EFFECT OF WELDING ON PRESSURE VESSEL
(THE EFFECT OF WELDING HEAT ON MATERIAL ARE DISCUSSED IN TERMS OF MANUFACTURING AND NON-DESTRUCTIVE TESTING)

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Abstract - The purpose of this work to study the manufacturing method of pressure vessel to find out the effect of welding, the type of testing and method of analysis adopted on Non-Destructive in nature and can be carried out in an effective manner. 15CDV6 is a major structural material and is used in variety of structural application including construction of boilers, Solid Rocket Booster (SRB), Solid Rocket Booster involves that provide most of the main force or thrust needed to lift the space shuttle off the launch pad

Keywords - 15CDV6, SRB, NDT, Distortion

I. INTRODUCTION
15CDV6 is a major structural material and is used in variety of structural application including construction of boilers, Solid Rocket Booster (SRB), Solid Rocket Booster involves that provide most of the main force or thrust needed to lift the space shuttle off the launch pad. The major operation involving in the manufacturing pressure vessel (i.e. – Solid Rocket booster) is welding operation. 15CVD6 is a low carbon alloy steels include those with a carbon content 0.12-0.18 percent. 15CDV6 steel is remarkably suitable for every welding process, wheather Oxyacetylene, Electric, Arc resistance, Electron beam or Laser. No preheating is needed to a thickness of 10mm, and welding in the treated state is just as easy as for annealed metals. After welding, there is no excessive hardening of the cord requiring stress-relief treatment. Indeed, the presence of Molybdemum and Vanadium means that the annealing effect near the cord, affecting the mechanical strength of steel welded assemblies is almost insensitive when 15CDV6 is used. The strength of the treated metal is maintained intact with in the cord and around it. So that assemblies with consistent strength exceeding 1000MPa can be obtained without any heat treatment. 15CDV6 steel not only welds very well with them, but preserves its properties after complex treatment.

II. EXPERIMENTAL
At first raw material is in the form of sheet of dimension (975 x 996 mm) in annealed condition. After this a raw material code number is given to every sheet. Then the sheet is divided as shown below. The material used is 15CDV6 steel.

Table 2.1 Chemical Composition of parent material

<table>
<thead>
<tr>
<th>Elements</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>0.12</td>
<td>-0.80</td>
<td>-</td>
<td>-</td>
<td>1.25</td>
<td>0.80</td>
<td>0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>0.18</td>
<td>0.20</td>
<td>1.10</td>
<td>0.015</td>
<td>0.015</td>
<td>1.50</td>
<td>1.00</td>
<td>0.30</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2 Elasticity modulus according to temperature

<table>
<thead>
<tr>
<th>°C</th>
<th>20</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>550</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPa</td>
<td>209</td>
<td>204</td>
<td>199</td>
<td>190</td>
<td>181</td>
<td>170</td>
<td>163</td>
<td>158</td>
</tr>
</tbody>
</table>

Fig: 2.1 Sheet Metal

Long seam start (LSS), long seam finish (LSF) test coupon plates are clamped in welding fixture, top parent and bottom parent material is used for inspection purpose like hardness testing in Rockwell hardness, tensile test in universal testing machine. Then the sample is cut from the raw material as shown above.

Edge preparation is made for welding. The purpose of this edge preparation is to increase the strength of weld. We know that the strength of weld is depending on the area of

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weld. We can mathematically prove the above statement as

\[ \text{Shear Stress} = \frac{\text{Force}}{\text{Area}} \quad \text{Equation: 2.1} \]

So, if the area increases the stress developed will be minimum for the same force therefore the edge preparation increases the strength of weld. The dimensions for the weld preparation is shown below,

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### Fig: 2.2 Weld Edge Preparations

We know that the weld edge preparation is varies depending on the thickness, for a very small thickness of about 1mm to 2mm edge preparation is not required. Otherwise edge preparation is required and the important thing is whatever the edge preparation is taken out in the sheet should also be done for seams as mentioned earlier.

There may be some cracks dots or punch marks in the welding surface, this reduce the strength of the weld. So, we need to check the surface is to weld. Here the surface is checked by using the penetrant which is in the form of spray. It is sprayed over the surface, after 10-15min. The penetrant sprayed is in the form of red colour, it is cleaned by applying kerosene or thinner over the surface sprayed and then the developer is sprayed over the same surface, which will show the cracks, dots, etc., by appearing red colour on the defected area. Then defects are identified and corrected and it will be sent to rolling. The black Japan is coated on the surface to avoid corrosion, it resist the corrosion over the period of (2-3 years), if the kerosene is applied over the surface for to easily clean the coated black Japan. Before rolling, pre bending is done at the edge of the plate as shown in the figure 2.3.

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### Fig: 2.3 Pre Bend Edge Plate

Pre bending is used to get the edges to match after rolling. The figure 2.4 (a) & (b) shows the purpose of pre bending pictorially.

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### Fig: 2.4 (a) & (b)
Therefore to get roundness, we need to prebend the sheet to achieve circularity. After this, it will send to the rolling machine and the sheet is rolled in to shell. After rolling, it is clamped in a welding fixture. Then the long seam start and long seam finish are aligned and the tag is done from LSS to LSF for continuous tag, then the root gap is checked by using feeler gauge. Then after inspection TIG welding is done. The assembled view of booster motor case is shown below,

![Assembled section of Booster Motor Case](image)

**III. REDUCING DISTORTION IN WELDING**

Welding distortion is a thing which cannot be avoided completely. When a weldment is restrained on all sided, the restraint can minimize distortion towards the end of the cooling period. The reduction in the number & cross sectional area of the weld joints in a given weldment, as this will reduce the heat input required for welding. There is a direct relationship between heat input and the magnitude of welding distortion. Therefore welding distortion in a product will be a minimum when the length and cross sectional of its weld joints are kept minimum, we are currently fabricated from large sheets and panel pre assembled at a factory and finally put together onsite.

3.1. Non Destructive Testing

At various stages of fabrication the casing is subjected to Non-destructive test like visible dye penetrant test for surface defects, X-Ray test for internal defects. The fabricated casing is also subjected to specific heat treatment cycles for improving its mechanical properties.

Owing to heat treatment, the concentricity of the component varies. So to make the component concentric the shell is inserted in to a jig and it is hammered by wood or aluminium hammer. After confirming the circularity, the edges are prepared for welding. And X-ray test is carried out in the welding area to check the defect. Then inspection is carried out to check the dimensions and defects. We have seen the process for single shell; the same procedure is followed for all shell. The number of shell is depends upon the length of the motor.

3.2. Proof Pressure Testing

There are many types of testing for ensure its strength of the booster case. The simple and the effective test is proof pressure test. In proof pressure test the two ends of the motor case is closed by using plates with o-rings. At one end, small hole is present, which is used to inject water in to case to increase pressure. At all surfaces of the casing dial gauges are fixed to measure the deflection. For every measure, deflection is recorded.

**IV. RESULT**

Generally 1.5 times of operating pressure is given to the motor case for inspection. If there is no leakage and if the strain is within the limit, the booster will be accepted, else rejected. In this case there will be no leakage in the solid rocket booster case (pressure vessel).

**V. CONCLUSION**

If we adopt the proper material and proper technique of welding, we can reduce the welding defects like radiating cracks, shrinkages cavity, suckback, porosity and underfill. Automatically the production rate can be improved and finished in proper time.

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