USE OF NON-DESTRUCTIVE TESTING FOR VERIFICATION OF DISCONTINUITIES IN FORGED PRODUCTS

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Abstract

In this study are analyzed possible discontinuities through the non-destructive testing on AISI 4140 steel samples subjected to compression testing. The realization of ultrasound non-destructive testing allowed the verification of the presence or absence of internal discontinuities in the compressed material. It was observed that the compression test, equivalent to the open die forging process, doesn't cause internal discontinuities in the material and also eliminates the small internal voids arising from the casting process that the bodies had originally. Thus, the forging process besides to provide improved mechanical properties also causes closure of voids that arise during manufacturing processes such as the casting and the powder metallurgy.

Key-words: Discontinuities; non-destructive testing; ultrasound.

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1. INTRODUCTION

Non-destructive testing is performed on products to determine the properties of the material or to detect possible discontinuities and doesn't compromise the product inspected.

The development of non-destructive methods have shown high potential for application in the evaluation of material properties (BURZIC, D.; ZAMBERGER, J.; KOZESCHNIK, E, 2010).

The determination of material defects using non-destructive testing is widely applied in various industries fields. The safe operation of transport vehicles such as airplanes, trains, ferries requires inspections of permanent components and relevant parts. The appropriate choice of non-destructive method is made depending on the defects size to be detected and depending on the material to be inspected (SPIES, M.; RIEDER, H., 2010).

Non-destructive tests are essential for the mechanical components manufacturing which allow the inspection without affecting the component operational. It is important to detect and to characterize point defects in order to predict their influences on the performance of the components in terms of service (VALENTINA, C.; MILENA, S.; MONICA, F.; FEDERICO, S.; MARIO, M.; MATTEO, B., 2008).

There are non-destructive testing that aren't efficient to evaluate changes in material properties due to the limitation of measuring only the surface layer of the material evaluated, knowing that there are differences in the materials mechanical properties of the inner and the peripheral regions. However, testing such as the ultrasound are quite efficient to analyze materials internal properties (CASAMICHELE, L.; QUADRINI, F.; TAGLIAFERRI, V., 2007).

The non-destructive testing techniques have been used as a method of evaluation of steel structures both in the design phase and in the construction phase. Many researches are being performed related to industries where there are pipe systems such as oil companies, refineries, power plants, among others due to possible faults that has been appearing in piping systems in conduction fluid. The ultrasonic inspection in pipelines has been very efficient and ease operation (CARVALHO, A. A.; REBELLO, J. M. A.; SOUZA, M. P. V.; SAGRILO, L. V. S.; SOARES, S. D., 2008).

Inspections by ultrasound for the evaluation of mechanical components are commonly used today to verify internal discontinuities in industries due to its ease operation (HOLMES C.; DRINKWATER B. W.; WILCOX P. D., 2008).

Ultrasound are sound waves with frequencies above the audible limit. Normally, ultrasonic frequencies are in the range from 0.5 to 25 Mhz. The echoes reflected by the ultrasound from inhomogeneities or discontinuities in the materials tested contain information pertaining to the location, size and characteristics of defects. The accurate detection, the location and the sizing of defects are limited by the ability to interpret accurately the information contained in the ultrasonic signals obtained during an inspection (ZHANG, G. M.; ZHANG C. Z.; HARVEY, D. M., 2012).

Generally, the actual dimensions of an internal discontinuity can be estimated with a accuracy reasonable by the height of the reflected echoes, providing ways for that the piece can be accepted or rejected based on the acceptance criteria of the applicable standard. The major applications of this testing are on welds, rolled or forged, casting, composite materials, thickness measurement, oxidation or corrosion and others processes.

2. PROCESSES AND METHODS

It were made 10 cylindrical specimens of AISI 4140 steel (0.41% C, 0.77% Mn, 0.02% P, 0.038% S, 0.21% Si, 0.98% Cr, 0.21% Mo) with 20.0 mm in diameter and 30.0 mm in height. The specimens were reduced in 60% related to the initial height in the compression test performed in a hydraulic press with a capacity of 40 tonf and constant tool speed of 5 mm/s. To perform the ultrasound non-destructive testing, shown in Figure 1, it used the ultrasound equipment with your system monitoring and a transducer from where the possible discontinuities are detected.

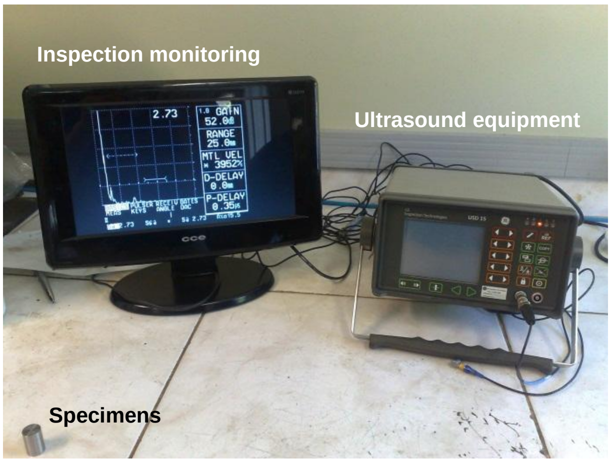

Figure 1 – Ultrasound equipment.

This testing was performed before and after the performing of the compression test in the specimens. In Figure 2 is shown the measurement by ultrasound of the part using a transducer which is connected to the ultrasound equipment and through the monitoring system is possible to identify if there is presence of some internal discontinuity.

Basically, the ultrasound equipment contains special electronic circuit that permit to transmit to the piezoelectric crystal, via coaxial cable, a series of controlled electric pulses, what are transformed by crystal in ultrasonic waves. In the same way, signals detected in the crystal are displayed on the screen of a cathode ray tube in form of sound pulses called echoes which can be regulated both in amplitude and in position on the screen graded. The echoes form the record of the discontinuities found within the material. The transducer is formed by the crystal, the electrodes, the outer shell and emits a pulse ultrasonic that going through the material and reflects in the interfaces, causing the echo. The echo returns to the transducer and generates a corresponding electrical signal. The block-pattern is material acoustically similar to the tested piece with thicknesses and holes calibrated of reference. If the calibration of the equipment was made in dissimilar materials, the measurement accuracy would be affected.

To perform the inspection, the transducer was coupled to the part, setting up a air layer between the transducer and the surface part. This air layer prevented that the mechanical vibrations produced by the transducer were propagated to the part because of the acoustics characteristics (acoustic impedance) very different of the material to inspect. For this reason, it used a liquid that has established a reduction of this difference and allowed the passage of the vibrations to the workpiece. This liquid, called liquid couplant, was chosen in function of the part surface finish.

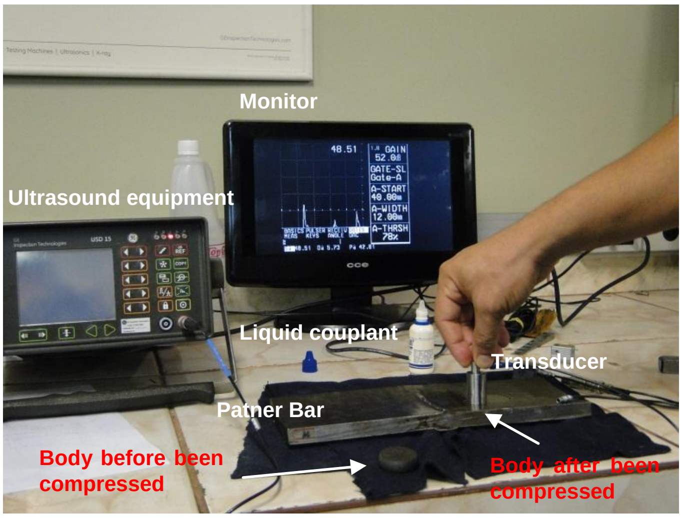

Figure 2 – Measurement by ultrasound.

With the completion of non-destructive testing, it was possible to verify the presence or absence of internal discontinuities from ultrasound nondestructive.

3. RESULTS

The trial of discontinuities encountered was established in accordance with the procedure written and applicable standard. The discontinuities were tried by its length and the echo amplitude of reflection, which are measurable quantities by ultrasound inspector. With the completion of inspections by ultrasound, it identified the discontinuities present. The body before been forged showed internal discontinuities, while the body after been forged showed no internal discontinuities. In the monitoring system where appear peaks in the curve of the graph are identified the defects. These peaks were viewed only in the inspection of the part before forged, as show the Figure 3.

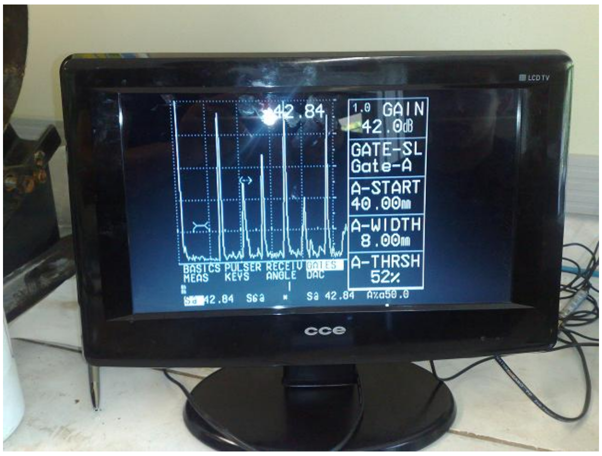

Figure 3 – Discontinuities peaks obtained in the ultrasound testing result.

4. CONCLUSIONS

The forging besides to supply betters materials mechanics proprieties also can aim the closing of possible voids that arise during the manufacturing process such as casting.

ACKNOWLEDGMENTS

The authors thank to the National Council of Scientific and Technological Development (CNPq) for funding the scholarships, the Mechanical Forming Laboratory (LdTM) and the Federal University of Rio Grande do Sul (UFRGS).

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