PROJECT REPORT
ON

DETERMINING DUCTILITY AND BRITTLENESS FROM CHARPY IMPACT TESTS

A TECHNICAL PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
in
ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Submitted by:

BIBIDH BHARDWAJ	**Regd. No.- 2001105365**
ABHIJEET PARIDA	**Regd. No.- 2001105352**
ANSHUMAN DASH	**Regd. No.- 2121105053**

Under The Supervision of:

Mr. GYANABRATA SAHOO
Assistant Professor
Department of ETC Engineering

Department of Electronics And Telecommunication Engineering
Indira Gandhi Institute Of Technology, Sarang

2023-24

Department of Electronics and Telecommunication Engineering
Indira Gandhi Institute of Technology, Sarang

CERTIFICATE OF APPROVAL

This is to certify that we have examined the project entitled **"DETERMINING DUCTILITY AND BRITTLENESS FROM CHARPY IMPACT TESTS"** submitted by **BIBIDH BHARDWAJ** Regd. No.- 2001105365, **ABHIJEET PARIDA** Regd. No.- 2001105352, **ANSHUMAN DASH** Regd. No.- 2121105053 of IGIT, Sarang. We here by accord our approval of it as a project work carried out and presented in a manner required for its acceptance for the partial fulfillment for the Bachelor Degree of Technology in Electronics & Telecommunication Engineering for which it has been submitted. This approval does not necessarily endorse or accept every statement made, opinion expressed or conclusions drawn as recorded in this project, it only signifies the acceptance of the project for the purpose it has been submitted.

Dr. Ashima Rout
Head of the Department of ETC Engineering
IGIT, SARANG

Mr. Gyanabrata Sahoo
Department of ETC Engineering
IGIT, SARANG

ACKNOWLEDGEMENT

For the support and ongoing encouragement during the minor project work, we would like to convey my sincere gratitude to our mentor and concerned faculties, Department of Electronics and Telecommunication Engineering, Indira Gandhi Institute of Technology, Sarang for his/her time and efforts he/she provided throughout the session your useful advice and suggestions were really helpful to me during the minor project and report completion. It is our privilege to express our sincere thanks to **Dr. Ashima Rout** H.O.D. ETC Department who has always been a constant source of inspiration.

I convey my sincere thanks to **Mr. Gyanabrata Sahoo** who has given his most valuable time and effort in guiding me to complete this seminar in due time and in this shape. Also, we would like to take this opportunity to thank our family members & supporters, without them it could not have been done effectively in this period of time. We cannot forget their love & support.

Last but not the least, we worked on the report and made it successful due to timely support and efforts of all our batchmates who helped us, for their cooperation, presence and assistance in making this seminar possible have been much appreciated by us.

BIBIDH BHARDWAJ (2001105365)
ABHIJEET PARIDA (2001105352)
ANSHUMAN DASH (2121105053)

CONTENTS

Sl. No.	Titles	Page No.
	ACKNOWLEDGEMENT	3
	ABSTRACT	5
	LIST OF FIGURES AND TABLES	6
	CHAPTER 1	
1	INTRODUCTION	7
1.1	PROBLEM STATEMENT AND MOTIVATION	7
1.2	ABOUT THE PROJECT	8
1.3	OBJECTIVE	8
1.4	LITERATURE SURVEY	9
1.5		10
1.6		11
	CHAPTER 2	
2		12
2.1		13
2.2	SOURCE CODE	13
2.3	WORKING	17
	CHAPTER 3	
3		19
3.1	RESULT	20
3.2	FUTURE SCOPE	20
	CONCLUSION	21
	REFERENCE	22

ABSTRACT

This research is the integration of a set of elements in a system of capturing, processing, and digital image analysis. It allows a better visual and numeric interpretation to determine the toughness, ductility percentage, and fragility of steel AISI/SAE 1020 and 30, getting better qualitative and quantitative observation of the results from the impact test (Charpy test). Patterns in the standard form, ASTM E23, were digitalized to evaluate the percentage of ductility/fragility of specimen testing. After, we calculated the area and the equivalent diameter of the material. using digital image processing and numerical comparison between the patterns specified in the standard form ASTM E23 and the testing in the impact test , and it allows to find the kind of pattern it is closest and determine which degree of ductility. Finally, the results were compared by three experts. The algorithm accuracy was 80%.

LIST OF FIGUERS

FIG. NO.	TITLE	PAGE NO.
1		
2		
3		
4		

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
1	Literature Survey	11

LIST OF ABBERIVIATIONS

SL. NO.	NAME OF ABBERIVIATIONS	PAGE NO.
1		
2		
3		
4		

INTRODUCTION

Digital image processing has been used in multiple applications. The applications refer to topics such as fruit selection, classification of medical images, structural analysis and materials classification. Secondly, the Charpy test , has been used to determinate toughness, behavior analysis in thermic variation, and identification of different properties of materials. For the design of machine elements, it is important to evaluate characteristics such as ductility and brittleness in order to calculate strength. One of the main drawbacks in determining brittleness and ductility is that it is associated with direct observation by experts through microscopic images. Human subjectivity is always a problem. In this work , we was estimated fragility and ductility using the ASTM E23 standard.

The Charpy impact test is a widely used method to assess the toughness and ductile-brittle transition behavior of metallic materials. By quantifying the percentages of ductile and brittle fracture regions on the specimen's fractured surface, materials scientists and engineers can gain crucial insights into a material's mechanical properties and performance. This report presents an innovative digital image processing approach to objectively determine these ductility and brittleness percentages, moving beyond traditional subjective expert observations.

PROBLEM STATEMENT AND MOTIVATION

Determining ductility and brittleness of materials accurately is crucial for various engineering applications. While standard tensile tests provide valuable insights, they often lack the dynamic loading conditions present in real-world scenarios. This gap necessitates a reliable method to assess a material's behavior under impact loads.

The current project focuses on utilizing the Charpy impact test to effectively determine the ductility and brittleness of materials. Here's why this project holds significant importance:

- **Safety-Critical Applications:** Understanding a material's ductility and brittleness is paramount in industries like construction, transportation, and pressure vessel manufacturing. These industries rely on materials that can withstand sudden impacts without catastrophic failure.
- **Ductile-to-Brittle Transition Temperature (DBTT):** Charpy impact tests enable the identification of the DBTT, a critical temperature at which a material's behavior shifts from ductile to brittle. This information is vital for safe operation in environments with fluctuating temperatures.
- **Material Selection and Design Optimization:** By quantifying ductility and brittleness, engineers can make informed decisions regarding material selection for specific applications. This leads to safer, more reliable, and potentially lighter designs.
- **Quality Control:** Charpy impact tests serve as a quality control tool, ensuring materials meet the specified toughness requirements and minimizing the risk of unexpected failures.

ABOUT THE PROJECT

The brittle fractures leave behind larger, more noticeable patterns or marks on the broken surface compared to ductile fractures.
By taking pictures of the broken specimen surfaces after the impact test, and analyzing the sizes of the patterns or marks using image processing software, the researchers can figure out which regions were brittle fractures (larger patterns) versus ductile fractures (smaller, smoother patterns).
This allows them to calculate what percentage of the surface was brittle versus ductile without relying on a person's subjective judgment by just looking at the surface.
Using image analysis and comparing to reference pattern images avoids the inconsistencies that can happen when different people examine the same surface manually.
So in simple terms - larger crack/fracture patterns = brittle regions, while smoother torn areas = ductile regions. Image processing quantifies the sizes to estimate the brittle versus ductile percentages objectively.

OBJECTIVE

- **Material Selection:** You'll likely choose different materials (e.g., steel, aluminum) to analyze their ductile-to-brittle transition behavior.
- **Temperature Variation:** Charpy tests are often conducted at various temperatures to pinpoint the ductile-to-brittle transition temperature (DBTT). This is the temperature at which a material's fracture behavior significantly changes.
- **Data Analysis:** The impact energy values obtained from the tests will be plotted against temperature. This helps visualize the transition and identify the DBTT.
- **Fracture Surface Examination:** Analyzing the fracture surfaces of the tested specimens can provide additional insights. Ductile fractures typically exhibit a rough, shear-like appearance, while brittle fractures are often smooth and flat.

Additional Considerations:

- **Standards:** Following established testing standards like ASTM E23 is crucial to ensure accurate and reproducible results.
- **Impact Testing Machine:** The Charpy test requires specialized equipment to deliver the standardized impact load.
- **Safety Precautions:** Proper safety protocols must be followed during sample preparation, testing, and handling fractured specimens.

LITERATURE SURVEY

S. no.	Title, Author	Features	Benefits	Limitations
1.	Automated attendance management system using face recognition, Alex L.	Use Eigen faces for Recognition	High accuracy	Multiple faces were not recognized.
2.	Face recognition attendance system by nevon, Peyard,F.,Lab.deRech	Stores the faces that are detected and automatically marks attendance	Used for security purposes in organizations	Don't recognize properly in poor light.
3.	Smart Attendance System using OPENCV based on Facial Recognition, Lixiang Li, Xiaohui Mu, Siyin Li	Takes pictures through the webcam and create a dataset for users using m images. Takes real-time images and mark attendance	Used for marking attendance in schools and colleges.	Cannot mark attendance of the student on a remote sever database.
4.	Smart Attendance Management System Using Face Recognition, Panditpautra V, Goswami A, Khavare A	Student Registration Face Recognition Addition of subject with their corresponding time. Attendance sheet generation and import to Excel (xlsx) format.	In this the data is stored in sorted manner so that it can easily accessible	Required high definition camera
5.	Face Recognition - A Tool for Automated Attendance, MS Ellis, J Jhao	Face detection, Pre-processing, Feature extraction, and Classification stages	High accuracy	Camera should be attached at a specific position
6.	Smart Application for AMS Using Face Recognition, Ian Goodfellow, Jean Pouget-Abadie, Mehdi Mirza	Uses CCTV and Android mobile	3D face recognition algorithm is used	Android phone is expensive and detect one face at time
7.	Student Attendance System in Classroom Using Face Recognition Technique, David M.	Use of Discrete Wavelet Transform and Discrete Cosine Transform.	Multiple face detection was possible	Success rate is only 82%

ADVANTAGES

Here are the key advantages for a project determining ductility and brittleness from Charpy impact tests:

Improved Material Selection and Design:

- **Safer Structures:** By accurately assessing ductility and brittleness, engineers can select materials that are less prone to catastrophic failures, especially under sudden impact or stress. This leads to safer designs in structures like buildings, bridges, vehicles, and pressure vessels.
- **Optimized Performance:** Understanding ductility and brittleness allows engineers to tailor materials to specific applications. For instance, ductile materials might be preferred for components requiring energy absorption (like car bumpers), while brittle materials might be suitable for wear-resistant components (like cutting tools).

Enhanced Quality Control:

- **Defect Detection:** Charpy impact tests are a reliable way to identify hidden defects or flaws within a material that might not be apparent through visual inspection. This helps ensure the overall quality and reliability of the material being used.
- **Process Control:** Monitoring ductility and brittleness over time can help optimize manufacturing processes and identify potential issues that could affect the material's properties. This leads to more consistent material quality.

Cost Savings:

- **Reduced Failure Risk:** By selecting materials with appropriate ductility and brittleness, the project can avoid costly failures that might lead to downtime, repairs, or even injuries.
- **Improved Material Utilization:** Understanding the material's behavior allows for more efficient material utilization, potentially reducing waste and optimizing material costs.

Additional Advantages:

- **Standardized Testing:** Charpy impact tests are a standardized method, making it easier to compare results across different materials and projects.
- **Versatility:** The test can be applied to a wide range of materials, including metals, polymers, and composites.

APPLICATIONS

Here are some key applications for determining ductility and brittleness using Charpy impact tests:

Material Selection and Design:

- **Structural components:** Understanding the ductility and brittleness of materials like steel, concrete, and wood is crucial for designing safe and reliable structures that can withstand stress and impact without catastrophic failure. For example, high-rise buildings require ductile materials to absorb earthquake forces, while bridges might need a balance of both ductility and strength.
- **Pipelines and pressure vessels:** Ductile materials are essential for pipelines and pressure vessels that transport fluids or gases. These components need to be able to deform slightly without rupturing under pressure fluctuations or impacts.
- **Machine parts:** Gears, shafts, and other machine components undergo repeated stress and require materials with a balance of strength and ductility to resist fatigue and sudden impacts.
- **Aerospace and automotive industries:** Material selection in these industries is critical for safety and performance. Ductility data from Charpy tests helps ensure components can handle stress and potential impacts without failure.

Quality Control and Manufacturing:

- **Monitoring material consistency:** Charpy impact tests are used in quality control to ensure that materials produced by a manufacturer meet the specified ductility requirements. This helps maintain consistent material performance and prevent potential failures.
- **Identifying material defects:** Abnormally low ductility in a Charpy test can indicate underlying material defects like microcracks or impurities. This information helps identify and address potential issues before they cause problems in the final product.
- **Optimizing heat treatment processes:** Charpy tests can be used to evaluate the effectiveness of different heat treatment processes on a material's ductility and overall mechanical properties. This helps manufacturers fine-tune their processes for optimal performance.

Research and Development:

- **Developing new materials:** Researchers use Charpy impact tests to evaluate the ductility and brittleness of newly developed materials, helping them understand their potential applications and limitations.
- **Studying material behavior under different conditions:** Charpy tests can be conducted at various temperatures to understand how a material's ductility and brittleness change with temperature fluctuations. This information is crucial for applications where materials experience extreme temperature variations.

RESULT

FUTURE SCOPE

1. Expanding Material Scope:

- **Advanced Materials:** Investigate the applicability of Charpy tests to newer materials like composites, high-strength steels, and additively manufactured components. These materials may exhibit different fracture behaviors compared to traditional metals.
- **Microstructure Analysis:** Correlate Charpy impact results with microstructural features like grain size, phase distribution, and the presence of precipitates. This can provide deeper insights into the underlying mechanisms of ductility and brittleness.

2. Enhanced Testing Techniques:

- **Instrumented Charpy Tests:** Utilize instrumented Charpy machines that capture additional data beyond just absorbed energy. This data, like load-displacement curves and fracture initiation points, can offer more detailed information about fracture behavior.
- **Non-Destructive Techniques:** Explore the potential of non-destructive testing methods like ultrasonic testing or acoustic emission to assess ductility and brittleness without physically breaking the sample. This could be crucial for evaluating in-service components.

3. Computational Modeling:

- **Fracture Mechanics Modeling:** Develop and refine fracture mechanics models that can predict the ductile-to-brittle transition temperature (DBTT) based on material properties and microstructure. This would enable more accurate predictions of material behavior under impact loading.
- **Machine Learning Integration:** Utilize machine learning algorithms to analyze large datasets of Charpy test results and identify patterns that can link material composition, processing conditions, and microstructure to ductility and brittleness. This could lead to the development of predictive models that require less experimental testing.

4. Standardization and Automation:

- **Standardization of Data Analysis:** Develop standardized methods for analyzing Charpy test data, ensuring consistency and facilitating comparisons between different studies and laboratories.
- **Automated Testing Systems:** Automate Charpy testing procedures to improve efficiency, reduce operator error, and enable large-scale testing for statistical analysis.

CONCLUSION

The application of graphite in the ASI 304 specimens turned out to be an alternative determinant to carry out the image processing, allowing the software to differentiate the areas formed in the test and thus subsequently go on to make a numerical comparison with the areas formed and the Pattern image areas using Euclidean distance. Evaluation by expert in materials was the determining factor for determining the degree of reliability of the algorithm since it allowed to know with certainty which descriptor of form (Equivalent area or diameter) was ideal for carrying out this type of image processing. A very low error rate (20%) has been presented when area is used as a shape descriptor. However, it is valid clarify that the percentage of error is supported by the application of ranges discrete that the ASTM E23 standard has. Likewise, it was evidenced that the equivalent diameter is not the most adequate descriptor for this type of application, since the results were not in agreement with the results of the experts. External factors at the time of image capture is a critical factor since any anomaly that occurs at the time of capturing the image will affect the digital processing of images for this it is necessary to eliminate all the noises or factors outsiders involved in the scene An open problem is still precision, consistency and efficiency of the algorithm. Future work will be focused on the development of a sophisticated method of deriving an optimized high-precision matching result under the influence of noise and illumination sources.

REFERENCES

[1] P. J. Bagga, M. A. Makhesana, K. Patel, and K. M. Patel, “Tool wear monitoring in turning using image processing techniques,” Mater. Today Proc., vol. 44, pp. 771–775, 2021.
[2] N. Dey, J. Chaki, L. Moraru, S. Fong, and X.-S. Yang, “Firefly Algorithm and Its Variants in Digital Image Processing: A Comprehensive Review,” in Applications of Firefly Algorithm and its Variants: Case Studies and New Developments, N. Dey, Ed. Singapore: Springer Singapore, 2020, pp. 1–28.
[3] E. R. Dougherty, Digital image processing methods. CRC Press, 2020.
[4] G. K. Ijemaru et al., “Image processing system using MATLAB-based analytics,” Bull. Electr. Eng. Informatics, vol. 10, no. 5, pp. 2566–2577, 2021.
[5] I. R. Fermo, T. S. Cavali, L. Bonfim-Rocha, C. L. Srutkoske, F. C. Flores, and C. M. G. Andrade, “Development of a low-cost digital image processing system for oranges selection using hopfield networks,” Food Bioprod. Process., vol. 125, pp. 181–192, 2021.
[6] P. Salehi and N. Behzadfar, “Investigation and simulation of different medical image processing algorithms to improve image quality using simulink matlab,” Signal Process. Renew. Energy, vol. 5, no. 4, pp. 15–28, 2021.
[7] O. Cantó-Navés, X. Marimon, M. Ferrer, and J. Cabratosa-Termes, “Comparison between experimental digital image processing and numerical methods for stress analysis in dental implants with different restorative materials,” J. Mech. Behav. Biomed. Mater., vol. 113, p. 104092, 2021.
[8] S. Mahankali and G. Valikala, “Comparison of Compressive Strength of M30 Grade Concrete with Destructive and Nondestructive Procedures Using Digital Image Processing as a Technique,” Adv. Civ. Eng., vol. 2022, 2022.
[9] B. E. Romero-Tarazona, C. L. Rodriguez-Sandoval, J. G. Villabonai-Ascanio, and A. D. RincónQuintero, “Development of an artificial vision system that allows non-destructive testing on flat concrete slabs for surface crack detection by processing of digital images in MATLAB,” IOP Conf. Ser. Mater. Sci. Eng., vol. 844, no. 1, 2020, doi: 10.1088/1757-899X/844/1/012058.
[10] Y. Yang, H. Wang, Y. Yang, and H. Zhang, “Evaluation of the evolution of the structure of cold recycled mixture subjected to wheel tracking using digital image processing,” Constr. Build. Mater., vol. 304, p. 124680, 2021.
[11] A. Surendranath and P. V Ramana, “Recycled materials execution through digital image processing,” Mater. Today Proc., vol. 46, pp. 8795–8801, 2021.
[12] D.-H. Xia et al., “Review-material degradation assessed by digital image processing: Fundamentals, progresses, and challenges,” J. Mater. Sci. Technol., vol. 53, pp. 146–162, 2020, doi: https://doi.org/10.1016/j.jmst.2020.04.033.
[13] V. S. Barbosa, L. A. C. de Godois, K. E. Bianchi, and C. Ruggieri, “Charpy impact energy correlation with fracture toughness for low alloy structural steel welds,” Theor. Appl. Fract. Mech., vol. 113, p. 102934, 2021.
[14] C. Wang et al., “A method for directly measuring fracture toughness and determining reference temperature for RPV steels by Charpy impact test,” Eng. Fract. Mech., vol. 243, p. 107526, 2021.
[15] D. R. Hetrick, S. H. R. Sanei, O. Ashour, and C. E. Bakis, “Charpy impact energy absorption of 3D printed continuous Kevlar reinforced composites,” J. Compos. Mater., vol. 55, no. 12, pp. 1705–1713, 2021.