Case Studies in Steel

Welding

Background

- Many steel structures held together by welds (bridges, ships pressure vessels)
- Fractures that occur often linked to weaknesses in the weld
- Alexander Keilland oil platform (1980)

Alexander Keilland Oil Platform

- Situated 235 miles east of Dundee, Scotland in the North Sea
- Owned by Phillips Petroleum (USA)
- The platform is a semi-submersible that floats on two pontoons with legs supporting the main deck. It houses workers while they carry out jobs on the oil rigs (similar to a 5-leg stool)

Alexander Keilland Oil Platform

- Original purpose was to travel place to place in the North Sea to locate oil beneath the sea floor
- Each leg constructed of steel members that were each supported on a pontoon
- Fabricated by a French company in 1976
- Considered obsolete therefore oil company decided to use it as a floating hotel for drilling crews

Alexander Keilland Oil Platform

- On March 27, 1980 gale force winds caused the platform to collapse and capsize into the sea killing 123 people
- A previously undetected crack in one leg of the platform is thought to be the reason the structure gave way
- Experts believe it took 15 minutes for the platform to collapse into the sea

Alexander Keilland Oil Platform

- Probably due to bad welding a crack of 80 mm in size was already present in one of the struts that connected the 5 legs together (small weld bead on a massive plate)
- In service crack expanded each time a new wave hit the strut
- Crack propagated undetected until it reached 2/3 the circumference of the strut before it caused failure
- On March 27, 1980 gale force winds caused the platform to collapse and capsize into the sea killing 123 people
- When the strut failed the fifth leg got loose, creating an unstable structure which flipped upside down and killed 2/3 of the people on board.

Typical weld operation

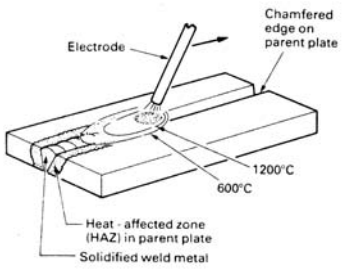


Fig. 13.6. Schematic of a typical welding operation.

- Electric arc struck between the electrode and parent phase
- Heat from arc melts filler metal dimensions
- Some parent material melted back
- As arc moves away molten steel solidifies rapidly fusing plates together

Temperature

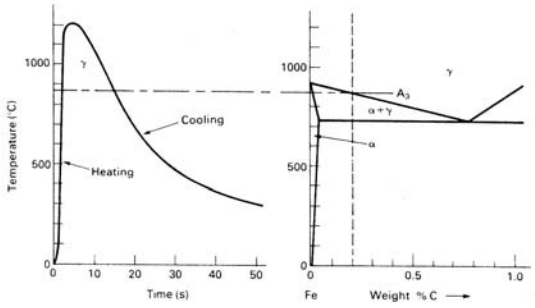
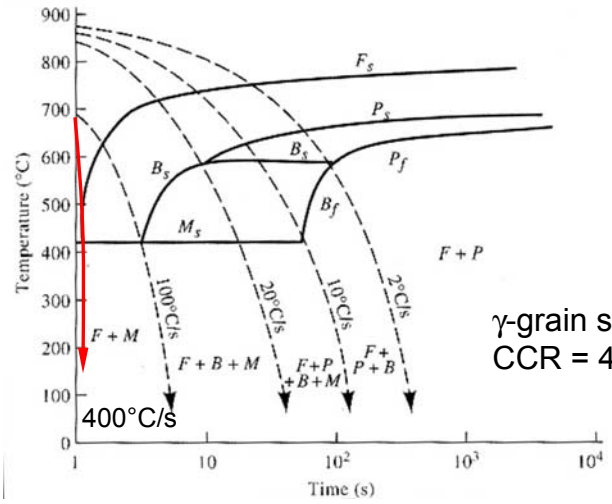


Fig. 13.7. The left-hand graph shows how the temperature at one point in the parent plate changes as the welding arc passes by. The point chosen here is quite close to the edge of the plate, which is why it reaches a high peak temperature. A point further away from the edge would not reach such a high peak temperature.

HAZ

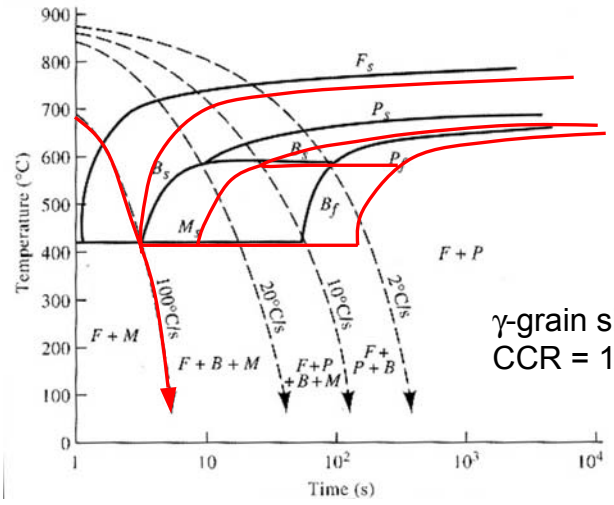
- Section of plate heated above ~650°C experiences a change of mechanical properties (HAZ)
- Most critical changes occur when T >A_3
- Cooling rates ~100°C/s
- Fine grained steel CCR > 400°C/s (therefore little martensite forms)
- At temperatures of 1400°C, diffusion rapid and grain growth occurs
- CCR much lower (effect of γ-grain size!!)

CCT Diagram



γ-grain size = 8
CCR = 400°C/s

CCT Diagram



γ-grain size = 4
CCR = 100°C/s