CHAPTER - 4
MATERIAL AND PROCESS SELECTION

4.1 Base Material selection for experimentation

4.2 Weld consumable selection

4.3 Process selection
MATERIAL AND PROCESS SELECTION

4.1 BASE MATERIAL SELECTION FOR EXPERIMENTATION

The base material, process, experimental procedure for the research work were chosen after a thorough literature survey and the research methodology and parameters for the proposed research work were evolved.

In the present study AISI 1020 is selected as base material due to the following reasons:

- It is a standard grade Plain Carbon Steel used widely in the industrial applications.
- Its properties like strength, elongation, etc mentioned below makes it as the choice for most of the engineering components.
- Its characteristics like machinability, weldability etc mentioned below makes it suitable for many applications.
- AISI 1020 is used widely where sacrificial adhesive wear and mild abrasion conditions are prevailing (previous examples in Sec 3.1).

AISI 1020 steel is composed of (in weight percentage)

- Carbon (C) - 0.18-0.23%
- Manganese (Mn) - 0.30-0.60%
- Phosphorus (P) - 0.04% (max)
- Sulphur (S) - 0.05% (max)
- Base metal Iron (Fe) - remaining

Other designations of AISI 1020 carbon steel include UNS G10200 and AISI 1020 [81].
The following are the properties of this steel:

### TABLE: 4.1 PROPERTIES OF AISI 1020 STEEL

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (×1000 kg/m$^3$)</td>
<td>7.7-8.03</td>
<td>25</td>
</tr>
<tr>
<td>Poisson's Ratio</td>
<td>0.27-0.30</td>
<td>25</td>
</tr>
<tr>
<td>Elastic Modulus (GPa)</td>
<td>190-210</td>
<td>25</td>
</tr>
<tr>
<td>Tensile Strength (MPa)</td>
<td>394.7</td>
<td>25 Annealed at 870°C</td>
</tr>
<tr>
<td>Yield Strength (MPa)</td>
<td>294.8</td>
<td></td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>36.5</td>
<td></td>
</tr>
<tr>
<td>Reduction in Area (%)</td>
<td>66.0</td>
<td></td>
</tr>
<tr>
<td>Hardness (HB)</td>
<td>111</td>
<td>25 Annealed at 870°C</td>
</tr>
<tr>
<td>Impact Strength (J) (Izod)</td>
<td>123.4</td>
<td>25 Annealed at 870°C</td>
</tr>
<tr>
<td>Thermal Expansion (10$^{-6}$/°C)</td>
<td>14.8</td>
<td>20-700 Annealed</td>
</tr>
</tbody>
</table>

The following are the characteristics of this steel:

- 1020 is one of the very commonly used plain carbon steels. It has a low carbon content of 0.20% with approximately 0.50% manganese. It is a good combination of strength and ductility and may be easily hardened or carburized.

- 1020 steel is used for application like machine parts, cold headed bolts, deep drawing parts, chain, pipe, wire, nails, etc. It can also be used in the case hardened condition.

- 1020 steel has good machinability at 65% compared to 1112 carbon steel as 100% baseline.

- 1020 steel has good formability when processed by all conventional methods as its ductility is good.

- 1020 is also readily welded by all of the standard welding methods.
- 1020 can be easily hardened followed by water quenching. It should then be tempered. More often it is used as case hardened by carburizing. The cost of doing any heat treatment to such low carbon steel often precludes doing so for the modest return in mechanical properties obtained.
- 1020 can be easily forged even at less temperature.
- 1020 steel is readily cold worked and also hot worked by all conventional methods.
- Full annealing is done to 1020 steel to give a good tensile strength. A stress relieving annealing can also be done.
- Tempering can be done after heat treatment and quenching, for 1020 steel depending upon strength level desired.
- 1020 steel hardens by cold working also.

4.2 WELD CONSUMABLE SELECTION

It was concluded in a research work [82] that weldability of steels depends on the base metal and filler metal (weld consumable), as well as the conditions in which the welded construction was made and the quality of construction. Of all the factors, the base metal has the greatest impact. Mechanical and technological properties of welded joints are directly dependent on the chemical composition (base metal and filler metal) and the structure of the weld metal and the heat-affected zone (HAZ). [79, 83]

In the present research it was proposed to study the effect of the welding process on the wear characteristics of the hard faced part depositing the same material which is used as base material, but by a different process, so that a better process can be suggested for a particular wear condition. Hence in the present study AISI 1020 steel has been used for Base material as well as for the Weld Consumable.
4.3 PROCESS SELECTION

The following process are proposed for the present research:

1) Oxy - Acetylene Gas Welding
2) Arc welding (SMAW)
3) TIG Welding

The reasons for selecting the above processes are:

- Though processes like PTA have better advantages compared to the processes selected by the researcher, it suffers with the following disadvantages:
  1) Uneconomical.
  2) It is not flexible and cannot be used in outdoor environment, especially when it comes to repair of worn out parts compared to hardfacing.
- These are most generally available processes in most of the industries and hence do not need separate investment for equipment.
- The aim of the present research was to reduce the cost of hardfacing by using simple processes and available general material.
- The aim of the present research was also to optimise the available process in the local vicinity in order to reduce the failure rate.

4.3.1 Hardfacing with the Oxy-Acetylene Torch

The oxy-acetylene welding or Gas welding torch can be used to deposit all four types of materials listed above (Sec 2.1). So can several arc welding processes. Generally, the arc processes are much faster; that is, more amount of alloy can be deposited in one hour of work, or more area of surface covered in one hour. However, oxy-acetylene hard-facing is often preferred for one of the following reasons:
1. The dilution of the hard-facing alloy by base metal melted during the welding process can be held to a minimum. When iron-base alloys are used on steel, this factor may not be of much importance; the alloy can be selected with the dilution factor in mind. However, when the cobalt-base and nickel-base alloys are used, minimum dilution of the deposit by the base metal is of great importance. A skilled oxy-acetylene operator, using the techniques to be described shortly, can hold the dilution of the alloy by the base metal below 6%. With the electric arc processes, dilution rates from 15-25% must be expected.

2. The thickness of deposit can be minimized. Especially in the case of the costly cobalt-base alloys, this can be quite important. With the oxy-acetylene torch, a skilled operator can deposit a layer of cobalt-base alloy which is only about 1 mm thick. Only one arc process, using fully mechanized equipment costing thousands of dollars, can do as well. While it is hard to think of an application where a 1 mm deposit, before finish machining, would be employed, for many applications it is desirable to hold the thickness of the deposit, after finishing, to 2 mm or less. Since the only practicable way to obtain absolute minimum dilution of the finished surface metal is to deposit at least two layers of hard-facing alloy, one over the other, the oxy-acetylene process has a real advantage in applications where minimum thickness of finished deposit is desirable or essential.

3. The welding equipment can always be brought to the work, rather than vice-versa. No other type of welding equipment is as portable as an oxy-acetylene outfit.

4.3.2 Hardfacing with Manual Metal Arc Welding

In this process an arc is drawn between a coated consumable electrode and the work piece. The metallic core-wire is melted by the arc and is transferred to the weld-pool as molten drops. The electrode coating also melts to form a gas shield around the
arc and the weld pool as well as a slag on the surface of the weld-pool, thus protecting the cooling weld-pool from the atmosphere. The slag must be removed after each layer. Manual Metal Arc welding is still a widely-used hardfacing process. Due to the low cost of the equipment, the low operating costs of the process and the ease of transporting the equipment, this flexible process is ideally suited to repair work. This is preferred due to the following reasons:

1. Flexible
2. Low cost
3. Mobile
4. Ideal for repairs

### 4.3.3 Hardfacing with Tungsten Inert Gas (TIG) Welding

In TIG (Tungsten Inert Gas) welding, an arc is drawn between a non-consumable tungsten electrode and the work piece. The electrode, the arc and the weld-pool are protected from the atmosphere with an inert shielding gas. For manual welding the hardfacing material is in the form of a rod. Advantages of the TIG process include simple manual operation and good control of the welding arc. The process can also be mechanised, in which case a manipulator is used to move the work piece in relation to the welding torch and the hardfacing rod or wire. Rods are also used for hardfacing with the oxy-acetylene welding process. With the correct operation, a very low level of iron dilution can be achieved in the overlay. The advantages are:

1. Manual operation
2. Can be mechanised
3. Low dilution
BIBLIOGRAPHY

carbon_steel--aisi_1020.cfm

Influence on Weld Metal Structure of Microalloyed Steel”, Supplement to the

[83] Mei Zhana, Hongfei Dua, Jing Liua, Ning Rena, He Yanga, Haomin Jiangb,
Keshan Diaob, Xinpin Chenb, “A method for establishing the plastic
constitutive relationship of the weld bead and heat-affected zone of welded
tubes based on the rule of mixtures and a microhardness test”, Materials