International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

ULTRASONIC TESTING CALIBRATION USING REFERENCE BLOCK

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Abstract - *Ultrasonic testing is a versatile non-destructive testing (NDT) method. Distance Amplitude Curve is a method of compensating for the fact that the pulse-echo response of a reflector will decrease as the distance of the reflector from the ultrasonic probe increases. Several standards used for ultrasonic inspection have limitations imposed on the wall thickness required for the calibration block. For curved blocks, where the inside diameter can significantly alter the reflected pressure distributions, this is probably an effective requirement to ensure similar condition between calibration and component scanning. This report details the modelling of echo responses from the traditional "side-drilled-hole" calibration target. Distance Amplitude Correction curves (DAC curves) are simulated by observing the echo-dynamic responses for direct and skip paths on blocks of different thicknesses. DAC may be employed in both longitudinal and shear modes of operation as well as either contact or immersion inspection techniques.*

Key Words: **Ultrasonic testing, NDT, calibration, pulse-echo, DAC, amplitude.**

1.INTRODUCTION

Non-destructive Testing is one part of the function of Quality Control and is complementary to other long-established methods. By definition non-destructive testing is the testing of materials, for surface or internal flaws or metallurgical condition, without interfering in any way with the integrity of the material or its suitability for service. The technique can be applied on a sampling basis for individual investigation or may be used for 100% checking of material in a production quality control system. Whilst being a high technology concept, evolution of the equipment has made it robust enough for application in any industrial environment at any stage of manufacture - from steel-making to site inspection of components already in service. Ultrasonic Testing is used for the detection of internal and surface (particularly distant surface) defects in sound conducting materials. In between 1929 and 1935, Solkov S J (1935) experimentally proven that ultrasonic waves can be used for detecting metal objects. The principle is in some respects similar to echo sounding. A short pulse of ultrasound is generated by means of an electric charge applied to a piezo electric crystal, which vibrates for a very short period at a frequency related to the thickness of the crystal. In flaw detection this frequency is usually in the range of one million to six million times per second (1 MHz to 6 MHz). In 1935, Mulhauser.O obtained a patent for using ultrasonic waves and two transducers to detect flaws in solids. Vibrations or sound waves at this frequency have the ability to travel a considerable distance in homogeneous elastic material, such as many metals with little attenuation. The velocity at which these waves propagate is related to the Young's Modulus for the material and is characteristic of that material. The use of a calibration block, which produces a reflection from the back wall a known distance away from the crystal together with variable controls on the flaw detector, allows the screen to be calibrated in units of distance, and therefore determination of origins of returned pulses obtained from a test piece.

2. SELECTION OF MATERIAL

Various materials have been in the list of initial selection for the DAC block which has a good range of characteristics and applications in the present industry. Some of the said materials are Aluminium 2024-T3, Aluminium 6061-T6, Carbon Steel 1018, Stainless Steel 304. The material selected for the manufacturing of DAC block is Carbon Steel 1018 (CS1018) is a general-purpose carbon steel that is easily machined and welded and may be hardened by carburizing and by other surface-hardening methods. AISI 1018 carbon steel has excellent weldability and produces a uniform and harder case and it is considered as the best steel for carburized parts. It has been productively welded by using most of all the general practices that include resistance, gas, oxyacetylene, and inundated melt welding. It offers a good balance of toughness, strength and ductility.

- Block: Material - Carbon Steel AISI 1018
- Density 7.87 g/cm3
- Compression Velocity 5920m/s
- Transverse Velocity 3250m/s
- Width 100mm, Length 300mm
- Block Thicknesses: 19mm, 38mm

Figure -1: CS 1018 round bar

3. DESIGNING OF REFERENCE BLOCK

The Distance Amplitude Correction (DAC) block is designed as per the American Society of Mechanical Engineers (ASME) standards. Furthermore, the dimensions of the standards have been customized as per the own requirement. Though the default ASME standards can be used for normal ultrasonic testing, the customized dimensions designed for this block is also used for advanced ultrasonic testing such as phased array UT method which will be implemented in the near future. This adds a greater advantage to DAC block been made.

ASME is the leading international developer of codes and standards, hereafter referred to as standards, associated with the art, science, and practice of mechanical engineering. ASME is the globally recognized, trusted source of consensus standards since 1884.

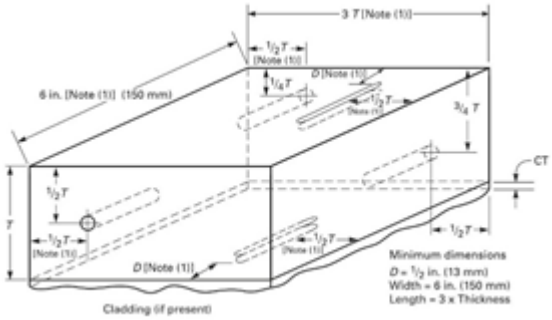

Figure -2: Nonpiping Calibration Blocks

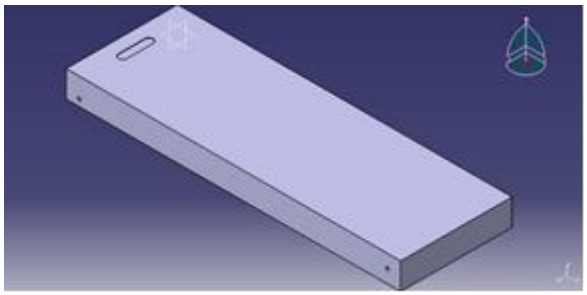

Figure -3: Reference block designed using CATIA

CATIA is an acronym for Computer Aided Three-dimensional Interactive Application. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products.

4. MACHINING OF REFERENCE BLOCK

The various steps involved in the process of machining of the DAC block are as follows.

4.1 Metal cutting

The 1018 carbon steel has been cut using oxygen gas cutting method. The tip of the cutting torch has a larger centre opening from which a jet of oxygen comes to cut the metal. This central opening surrounded by a set of orifices (generally four) which supply the oxygen-acetylene mixture for pre-heating. The cutting torch is provided with a high-pressure valve in from oxygen and acetylene control valves. On pressing the lever, the high-pressure valve releases a jet of oxygen from central orifice, after preheating. Allowances are given in the material to get rid of the heat affecting zones.

4.2 Shaping

The material is then moved to the shaper machine and the desired flat shape is made. Shaper is a reciprocating type of machine tool in which the ram moves the cutting tool forward and backward in a straight line. No metal is cut during its return stroke is called an Idle stroke. The feed is given at the end of the cutting stroke. The cutting stroke is carried out at slow speed and the idle stroke is carried at high speed with the help of quick return mechanism.

4.3 Drilling

The shaping process of the metal is followed by the drilling process which is done using vertical milling machine. Drilling is a material-removing or cutting process in which the tool uses a drill bit to cut a hole of circular cross-section in solid materials. The side drilled holes are perpendicular to the block in such a way that the probe can be moved to a greater distance and the calibration can be done effectively.

Figure -4: Drilling of side holes

4.4 Milling

The milling operation is carried out to make the notches in the block. The feed rate and cutting speed are given as per the required dimensions of the notch. Milling Machine is used for machining flat surfaces, slotting, contoured surfaces.

4.5 Surface Grinding

The surface grinding process is carried out to get the required dimensions of the block as per the design. Surface Grinding Machine is a machine in which a grinding wheel is used as a cutting tool for removing the material from the surface of the workpiece. It is also called an abrasive machining process where abrasives are placed on the surface and corners of the grinding wheel so as to do the finishing process with much more accuracy.

The block can be coated with Nickel or Zinc to prevent it from rusting in the future.

5. APPLICATIONS

AISI 1018 carbon steel is commonly used in high volume screw machine parts applications. The other applications of this alloy are as follows:

- Shafts
- Spindles
- Pins
- Rods
- Sprocket assemblies.

6. OBSERVATIONS AND DISCUSSION

It has been observed that pressure losses are indeed associated with reflections on calibration blocks. However, these losses are relatively small. But they affect the sensitivity of the UT equipment. So, calibration is the prominent way to counter the sensitivity correction of the equipment. Here the block has been custom designed with more space for the probe to move freely and the probability of flaw detection increases drastically than normal reference blocks. Thus, the above parameters help to increase the sensitivity of the equipment using custom designed reference through DAC curve. The DAC curve obtained using the reference block with full screen height (FSH) set at 80% is shown below.

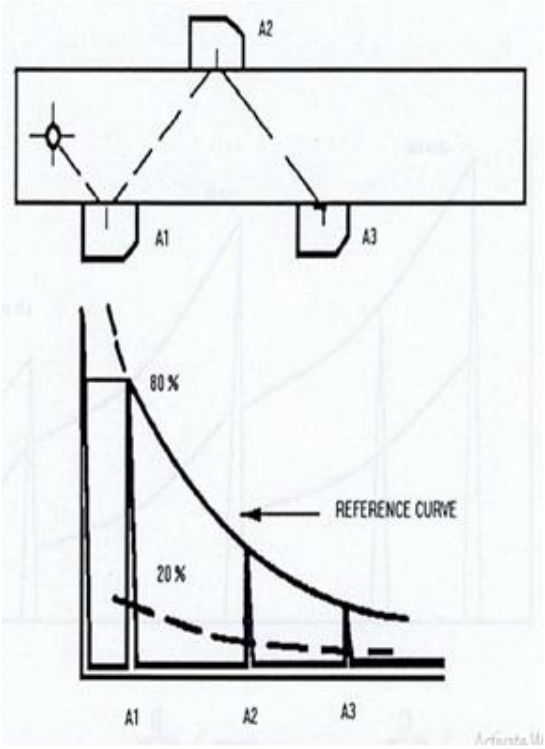

Figure -5: DAC curve for angle probe using reference block

7. CONCLUSION

The reference blocks have been custom designed and manufactured through various machining processes. The reference blocks have been inspected by ultrasonic testing for surface and internal flaws except predetermined flaws. A DAC curve is generated for calibrating the equipment by detecting the predetermined defects in the blocks.

The reference blocks are customised so as to increase the probability of efficient defect detection. These reference blocks are designed with futuristic consideration of using it in advance NDT methods such as Phased Array Ultrasonic Testing in which the probe dimensions will be much higher than normal probe dimensions and the conventional reference blocks has the drawback that it cannot be used in such methods. These blocks are most applicable in calibration of equipment used in detection of defects in welded components, structures, etc.

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