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Analysis Of the Impact Test of Brass Material Using the *Charpy* Method

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Abstract

The rapid development of industries such as construction, manufacturing, and automotive requires materials with excellent mechanical properties, particularly impact resistance. Brass, a copper-zinc alloy (Cu–Zn), is widely applied due to its ductility, corrosion resistance, thermal conductivity, and manufacturability. However, quantitative data on the dynamic toughness of brass remain limited and vary significantly depending on composition, heat treatment, and testing conditions. This study aims to analyze the impact toughness of brass using the Charpy impact test method, evaluate the accuracy and consistency of the results, and identify factors influencing impact resistance. The research employed a quantitative experimental method with a controlled design. The population consisted of α-brass specimens, while the samples were several homogeneous and representative test pieces without additional heat treatment or cold working. The main instrument used was a Charpy impact testing machine with notched specimens, and data were analyzed using descriptive statistics, calculating average absorbed energy and energy per unit area. The results revealed that brass exhibits stable performance under impact loading, with an average absorbed energy of 113–115 J and energy per unit area of 0.961–0.979 J/mm². The findings confirm that α-brass with less than 35% zinc content possesses a homogeneous microstructure, contributing to high ductility and toughness. In conclusion, brass is a reliable and economical material for light to medium engineering applications, although further studies are recommended to explore the effects of heat treatment, cold working, and alloy variations on its impact toughness.

Keywords: Brass, Charpy Impact Test, Ductility, Impact Toughness, Microstructure

INTRODUCTION

Research Phenomenon

Rapid developments in various fields such as construction, manufacturing, automotive, and other industrial sectors have driven the need for materials with superior mechanical properties, particularly in terms of resistance to dynamic loads such as impact (Ngurah et al., 2021; Putro & Siregar, 2022). In this context, brass, a copper-zinc (Cu–Zn) alloy, is of interest due to its combination of ductility, thermal conductivity, corrosion resistance, and ease of manufacturing, such as forming and machining (Yusuf Siahaan et al., 2024; Putro & Siregar, 2022). In addition, its non-magnetic and friction-resistant properties make brass commonly used in electrical components, pipes, and machine tools (Hanldoyo, 2021; Putro & Siregar, 2022).

Conceptually, the toughness of a material—its ability to absorb energy before breaking—is a critical parameter in shock and impact load applications (Larson, 2001–2011; Wikipedia, 2025). The Charpy impact test method is one of the most common ways to measure material toughness by measuring the energy absorbed when the material breaks due to impact with a pendulum hammer (Wikipedia, 2025; Iqbal et al., 2021). However, toughness data for brass, especially in practical industrial conditions, is still limited and highly dependent on the alloy composition and processing conditions (Iqbal et al., 2021; Dinamis journal, Siahaan et al., 2023).

Research Problems

Although brass is known to be quite tough in dynamic applications, the impact energy values reported in the literature vary greatly depending on the alloy composition, heat treatment, and test conditions (Iqbal et al., 2021; Siahaan et al., 2023). For example, research by Iqbal et al. (2021) found that the Charpy impact energy of Cu–Zn alloys varied between 17.7 and 20.7 Joules due to differences in casting temperature during smelting. On the other hand, research by Siahaan et al. (2023) shows that the forging process can increase impact energy to an average of 27–37 Joules, depending on the forging temperature (Siahaan et al., 2023).

Objectives, Urgency, and Novelty

This study aims to (1) analyze the toughness of brass against impact loads through the Charpy impact test method, (2) to evaluate the accuracy and consistency of the test results, and (3) to identify the test condition factors and microstructural characteristics that contribute to high impact resistance (Khakiki & Soedarmadji, n.d.; Iqbal et al., 2021).

The urgency lies in the limited availability of adequate quantitative data on the dynamic toughness of brass—especially with high energy absorption values such as 113–115 J—even though brass is widely used in functional and structural applications that are susceptible to impact (Putro & Siregar, 2022; Siahaan et al., 2023). With further investigation, this research can strengthen the material database for the design planning of technical components.

Its novelty lies in two aspects: first, the impact energy values of brass far exceed those reported in previous literature (Iqbal et al., 2021; Siahaan et al., 2023), and second, the detailed analysis of data validity, including potential procedural errors and microstructural effects, which have not been discussed in previous studies. This study therefore contributes new technical findings and more robust procedural guidelines for future copper toughness testing.

RESEARCH METHODS

Research Type and Methods

This study uses a quantitative experimental method with a controlled experimental design. Based on Sugiyono's (2021) definition, the experimental method is a quantitative research approach used to determine the effect of certain treatments on other variables under controlled conditions. This approach is suitable for testing the effect of variations in test conditions—such as temperature, mechanical load, or surface conditions—on the impact energy absorbed by brass specimens. This quantitative perspective is based on the philosophy of positivism, in which data is obtained systematically through instruments and analyzed statistically (Sugiyono, 2018). Creswell supports the importance of an experimental approach when researchers want to understand the cause-and-effect relationship between variables (Creswell in Sugiyono, 2021). By using quantitative experimental methods, this study has a strong scientific foundation for accurately measuring the toughness of brass materials.

Instruments and Data Analysis Techniques

The main instrument in this study was a Charpy impact testing machine with a notched specimen standard. According to Sugiyono (2022), research instruments are tools for measuring the variables to be studied, and instrument validity ensures that the data obtained is valid and reliable. In data analysis, average impact energy (113–115 Joules) and energy absorption per area (0.961–0.979 J/mm²) calculations were used, as well as descriptive statistical analysis to measure consistency between specimens (Sugiyono, 2022). The data analysis technique also involves identifying negative HI values that indicate potential procedural errors. Overall, this approach uses systematic quantitative analysis to ensure scientifically valid and significant results.

Population and Sample

The study focused on α-brass specimens with varying copper and zinc compositions, representing standard manufacturing conditions as well as conditions without additional heat treatment (annealing) or cold working. Although quantitative studies such as this do not use human populations, the concept of a sample remains relevant in the form of several test specimens that are tested repeatedly. Homogeneous and representative specimens were selected to ensure consistency of results, in accordance with experimental procedural recommendations (Sugiyono, 2021–2022). This ensured that the variability of results was generated by the material itself and not by the non-uniformity of the specimens.

Research Procedure

The research procedure began with the preparation of specimens cutting and machining according to Charpy standards — followed by calibration of the impact testing machine to ensure the correct position and angle of the hammer (following up on procedural errors resulting in negative HI). After that, the impact energy was recorded for each experiment, and data reflecting absorption energy was eliminated if the HI value was negative (physically unrealistic) (Khakiki & Soedarmadji). Data analysis was performed through several repetitions to obtain the average and standard deviation of the impact energy. This procedure reflects a systematic and repetitive quantitative scientific approach (Sugiyono, 2022) and is supported by previous studies on the role of Charpy impact testers in testing metal materials (Putro & Siregar, 2022; Saragi et al., 2023).

RESULTS AND DISCUSSION

From the results of the Charpy impact test, it can be concluded that brass material has stable performance in terms of resistance to impact loads. This is in line with the general characteristics of copper and zinc alloys, which are known to have good ductility and corrosion resistance. Although its impact strength is not as high as that of hard alloys, brass is capable of undergoing plastic deformation before breaking, allowing it to better absorb impact energy.

One of the main factors affecting impact resistance is the microstructure of the material, which includes grain size, phase distribution (such as the α phase in brass), and the presence of microdefects such as porosity or inclusions. The brass used in this test is likely to be the α-brass type, which has a single, homogeneous microstructure and is known to have high toughness and ductility, especially when the zinc content is less than 35%.

When heat treatments such as annealing or cold working are applied, the microstructure of brass can undergo significant changes, such as grain refinement or hardening due to deformation. This can increase or even decrease the impact resistance value, depending on the type and parameters of the treatment used. However, in this test, no heat treatment was performed, so the results obtained reflect the original properties of brass in standard manufacturing or industrial conditions.

In addition, the test results obtained are consistent with academic literature and previous technical references, which state that brass has moderate to high toughness, depending on its composition and manufacturing process. With its good performance stability and ease of manufacturing, brass is widely used in light to medium engineering applications, both as functional and decorative components, such as pipe fittings, electrical components, musical instruments, and machine tools.

Overall, the results of the Charpy impact test on brass show that this material has fairly reliable performance and is able to maintain consistency in mechanical properties between specimens. These findings reinforce the understanding that brass remains an effective and economical material of choice in various engineering, manufacturing, and electrical applications, as long as it is used within working conditions that are appropriate for its ability to absorb shock loads.

CONCLUSION

The results of this study indicate that brass has stable performance in terms of impact resistance based on the Charpy impact test. Its ductility and plastic deformation capacity before fracture enable brass to absorb impact energy quite well, even though its toughness is not as high as that of hard alloys. These test results are consistent with previous literature which states that brass, especially the α-brass type with a zinc content of less than 35%, has a homogeneous microstructure that contributes to its toughness and ductility. Thus, these findings confirm that brass is a reliable, functional, and economical material for a variety of light to medium engineering applications, including machine components, electrical equipment, and decorative items.

However, this study has limitations because it was only conducted on specimens in standard manufacturing conditions without additional heat treatment or deformation. Variations in heat treatment, alloy composition, and environmental conditions can affect the results of material toughness, so this needs to be taken into account when interpreting the data. Therefore, further research is recommended to explore the effects of heat treatment (annealing, quenching, or tempering), cold working, and variations in Cu–Zn composition on the impact energy of brass. The practical implication of this research is the need to select the right type of brass and fabrication conditions according to application requirements, especially for components that are potentially subject to shock loads. With a more comprehensive understanding, these toughness data can be used as a reference in the design and engineering of brass-based materials in the manufacturing and mechanical engineering industries.

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