ANALYSIS OF MECHANICAL PROPERTIES OF HEAT TREATED EN-24 STEEL USING NON-DESTRUCTIVE ULTRASONIC TECHNIQUES

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Abstract

The mechanical parameters of various engineering applications include facilities for assessing the validity of various equipment. The research goal aims to establish the association among the tensile parameters along with the reduction characteristics of ultrasonic evaluation and also to facilitate logistics for direct tensile parameter procurement. In this research, three EN-24 steel specimens are selected as a reference. The samples are exposed to annealing at 900°C, 1000°C & 1100°C. Also, Ultrasonic, Tensile, Hardness, & Impact Tests were done. The attenuation coefficient of ultrasonic testing was established using a Pulse-Echo ultrasonic test. An excellent agreement was observed among the tensile parameters and the reduction characteristics.

***IndexTerms*:** Annealing, Ultrasonic Test, Tensile test, Hardness Test, Impact Test, Attenuation, Pulse-Echo ultrasonic test

I. Introduction

Sound wavelets of enhanced frequency are termed Ultrasonic waves. The ultrasonic waves are malleable in nature and implemented extensively in NDT which involves enhanced incidence automatic pulsation. The common business-related evaluation is implemented with frequencies ranging from 0.5 MHz and 25 MHz.

1.1 Testing

The evaluation involves augmented amplitude noise wavelets (assortment ranging from 0.5 and 25 MHz) for evaluation & testing purposes. The technology finds immense application in a wide assortment of engineering applications which involves error assessment, number analysis, alloy formulations, and so on. The technology also finds applicability in clinical sectors. On the whole, the UT is established on either the emulated type or the disseminated type. Each of the two categories is used in selective applications. The emulated type has several advantages over the disseminated type because the former requires a single-sided admittance to the component under scrutiny.

Fig.1 UT Inspection in pipes

Fig .2.Stenography

1.2 Fundamental characteristic of UT:

A common signal-resonance ultrasonic testing scrutiny arrangement involves various functional components, including the pulse recipient and exhibit implements. A pulse recipient is an electronic arrangement capable of producing enhanced voltage electrical pulses.

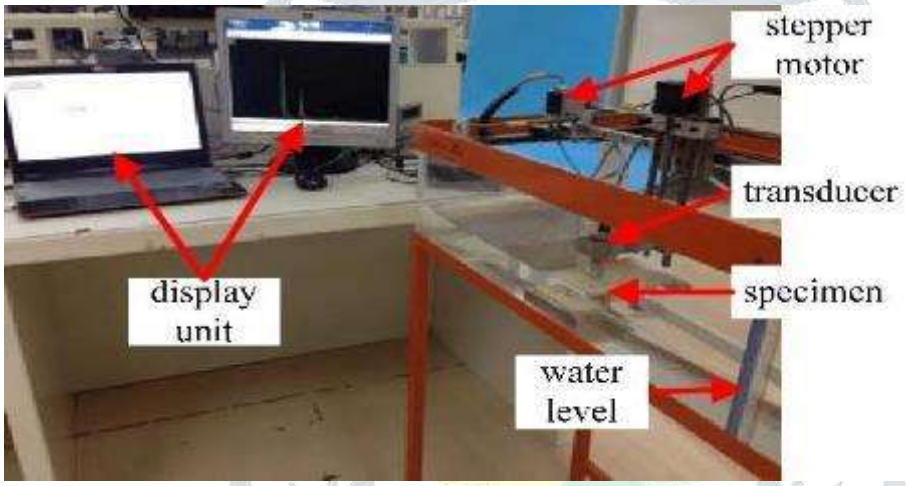


Fig.3 Set of Ultrasonic Testing

II. Materials and Methods

Procedure:

1) Procurement of longitudinal rate of an USW in various specimens/standards was done.

Water was stored in a vessel. A signal of 5MHz was transmitted through the water. With the assistance of a exhibit component, the duration taken by the signal for its come-back to the recipient was observed.

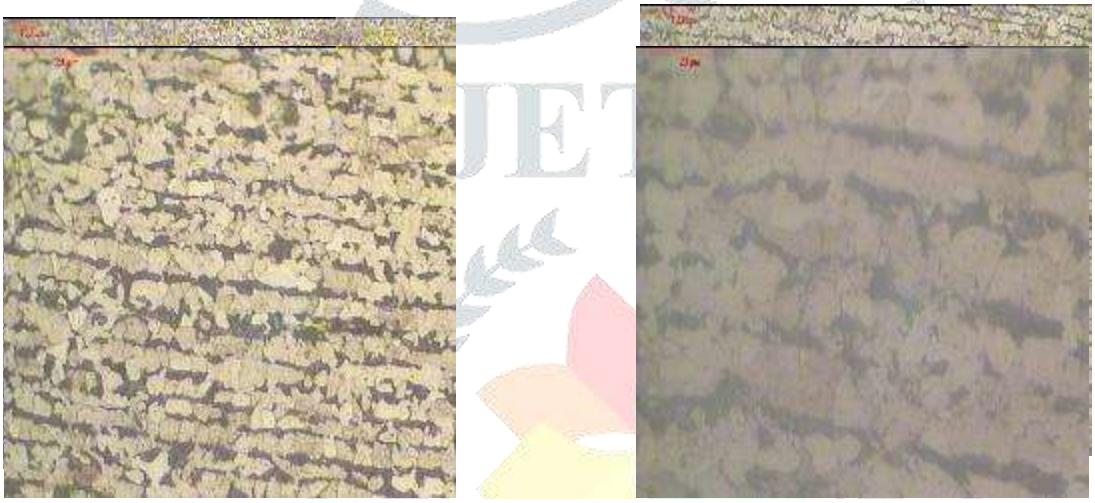
Fig. 4Rolled Steel Sheet & Cutting equipment

2) A steel specimen (MS in the shape of a rolled pane having an approximate width of 8.03 mm) was severed into four components of same dimension by a standard cutting machine.
3) One of the specimens was polished using emery paper of various grades. This is trailed by cloth buffing across its exterior to analyze its micro-arrangement.

Fig.5 Buffing equipment

4) The micro-arrangement figures of the procured specimen were taken at different magnifications using the standard Image analyzer. Also, it was determined in the manual mode using the area technique.

100 X 200X



400X 800X

Fig. 6 Microstructure Images of the procured specimen at various magnifications

5) The oxidized region of the procured specimen was eliminated by buffing the higher and minor exteriors of the specimen prior to the conduct of UT across its width.

Fig.7 Prior to buffing Fig. 8 Subsequent to buffing

6) Implementing the UF of the 5MHz prod, the longitudinal speed of the ultrasonic noise wavelet of the procured specimen was determined. The shear velocity of the resonance in the specimen is presumed to be one-part of the longitudinal pace.

Additionally, the attenuation parameter of the UW in the procured specimen was determined.

Fig.9 Attainment of UW in the model

7) The compactness of the specimen was determined by the procurement of the area and thickness by means of a Vernier caliper. The volume was determined at the end using the mass procured from the standard weight determination equipment. The specimen density was determined using the standard procedure listed below.

$$\sigma = \frac{1-2\,(V_T/V_L)^2}{2-2\,(V_T/V_L)^2}$$

$$E = \frac{VL^2\rho\ (1+\sigma)(1-2\,\sigma)}{(1-\sigma)}$$

$$G = V_T^2\rho$$

σ	=	Poisson's Ratio
V_L	=	Longitudinal Velocity
V_T	=	Shear (Transverse) Velocity
ρ	=	Material Density
E	=	Young's Modulus
G	=	Shear Modulus

8) The residual 3 specimens were thermally characterised (annealed) at various retaining temperatures of 900°C, 1000°C, 1100°C.

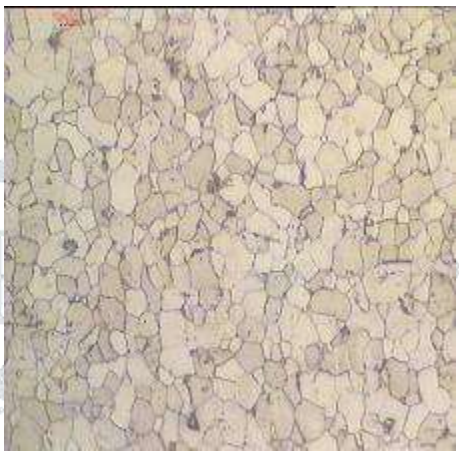
The annealing cycle subjected specimen was retained in the furnace after it was turned on. After the furnace attains the prescribed holding temperature (900°C, 1000°C, 1100°C), the specimens were permitted to be get drenched for a duration of 5 hours. The equipment was subsequently toggled off, and the specimens were cooled down to the normal temperature.

Fig. 10 Muffle furnace

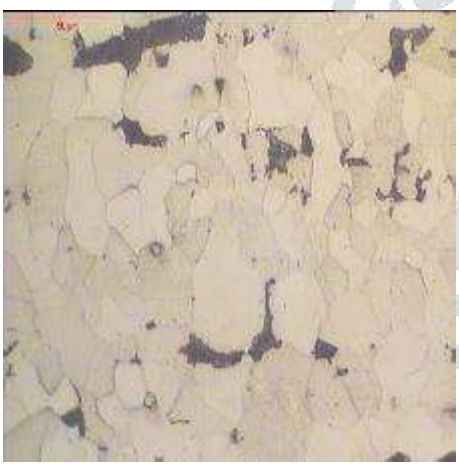
9) The sequences (4), (5), (6), (7) & (8) were subjected to the repetitive mode for all the heat-treated samples.

Fig.11 Different heat-treated Samples.

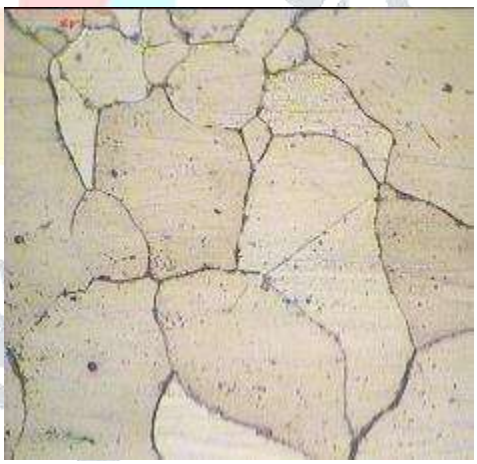
As Received Sample



900°C



1000°C

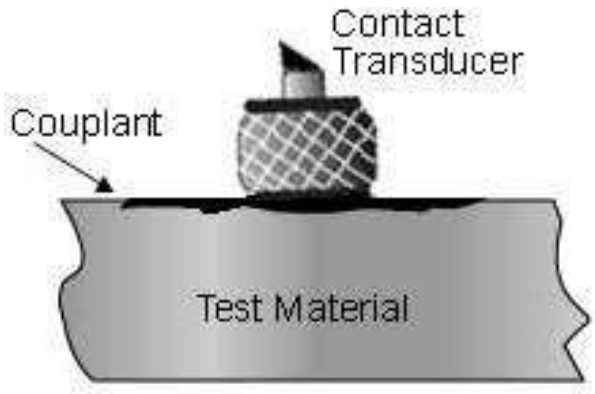


1100°C

Fig.12 Microstructural pictures of various thermally characterised specimens at 400X.

III. Results and Discussion

A couplet is a fluid that enables transfer of ultrasonic energy from the transducer to the evaluation sample. Hence, a couplant is absolutely essential due to the high acoustic intransigence disparity between the air and solid. Hence, the almost entire quantum of energy is replicated, and the remaining is transmitted back to the evaluation specimen. The couplant relocates the air and enables the possibility to obtain more sound energy into the evaluation component. As a result, a functional ultrasonic indication can be procured. In ultrasonic network evaluation, a small sheen of oil, glycerine, or water is usually used.



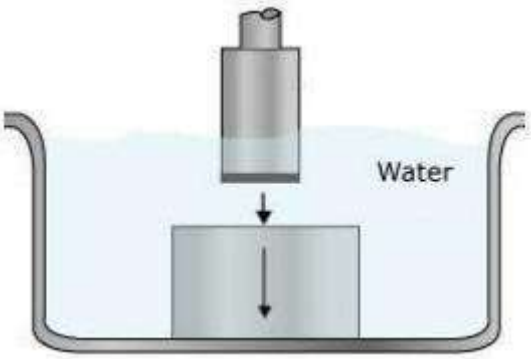


Fig. 13 Couplant in UT Fig. 14 Submerged UT

Submerged methodology is commonly implemented when the component is subjected to scrutiny. In submerged ultrasonic evaluation, both transducer and component are submerged in the water couplet. This technique enables the sustenance of uniform connection while traversing.

3.1 Pulse-Receivers:

Ultrasonic pulse-receivers are generally applied in all sorts of ultrasonic evaluation. They can be implemented for error discovery and width estimation in a huge assortment of materials. The UPRs enable an exceptional, minimal-expense ultrasonic dimension assessment. Dedicated transportable apparatus are used in ultrasonic evaluation, which involves the combination of the pulse-receiver, scope exhibit, and a minuscule dimension battery enable component.

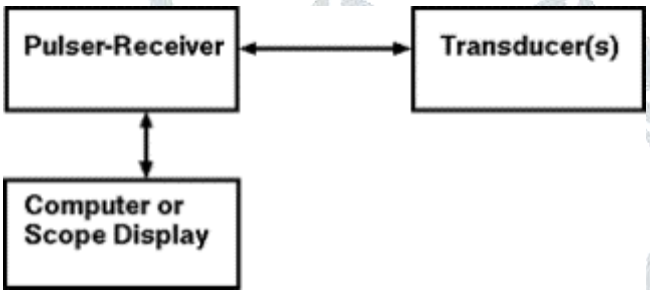


Fig. 15 A-Scan exhibition of UE

The pulsation segment of the device produces minimum and maximum magnitude electric pulsations of focused energy. They are transitioned into small ultrasonic pulsations when taken to the transducer. The organizing parameters are

- Pulsation span or assimilation: The extent of duration for the pulsation to be taken to the transducer.
- Pulsation power: This represents the voltage fed to the transducer. A nominal pulse circuit will produce 100 to 800 volts.

In the receiver zone, the voltage indications are created by the transducer, which symbolizes the procured ultrasonic pulsations that are magnified. The magnified indication is attainable as a yield for exhibit or incarceration for the signal concoction. The control manipulations linked with the receiver configuration consists of:

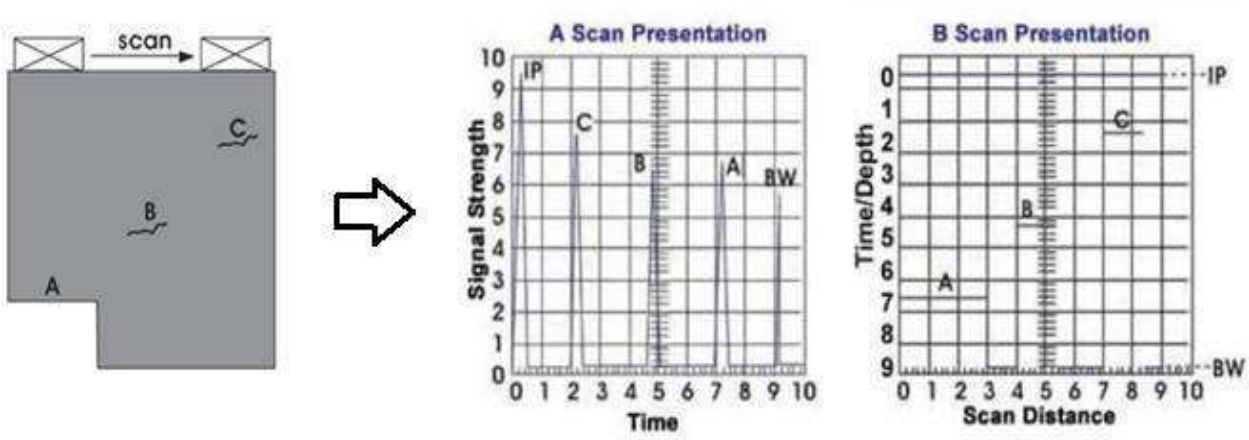
- Indication improvement: The signal can be seen as a positive half-wave
- Percolation to form and to flatten
- Gain, or indication magnification
- Decline command

3.2 Statistics arrangement:

The 3 ordinary arrangements available include the A-scan, B-scan, and C- scan appearances. Each appearance modality gives a dissimilar methodology of perception and assimilation of the zone of the substance, which is scrutinized. The latest PC ultrasonic scrutinizing configurations can present statistics in all 3 formats at the same time.

3.2.a A-Scan arrangement: The revelation shows the volume of procured power as a functionality of time. The virtual extent of procured power is marked along the perpendicular axis, and the lapsed duration is shown along the level axis. Many equipment with this type facilitates the pulse to be shown in the normal radio incidence format (RF), as a completely corrected RF indication. Here, the comparative imperfection dimension can be computed by contrasting the indication magnitude procured from an unidentified speculum that from a recognized speculum. The speculum dimension can be obtained by the location of the indication on the level duration axis. The first indication produced is indicated by the sign IP, which is approximately zero. As the transducer is scrutinized beside the exterior, 4 more indications will probably occur at various durations. When the device is traversed to the extreme left location, only the IP and indication A will be seen on the outline. As the transducer is moved to the other side, an indication from the BW will come into view, which indicates the travel of noise in the other direction. When the transducer produces an over-fault scenario, indication B will be seen at a location that is approximately at the middle among the IP and the other indications. Since the IP indication coincides with the facade exterior, the fault B is seen as intermediate between the facade and rear exteriors of the specimen. When the transducer is made to travel over imperfection C, the indication C will be seen because since the noise move passage is lesser. The indication B will vanish due to the lack of sound reflection.

3.2b. B-Scan revelation: This is a category of appearance which is probable for automatic linear scrutinizing configurations where it shows a shape(cross-sectional) schematic of the evaluation sample. Here, the duration of travel of the sound wavelet is shown along the perpendicular direction, and the linear location is shown along the level direction. Using this configuration, the linear dimension of the speculum is procured. The B-scan is characteristically created by instituting an activator. Whenever the



indication magnitude is elevated for manipulation, a location is formed. The entrance is activated with noise replication starting at the back wall and also with small replicators inside the substance. The line A is created as the device is scrutinized above the lessened width part of the sample. When the device travels to the right, the back wall column is created. When the transducer is moved over flaws B and C, the lines which are identical to the imperfection dimensions and similar dimensions within the substance are marked. It should be observed that there is a restraint to this method as the replicators are usually covered by bigger replicators near the exterior.

3.2.c C-Scan revelation: This is suited for automated two-dimensional scanning arrangements, which gives a plan-type vision of the position and dimension of the evaluation sample. The area of the picture is equivalent to the scrutinizable prototype of the transducer. The third type evaluations are usually created with an automatic data procurement configuration which includes a PC manipulated submerged scrutinization arrangement. Characteristically, a statistics procurement entrance is recognized on the A-scan, and the frequency is noted at usual gaps as the device is moved over the evaluation specimen. The virtual indication magnitude is seen as a hue of grey color or a tint for every location wherever the information was recorded. The revelation gives a picture of the characteristics that reproduce and disperse the sound inside and on the exteriors of the sample.

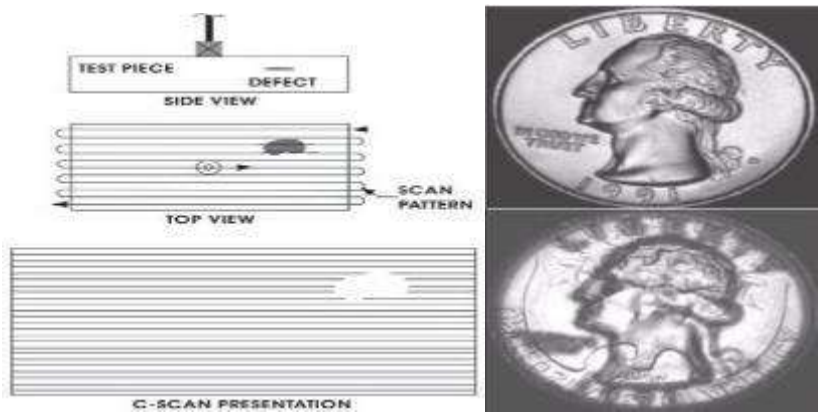


Fig.16 C scan revelations

Enhanced clarity configurations can create comprehensive pictures. The diagram shows 2 revelation pictures of a US section. They are created using a pulse-echo method with the device traversed over the top-region in a submerged scrutiny configuration.

For the C-scan picture on the pinnacle, the opening was arranged to receive the magnitude of the noise emanating from the facade exterior. Light regions in the picture reveal zones that deflect increased volumes of power. In the picture on the lower side, the opening was stimulated to trace the concentration of the noise bouncing from the rear exterior. The particulars on the rear exterior are obviously perceptible, but the exterior facade characteristics are also still noticeable since the sound is influenced by these characteristics as it moves through the front exterior of the coinage.

IV. Conclusion

a) The granular dimension of the specimen elevates in an almost expanding manner with the augmentation in annealing temperature. The dispersion pace of the granular frontier amplifies. Also, the fastidious holding duration of the granular dimension augments proportionately with temperature.
b) The longitudinal velocity in the given substance reduces with the augmentation in the granular frontier region in the specimen.
c) With the elevation in the AT which implicates the granular dimension, the Young's modulus reduces.
d) The concentration of the UW reduces in an unexpected manner when traveling through the substance.
e) The Attenuation Coefficient of the UW of a particular frequency in a functionality/substance augments with amplification in its granular microstructure dimension. As a result, a reduction in the granular dimension exterior zone per unit volume takes place in the substance. This is because; the granular frontier functions as an origin of refraction.

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