**Background**

- Type 410 martensitic stainless steel is currently used for its sulfide corrosion resistance in downstream hydro-processing installations.
- Martensitic stainless steel was chosen over austenitic stainless steels due to its superior resistance to halide and polyphonic acid stress corrosion cracking found in hydro-processing environments.
- Type 410 stainless steel is currently used in applications such as heat exchangers, furnaces, and transfer piping in the form of tubes, pipes, plate, forgings, and castings.

**Motivation**

- Generic E410, ER410 consumables and ASTM A240 base metal result in insufficient weld properties due to wide composition window.
- Due to limited market, modified Type 410 welding consumables with suitable compositions are difficult to acquire.
- A refined composition window is needed to produce acceptable weld properties conducive to petrochemical applications.

**Objectives & Approach**

**Overarching Goals:**
- Development of an optimal composition window of type 410 stainless steels and welding consumables for use in hydro-processing installations that achieve requirements set by both ASME and NACE for toughness, PWHT, and hardness in both the Weld metal and HAZ.
- Comply with AWS and ASTM composition specifications of type 410 stainless steel.
- Development of Holloman-Jaffe parameter for these optimized materials.

**Modified Materials**

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Cr</th>
<th>Mn</th>
<th>Si</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMA 770C</td>
<td>0.03</td>
<td>19.0</td>
<td>0.1</td>
<td>0.4</td>
<td>0.01</td>
</tr>
<tr>
<td>BMB 800C</td>
<td>0.03</td>
<td>19.0</td>
<td>0.1</td>
<td>0.4</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Tempering Schedule**

- Base Material Tempering at 800°C Hardness
- Filler Metal 4.2 Lateral Expansion (mm)

- New Optimizing Algorithm

```
C   Cr   Mn   Si   Other
big | big | big | big | big
mid | mid | mid | mid | mid
low | low | low | low | low
```

**Conclusions & Future Work**

- The Holloman-Jaffe parameter for BMA, BMB, FM 1.2 and 4.2 has been developed.
- Base materials PWHT at upper limit of ASME B31.1 have shown formation of martensite.
- Two 410 filler metal composition have been developed that met ASME and NACE code requirements.
- Characterize HAZ simulation samples and complete tempering response study on compositional optimized 410 consumable and commercial 410 base material.
- Identify refined compositional window, suitable for mass production of Type 410 solid filler wires that meet ASME and NACE toughness and hardness requirements.
- Develop guidelines for material selection, welding and PWHT procedures of Type 410 steel welds.