# Testing of Ultrasonic Propagation in ASTM A 216, ASTM a 217, ASTM a 743 Grades of Steel Samples Using Ultrasonic Flaw Detector DIGISCAN DS 322

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## 1. ABSTRACT

The research work is concentrated on the ultrasonic inspection on three grades of different steel samples. Ultrasonic testing (U.T) was one of the methods that used in non destructive testing (NDT) to find defects in casting. In this work three grades of steel samples are selected for ultrasonic inspection and they are, ASTM A 216 (WCC), ASTM A 217 (C12A), ASTM A743 (CA6NM). The aim of the work is to check the amount of ultrasonic wave propagation in the selected grades and to find which grade among them was suitable for ultrasonic inspection.

*Key words: Non destructive testing, ultrasonic inspection, wave propagation*

## 2. INTRODUCTION

Ultrasonic non destructive testing is a competently technique that used in wide variety of application. While ultrasonic NDT is mainly applicable in defect finding, thickness gauging and acoustic imaging. In steel castings different types of defects are forming like cavity inclusion, shrinkage, porosity, cracks, blow holes etc by using the ultrasonic testing the unknown defect in casting can be located. The ultrasonic waves can be used to find defects in ferrous and non-ferrous metallic objects as well as in plastics and ceramics. In ultrasonic testing frequency of 20KHz to over 100MHz waves are approximately using. Both longitudinal and shear modes of vibration are commonly using in U.T and in some special cases Rayleigh and plate waves are also using. In ultrasonic flaw detector the transducer are connected to a cathode ray oscilloscope (CRO) unit and the defects in the casting can be identified by checking the waves in CRO. The ultrasonic waves are produced by using a piezoelectric material which converts the electrical energy in to mechanical energy. A quartz crystal is used for this purpose. The ultrasonic waves are transmitted from the transducer to the selected casting and it makes a sharp echo at the left side of the CRO and the wave will strikes the bottom side of the casting get reflected back. The backwall echoes are indicated on the right side of the CRO. If there is any defect in the casting the echo will touches the defect and return back to the CRO so a defect echo will get in the CRO in between the initial and backwall echo.



## 3. RESEARCH METHODOLOGY

The purpose of the research work is to find the ultrasonic propagation in ASTM A 216, ASTM A 217, ASTM A 743 hence to check this two specimens with different size are made for each grades. The chemical and mechanical properties of the selected three grades are tested and the values are compared to the ASTM standards, the experimental part of the study and the results are explained below.

### 3.1 MATERIAL STANDARD SPECIFICATIONS

The ASTM standards of WCC, C12A and CA6NM grades are given below.

**Table 1. Mechanical properties**

| | WCC | C12A | CA6NM |
|---|---|---|---|
| Tensile strength (Mpa) | 485 to 655 | 585 to 760 | 755 |
| Yield strength (Mpa) | 275 | 415 | 550 |
| Elongation | 22 | 18 | 15 |
| Reduction of area | 35 | 45 | 35 |

**Table 2. Chemical properties**

| Element<br><br>Grades | C% | Mg% | P% | S% | Si% | Cu% | Ni% | Cr% | Mo% | V% |
|---|---|---|---|---|---|---|---|---|---|---|
| WCC | 0.25 | 1.20 | 0.04 | 0.045 | 0.60 | 0.30 | 0.50 | 0.50 | 0.20 | 0.03 |
| C12A | 0.08-0.12 | 0.30-0.60 | 0.030 | 0.010 | 0.20-0.50 | | 0.40 | 8.0-9.5 | 0.85-9.5 | |
| CA6NM | 0.06 | 1.00 | 0.04 | 0.03 | 1.00 | | 3.5 | 11.5-14.0 | 0.40-1.0 | |

### 3.2 MECHANICAL TESTING

The specimens were prepared from the three samples as per the ASTM standards, by machining operations like grinding, turning and milling. This was done to obtain the required dimensions (grip dia= ø20mm, gauge length=90mm, gauge dia= ø12.5mm and grip length=50mm). The engineering stress-strain curve was used in the tensile test, test bars is prepared according to standard specification. The test specimens are prepared as cylindrical shape as shown in the fig1. it is gripped at the two ends and pulled a part in a machine by the application of a load. The machine used in this test was Universal Testing Machine with Digital Extensometer, Model: UTE 40, Capacity 40 Tones.

Fig 1. Testbars used for mechanical testing

### 3.3 CHEMICAL TESTING

The chemical compositions are analyzed using a spectrometer. The technique utilizes a high-energy spark created across an argon-filled gap between an electrode and a sample of the material to be analyzed. The spark creates an emission of radiation from the excited sample surface with wavelengths characteristic of the elemental composition. The spectrum of radiation is separated into the distinct element lines and the intensity of each line is measured. Finally, these are precisely converted into concentration values for each element present. Typical applications involve determination of the alloying content of iron and steel, aluminum, copper, nickel, zinc, lead and many other metals and alloys

### 3.2 SPECIMEN PREPERATION

The specimens are prepared as per the figure 2. Two specimens are prepared for each grade

Specimen (S1) - ø70mm and 170mm length

Specimen (S2) - ø50mm and 70mm length.

The specimens are subjected to normalizing at 920°C and soaking 6Hrs normal air cooled

Fig 2. Specimens for the U.T test

### 3.4 ULTRASONIC TESTING USING DIGISCAN DS322

The machine that used in this experiment is ultrasonic flaw detector DIGISCAN DS 322 with ø 24mm dia, 2MHz and 4MHz normal probe. The tests are conducted as per the ASTM A 609 testing procedure with acceptance standard of ASME A 16.34. Grease was used as a couplant and the testing was carried out by pulse echo method using longitudinal wave. First and foremost the specimens are cleaned and the couplant is applied to the specimen then the range and gain was set in the detector for the test. Each specimen is examined by the U.T detector and checks the amount of wave propagation in the three grades.



## 4. RESULTS

### 4.1 CHEMICAL TESTING

The three samples chemicals are tested using a spectrometer and the results are shown below.

Table 3. Chemical composition of ASTM A 216 (WCC) grade.

| C% | Si% | Mn% | P% | S% | Cr% | Mo% | Ni% | Al% | Co% |
|---|---|---|---|---|---|---|---|---|---|
| 0.2156 | 0.4548 | 0.813 | 0.0238 | 0.0138 | 0.1749 | 0.0188 | 0.1351 | 0.0260 | 0.0050 |
| Cu% | Nb% | Ti% | V% | W% | Pb% | Sn% | As% | Sb% | Fe% |
| 0.0517 | 0.0020 | 0.0017 | 0.0232 | 0.0050 | 0.0020 | 0.0034 | 0.0027 | 0.0020 | 98.0 |

Table 4. Chemical composition of ASTM A 743 (CA6NM) grade.

| C% | Mn% | Si% | P% | S% | Cr% | Ni% | Mo% | Cu% | V% |
|---|---|---|---|---|---|---|---|---|---|
| 0.036 | 0.638 | 0.624 | 0.023 | 0.006 | 11.96 | 4.342 | 0.650 | 0.101 | 0.041 |

Table 5. Chemical composition of ASTM A 217 (C12A) grade.

| C% | Si% | Mn% | P% | S% | Cr% | Mo% | Ni% | Al% | CO% |
|---|---|---|---|---|---|---|---|---|---|
| 0.0912 | 0.4064 | 0.516 | 0.0517 | 0.0060 | 9.10 | 0.956 | 0.2710 | 0.0075 | 0.0281 |
| Cu% | Nb% | Ti% | V% | W% | Pb% | Sn% | As% | Fe% | Sb% |
| 0.164 | 0.0764 | 0.0010 | 0.2229 | 0.0442 | 0.0020 | 0.0090 | 0.0056 | 88.1 | 0.0006 |

## 4.2 MECHANICAL TESTING

Table 6. Mechanical properties of WCC, C12A, CA6NM

| GRADE | TENSILE STRENGTH N/mm² | YIELD STRENGTH N/mm² | ELONGATION % | REDUCTION OF AREA % | HARDNESS BHN |
|---|---|---|---|---|---|
| WCC | 529.747 | 332.94 | 29.340 | 54.914 | 149 |
| C12A | 625.843 | 471.59 | 27.080 | 66.878 | 152 |
| CA6NM | 917.015 | 778.54 | 19.070 | 59.754 | 277 |

## 4.3 ULTRASONIC TESTING RESULT

Each specimen are tested using U.T flaw detector DIGISCAN DS to find the amount of wave propagation in each grades and the testing results are given in the table below.

***Ultrasonic testing on specimen S1 and specimen S2 using 2.5MHz probe with 5Db and 11Db gain***

- Energy level – 2
- Probe – normal
- Frequency – 2.5 MHz
- Probe Dia – 24mm
- Range – 200 for(S1) ,100 for(S2)
- Near field – 25
- Velocity – 5890

Table 7. Test result of Specimen S1with range 200, frequency, 2.5MHz

| Specimen (S1) | GAIN 5Db | GAIN +6Db (11Db) |
|---|---|---|
| ASTM A 216 (WCC) | 40% | 70% |
| ASTM A 743 (CA6NM) | 20% | 60% |
| ASTM A 217 (C12A) | 30% | 70% |



Table 8. Test result of Specimen S2 with range 100, frequency, 2.5MHz

| Specimen (S2) | GAIN 5Db | GAIN +6Db (11Db) |
|---|---|---|
| ASTM A 216 (WCC) | 50% | 94% |
| ASTM A 743 (CA6NM) | 35% | 80% |
| ASTM A 217 (C12A) | 47% | 90% |

***Ultrasonic testing on specimen S1 and specimen S2 using 4MHz probe with 5Db and 11Db gain***

Table 9. Test result of Specimen S1 with range 200, frequency 4MHz

| Specimen S1 | GAIN 5Db | GAIN +6Db (11Db) |
|---|---|---|
| ASTM A 216 (WCC) | 45% | 75% |
| ASTM A 743 (CA6NM) | 20% | 63% |
| ASTM A 217 (C12A) | 33% | 75% |

Table 10. Test result of Specimen S2 with range 100, frequency 4MHz

| Specimen (S2) | GAIN 5Db | GAIN +6Db (11Db) |
|---|---|---|
| ASTM A 216 (WCC) | 53% | 95% |
| ASTM A 743 (CA6NM) | 35% | 81% |
| ASTM A 217 (C12A) | 50% | 95% |

## 5. CONCLUSION

The ultrasonic wave propagation in the three different grades of steel samples are analyzed and the following are the conclusions.

In the three grades ASTM A 216 (WCC) grade shows the maximum wave propagation compared to ASTM A 217 AND ASTM A 743 so ultrasonic inspection was much effective in WCC grade casting to detect defects. Sound wave propagation is a main factor in ultrasonic inspection hence, in ASTM A 743 (CA6NM) grade shows low wave propagation and high attenuation, so to detect defects in ASTM A 743 castings ultrasonic testing was not a effective method. In ultrasonic testing the echo height is a important factor then it is better to use grease instead of machine oil as a couplant. The ASTM A 216 and ASTM A 217 are body centered cubic (BCC) in structure and ASTM A 743 was in face centered cubic (FCC) structure.

## 6. REFERENCES

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