its versatility is something that has a profound cost-benefit that can also be developed for future industrial usage. Concerning the recent trends in car production, the application of lightweight constructions principles is the main priority to meet customers' demands and the increased legal requirements. To meet these expectations, the application of high strength materials is regarded as one of the most promising possibilities. Mild steel not only meets a car manufacturer's desire for light-weight vehicles, but it also helps the (essential for making automobiles as fuel efficient as feasible). It is, nevertheless, quite cost effective and could be constructed in such a number of ways to meet both collision safety and performance requirements. Mild steel's elasticity does not compromise its ability to absorb the energy in the case of a collision. In terms of safety, it should go without saying that impact resistance is critical in the vehicle business. In automotive and other safety-critical industries, impact testing is a vital evaluation of a material's failure qualities and useful tool for determining a material's failure properties.

Engineers can prevent failures, develop long-lasting items, and save lives by properly testing raw materials and molded components for strength and durability. For better understanding and study of impact testing on automotive industry, Charpy Impact Test is the most commonly used test to evaluate the relative toughness of a material in a fast and economic way. The Charpy impact test was invented in 1900 by Georges Augustin Albert Charpy (1865–1945), and still in used in many industries for testing materials today. The Charpy impact test measures the energy absorbed by a standard notched specimen while breaking under an impact load which is used for determining the amount of forces that are absorbed by materials when it reaches the point of fracture. The Charpy Impact Test can be used to determine the malleability and ductility of a material that is being forged or produced for the parts of the automobile.

One of the most concentrates matter of impact tensile test in automotive industry is a result of experiments obtained on the different welded steel grades by means of the new developed automobile products. This including two aspects; 1) State of the art concerning joining techniques for automotive industry and 2) State of the art concerning dynamic testing of high strength welds for automotive industry (Bayraktar et al., 2009) [1]. Frames, channel, angle, as well as plates are among the welded construction methods steel structures used in automobiles. Bolts, welded connections, or rivets are then used to attach them together. These structures in automobiles are frequently subjected to loads, and they can exceed their design load. It must be in service for an extended period of time and must fight with environmental and service conditions that may cause changing strains. A steel piece that is part of the structure, such as a car chassis or bodyframe, will have a structural function that is independent of the rest of the structure. That most of these component pieces are welded together, adding to the application's toughness, durability, and longevity. Steel structures then were going to be subjected to varying stresses as a result of vehicle loads, road conditions, or driving style, and can experience fatigue failures as a result of the weld.

A research of (Barbosa et al., 2021)[22] provided a fracture testing program that measured cleavage fracture toughness data for welded steel by using various welding procedures with in ductile to brittle transition region. Verification studies of the correlation between CVN energy and fracture strength and hardness for trialed weldments formed by the SMAW as well as FCAW processes may provide nonconservative integrity assessment for imperfect structural parts because the calculated impact strength values are greater than the result test values. More addition research (Kunigita et al., 2020)[23], the findings of Charpy impact testing for a variety of simulated heat-affected zone (HAZ) samples with various chemical compositions and temperature cycles on weld specimen. The results shown different microstructural parameters HAZ does give an effect on absorb energy of the specimen.

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1.2 Problem Statement

Welding process does bring an impact or effect on the material. According to the research (Thomas, 2018) [2], on a certain parameter, types of welding or even welding skills can cause changing of metal microstructure and its mechanical properties. Failure of welded construction steel components can occur due to inappropriate design, wrong steel choice or quality, substandard welding processes and through defective maintenance. The degree of deformation before the creation of a brittle crack varies significantly for metals with varied microstructures. It is demonstrated that the metal of welded joints is destroyed with a considerable amount of energy consumed on the ultimate fracture of the specimen relative to the base metal (Sudin et al., 2020) and (Kim et al., 2015) [11-12]. (Barbosa et al.,2021) [22] developed a fracture testing methodology for steel welds in the ductile-to-brittle transition area that assessed cleavage fracture toughness data. Because the calculated toughness values are greater than the experimentally measured values, verification investigations of the link between CVN energy and fracture toughness may give nonconservative integrity assessment for defective structural components. In addition, the outcomes of Charpy impact testing for a variety of simulated heat-affected zone (HAZ) samples with varying chemical compositions and temperature cycles on weld specimens (Kunigita et al., 2020) [23]. The results reveal that different microstructural factors HAZ have an effect on the specimen's absorb energy. Furthermore, according to the research (Sudin et al., 2020) and (Kim et al., 2015) [11-12], the behavior of welded joints and low-alloy low-carbon steel during impact bending is investigated from the standpoint of energy partitioning due to the crack formation process. It states that, there are significant variances in the degree of deformation preceding the creation of a brittle crack for metals with varying microstructures.

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To better understand about this phenomenon, a study has to be done between two types of specimens which is welded material and unwelded material. These specimens must be test with the Charpy impact test, also known as the Charpy V-notch test to measure the amount of energy absorbed by the specimen during fracture. Through this test we can calculate and observe the amount of energy absorb by both of the specimens and also can visualize the difference of impact signal between them. At the end of the test, we can finally conclude that whether the welding process does give an effect on the material in certain characteristic compared to the unwelded material.

1.3 Research Objective

The main aim of this research is:

a) To study weld impact testing in automotive application

b) To correlate the absorb energy between welded and unwelded material.

c) To analyze the impact signal between welded and unwelded material.

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1.4 Scope of Research

The scope of this research are as follows:

- There are two types of specimens which is welded and unwelded material using mild steel material follow ASTM E23 standard with different thickness.
- The machine that is used is a Pendulum Charpy Impact machine testing maximum capacity 500J (Jinan Precision JBW-500).
- Impact velocity Charpy impact machine 5.4 m/s.
- Using shielded metal arc welding (SMAW) process to produce CVN welded material specimen

CHAPTER 2

LITERATURE REVIEW

2.1 Impact

In physics, collision, the sudden, forceful colliding of two bodies in immediate touch also called impact There are three types of collisions between two bodies: linear central impacts, oblique central impacts, and eccentric impacts (Oztas A.G., 1999) [3]. In highway collisions, eccentric impact is more common than other types of impact. When the energy of an impact is transferred from one person or item to another, it is called collision. This wave of energy has the potential to injure or damage those who are affected, as well as items. The impact's cumulative effect, such as changes in mass velocities, is frequently calculated using the concept of a big force acting over a short period of time. To simplify the study of impulsive motion of two masses during contact, a concept of a large force operating for a short time is used. The average force of impact can be determined from the momentum exchange between the masses when the impact time is known (Rajalingham & Rakheja, 2000) [4].

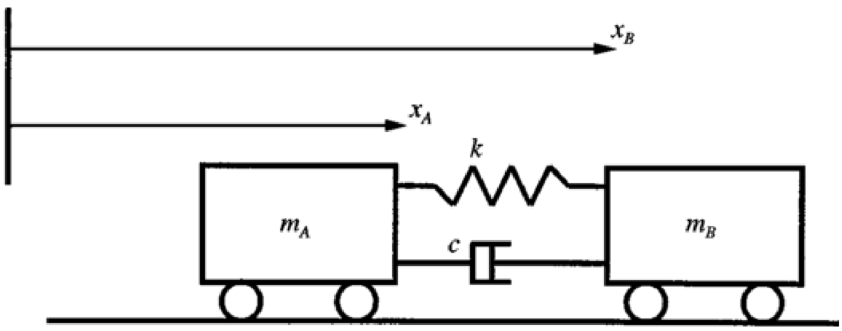

Figure 2.1: Model of mechanical system in collision between two masses (Rajalingham & Rakheja, 2000) [4]