How to Save Millions Thru Repair and Maintenance Welding Technique

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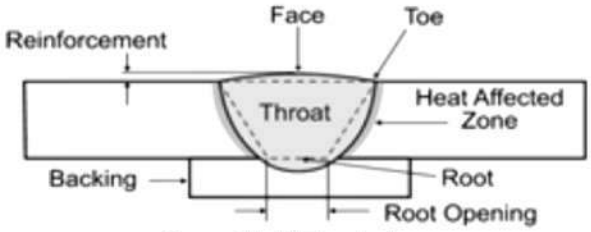
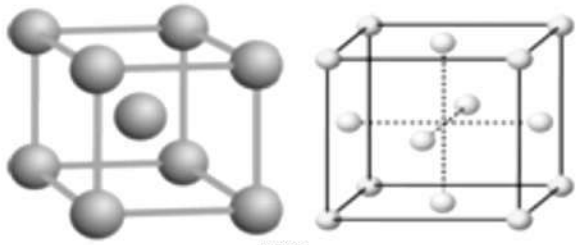
The world has limited deposits of mineral resources. However, the depletion rate is resulting from increase in population, growth and development of industries, and consumption of raw materials that is on the rise. The consumption of new materials can be reduced by increasing the working life of components by recommending and implementing value added solutions. This will add further in reducing inventories, machinery down time and inventory costs. Therefore, reclamation and re-cycling of vital machinery components assumes high priority.

To suggest a suitable reclamation solution, the recommended electrode is to be deposited through a process called welding. Welding is defined as a process of joining two or more metals which are similar / dissimilar in nature, with or without flux, with or without filler so that the joint will be of homogenous in nature or superior to base metal properties. A typical weld along with its nomenclature is shown in **Fig. 1**.

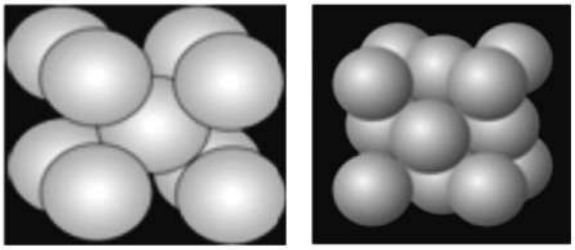


Groove Weld Terminology
Fig. 1

Most of the parts one uses in any industry are of ferrous metals, hence, this author limits the discussions/solutions to ferrous metals only. When liquid metal solidifies from its melting point, structure will be crystalline - either BCC or FCC at room temperature. Metals shown in **Fig.2** have different atomic structures. These are shown in **Fig.2** and **Fig.3** as appropriate.



BCC



FCC

Fig. 3

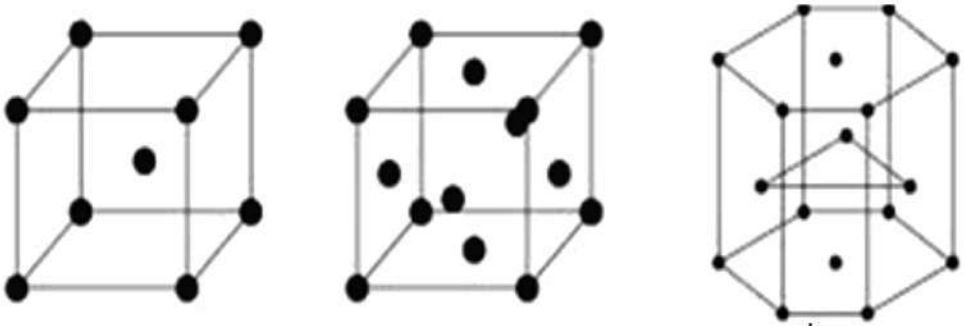


Fig. 2

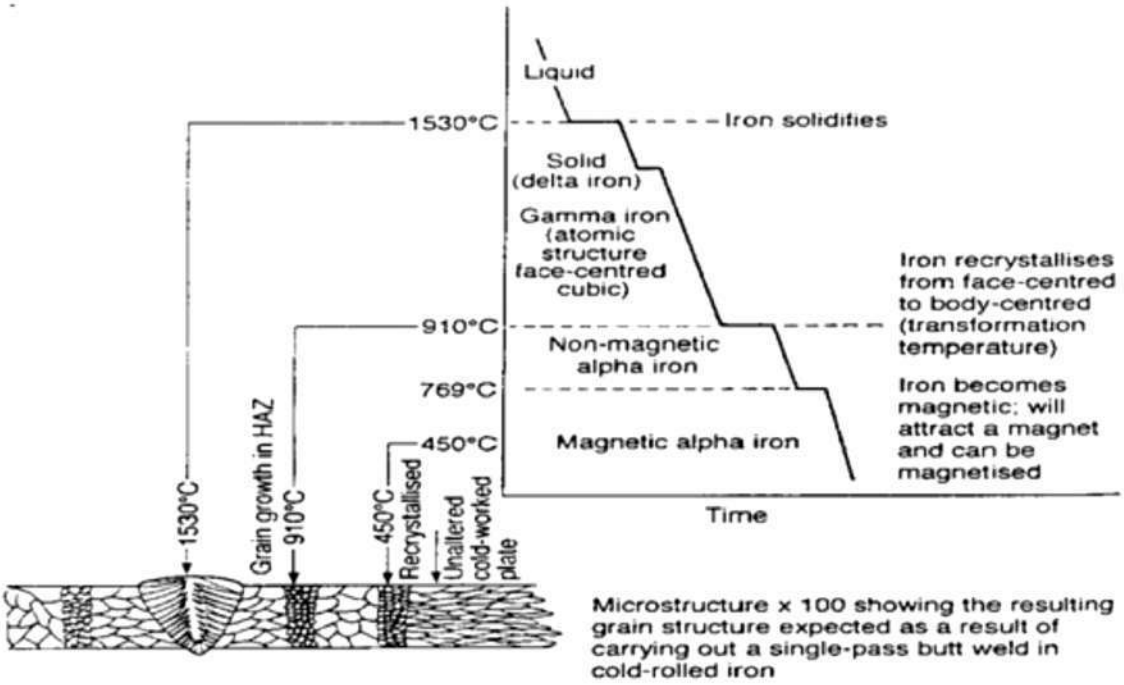
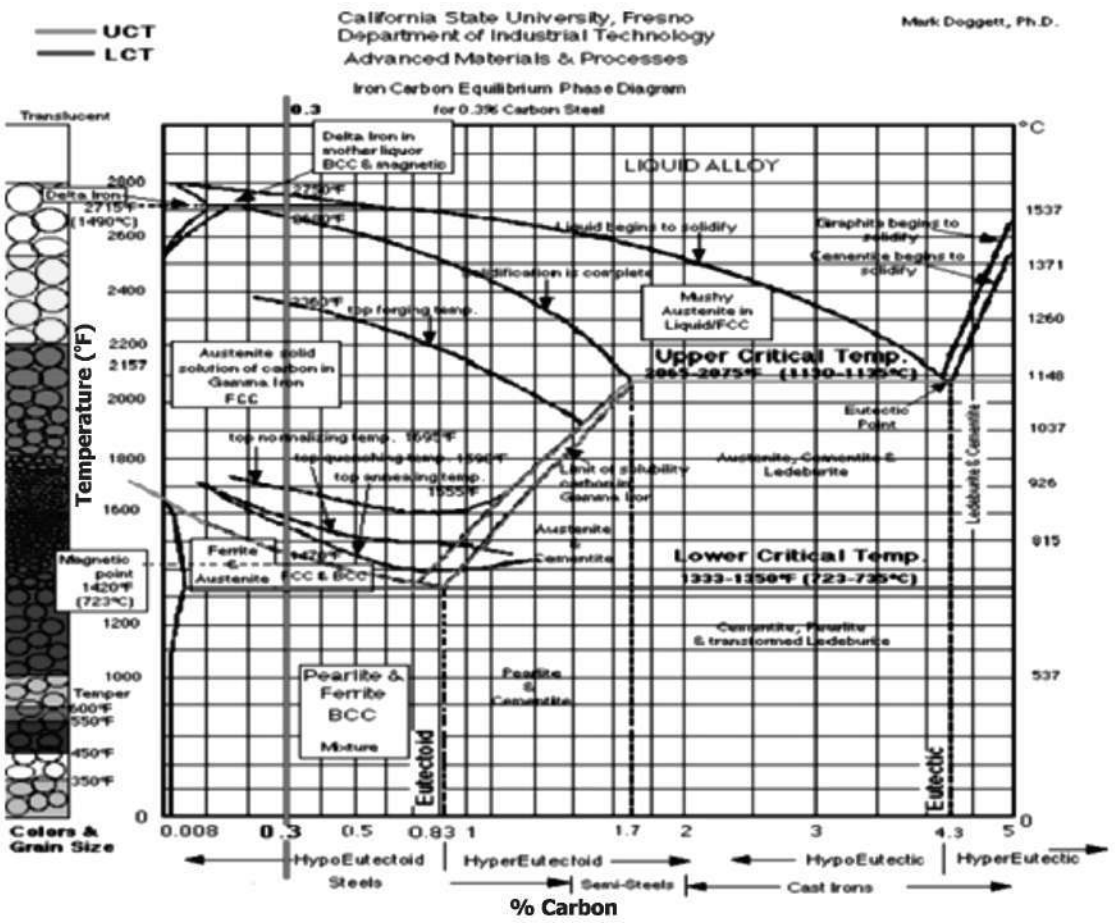

Liquid
1530°C
Iron solidifies
Solid
(delta iron)
Gamma iron
(atomic
structure
face-centred
cubic)
Iron recrystallises
from face-centred
to body-centred
(transformation
temperature)
910°C
Non-magnetic
alpha iron
769°C
Iron becomes
magnetic; will
attract a magnet
and can be
magnetised
450°C
Magnetic alpha iron
Time
1530°C
Grain growth in HAZ
910°C
450°C
Recrystallised
Unaltered
cold-worked
plate
Microstructure x 100 showing the resulting
grain structure expected as a result of
carrying out a single-pass butt weld in
cold-rolled iron

Fig. 4


UCT
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Advanced Materials & Processes
Mark Doggett, Ph.D.
Iron Carbon Equilibrium Phase Diagram
for 0.3% Carbon Steel
Translucent
Delta Iron in another liquor BCC & magnetic
LIQUID ALLOY
Liquid begins to solidify
Solidification is complete
Mushy Austenite in Liquid/FCC
Upper Critical Temp.
Austenite solid solution of carbon in Gamma Iron FCC
top forging temp.
top normalizing temp.
top annealing temp.
Eutectic Point
Austenite, Cementite & Ledeburite
Limit of solubility carbon in Gamma Iron
Austenite & Cementite
Lower Critical Temp.
Ferrite & Austenite FCC & BCC
Magnetic point 1420°F (723°C)
Cementite, Pearlite & transformed Ledeburite
Pearlite & Ferrite BCC Mixture
Pearlite & Cementite
Eutectoid
Eutectic
Ledeburite & Cementite
Temperature (°F)
°C
Temper
Colors & Grain Size
0.008
0.3
0.5
0.83
1
1.7
2
3
4.3
5
HypoEutectoid Steels
HyperEutectoid
Semi-Steels
HypoEutectic
Cast Irons
HyperEutectic
% Carbon

Fig. 5

When ferrous metal is subject to heat by welding what happens in the process to form HAZ of the base metal is clearly shown in **Fig. 4.**

The iron which is known also as allotropic metal occupies different crystalline structures at different temperatures and carbon percentages. This is given in **Fig. 5** below. There are mainly 3 phases for iron, i.e., ferritic structure which is soft, austenitic structure which is tough and martensitic structure which is hard. Whenever welding is carried out, base metal is of either ferritic or austenitic structure.

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A simplified version of carbon equilibrium diagram is shown in **Fig. 6** for better understanding.

Classification of Steels: For better understanding, steel is classified in to

1. Plain carbon steels
   - Low carbon steels : up to 0.30%C
   - Medium carbon steels: 0.30-0.60% C
   - High carbon steels: 0.60-1.70% C
2. Alloy steels
3. Stainless steels

When one comes across a steel component which has cracked/ worn out, it can be repaired instead of replacing with a new component (this will be 70-80% cheaper, better and faster compared to a new part) when one tries to do repair welding, one advises to use low heat input welding electrodes which will produce low heat input in to base metal, give high factor of

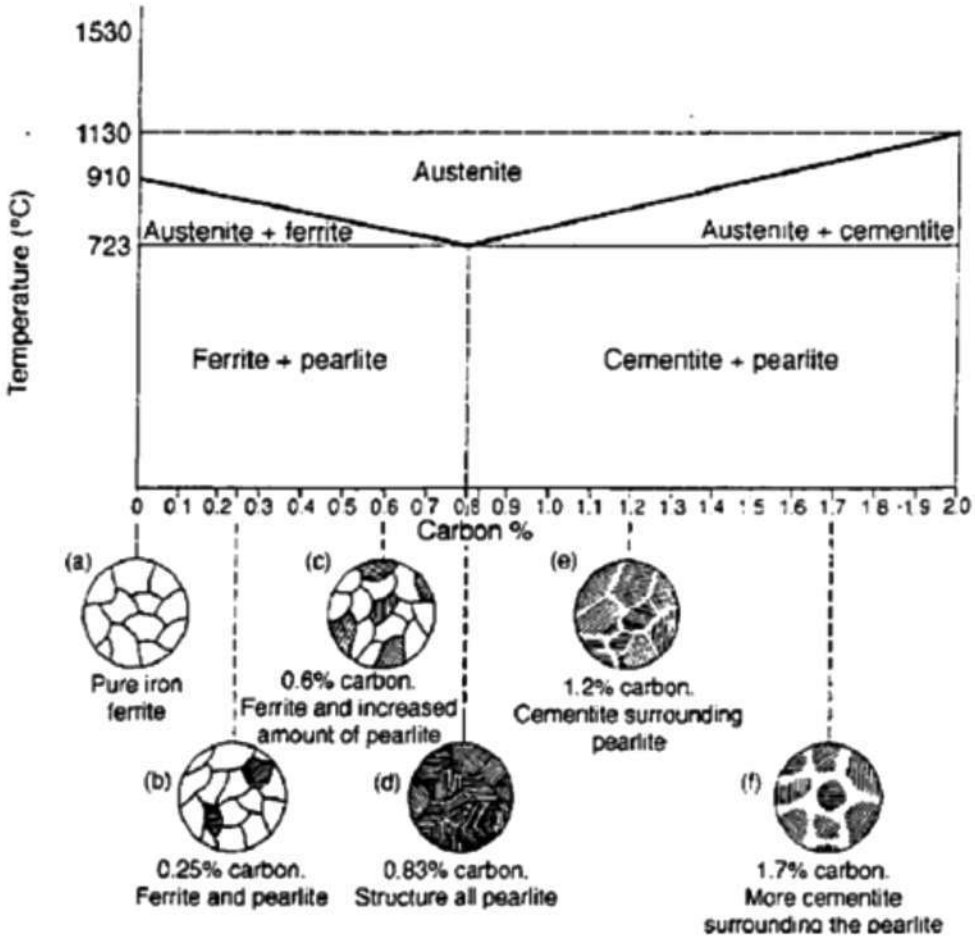

Fig. 6

safety and compatibility over wide variety of base metals such as low carbon steel, medium carbon steels, low alloy steels, high alloy steels, spring steels, manganese steels etc., For example, LH 106 is a low heat input welding electrode for SMAW process giving an UTS of 1,20,000 PSI and needs only 25-30 Amps of current for 1.6mm size.

For a successful reclamation of a component, one needs to follow correct procedure of welding depending on the type of base metal. When steel with carbon more than 0.3% is welded, it develops martensitic structure at the HAZ which is hard. Any hard structure, when load is applied, may develop cracks, and hence, failure is the result. Therefore pre-heating the job becomes very important. The following are the most important steps in successful welding of steels, alloy steels.

1. To pre-heat the base metal depending on its carbon equivalent.
2. To maintain inter-pass temperature below 200°C.
3. To post heat the job to 450°C and to slow cool to room temperature.

The welding rod selection should be nearest to base metal composition or alternatively higher range. Some of the jobs in different fields like cement, power mining, steel, paper, etc. are shown in **Fig. 7** through **Fig. 12** with considerable amount of savings for the benefit of the reader.

Table 1

Application	**Crusher Shaft**
Product	LH-106
Cost of Reclamation	Rs. 0.5 L
Approx. Savings	Rs. 1.5 L

Table 2

Application	**Excavator Bucket**
Product	LH-108/O-7020/P-7050
Cost of Reclamation	Rs. 1.2 L
Approx. Savings	Rs. 1.80 L

Table 3

Application	**Excavator Bucket**
Product	LH-713/Tubular Alloy 1
Cost of Reclamation	Rs. 1.50 L
Approx. Savings	Rs. 3.00 L

Table 4

Application	**Kiln**
Product	LH-104/LH-521
Cost of Reclamation	Rs. 10.00 L
Approx. Savings	Rs. 50.00 L

Table 6

Application	**Support Roller**
Product	LH-104/LH-128/LH-710
Cost of Reclamation	Rs. 3.50 L
Approx. Savings	Rs. 8.00 L

Table 5

Application	**Base Metal**	**Product**	**Cost of reclamation**
Thrust roller	Carbon steel	LH 104/LH710	RS.0.60L
Immersion tubes	SS 310	LH 126	RS.1.30L
Tip Casting	HK 40	LH 126/TA4CXX	RS. 3.50L
HIC Rotor	HK40	TA5	RS.0.80L
Feeder screws	Carbon steel	LH 720	RS.0.30L
Table liner plates	HC-HCr	LH 7450	RS.2.50L.
Compressor Piston	Al	LH 409	RS.0.20L

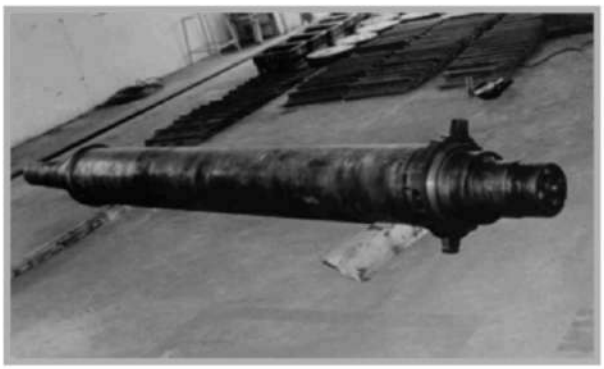

Fig. 7 : Refer Table 1

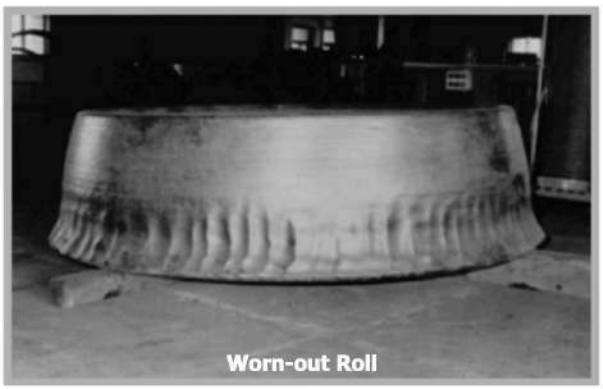

Fig. 10 : Refer Table 4

Fig. 8 : Refer Table 2

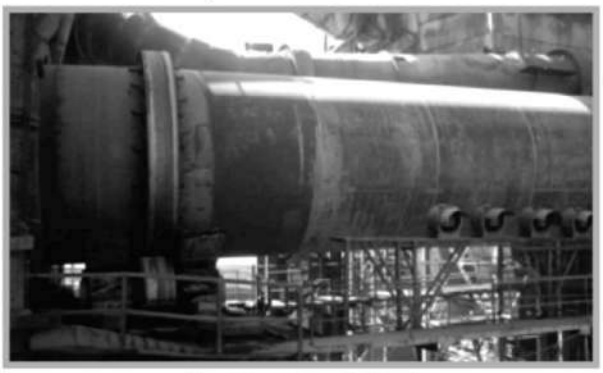

Fig. 11 : Refer Table 5

Fig. 9 : Refer Table 3

Fig. 12 : Refer Table 6