



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

Failure Analysis and Prevention

General Procedure of Failure Analysis: Metallography of failed components

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Purpose of metallography

- Class of metal: desired/undesirable features e.g. grain size, orientation, micro-discontinuities pores, inclusions
- Estimation of chemical composition
- Determining effect of service condition e.g. precipitation of chromium carbide, iron nitride, loss/enrichment of alloying elements
- Method of manufacturing casting forming
- Heat treatment : manufacturing or accidental



Purpose of metallography

- Effect of other conditions such corrosion, oxidation work hardening
- Characteristics of cracks and mode of crack propagation
- Factors responsible for crack nucleation and their growth



Sample correction for metallography

- No general rule
- Usually taken from near fracture surface or location which developed defects
- A location representative of sample
- Fracture surface it self to study path of crack growth
- Fatigue fracture: region of crack initiation for defects, decarburizing, inclusion and pores

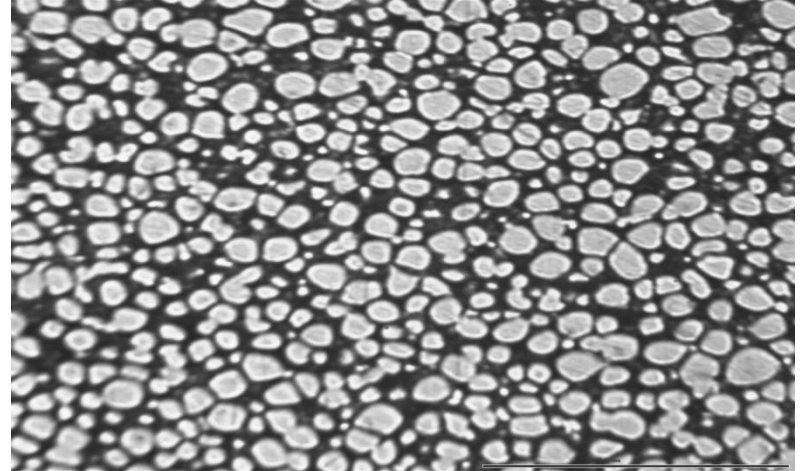
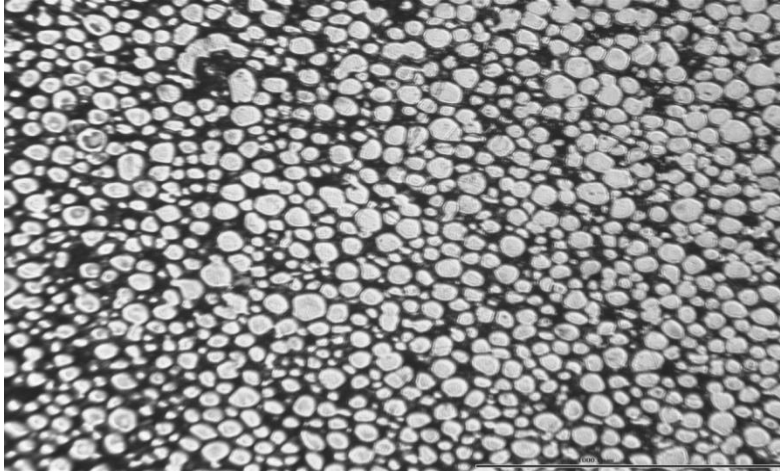


What to observe

- Micro-structure: phase and grain structure
- Segregation
- Decarburising,
- Carbon pick
- Improper heat treatment
- IG corrosion
- Martensite formation

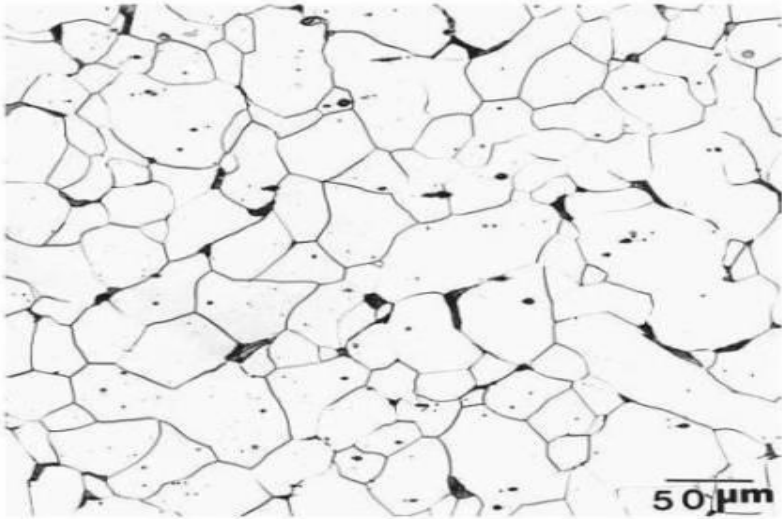


Microstructure analysis



- Grain structure: Size, shape and distribution
- Phase structure: Type of phase, their relative amounts and distribution
- Image Analyzing software:
 - Image J and
 - Dewinter “Materials Plus”

Composition estimation

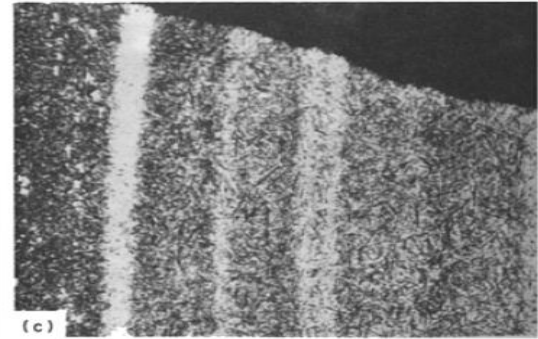
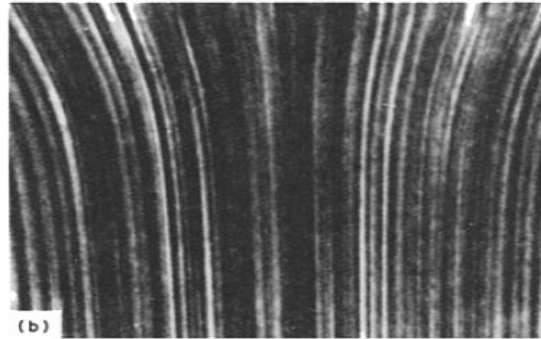
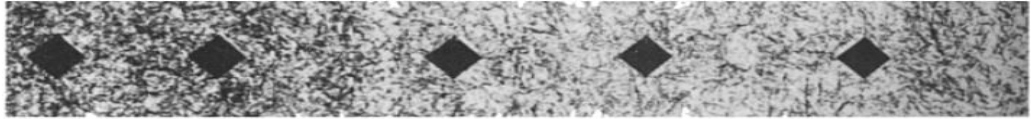
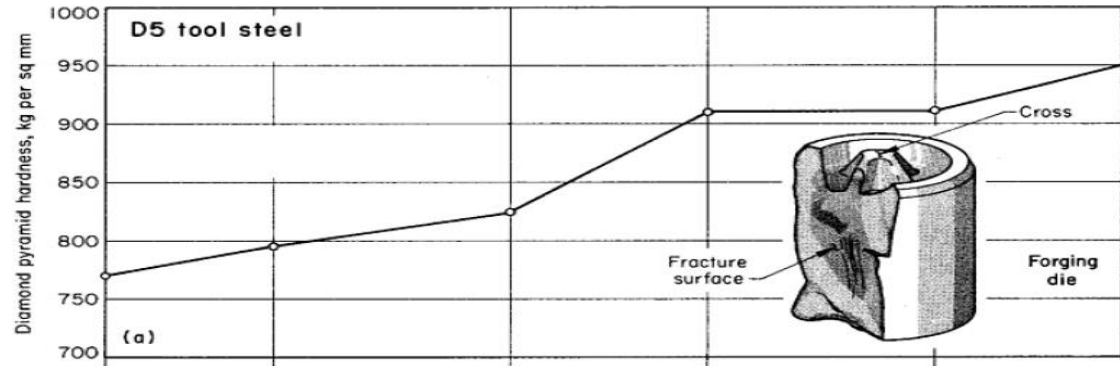


Low-carbon AISI/SAE 1010 Steel

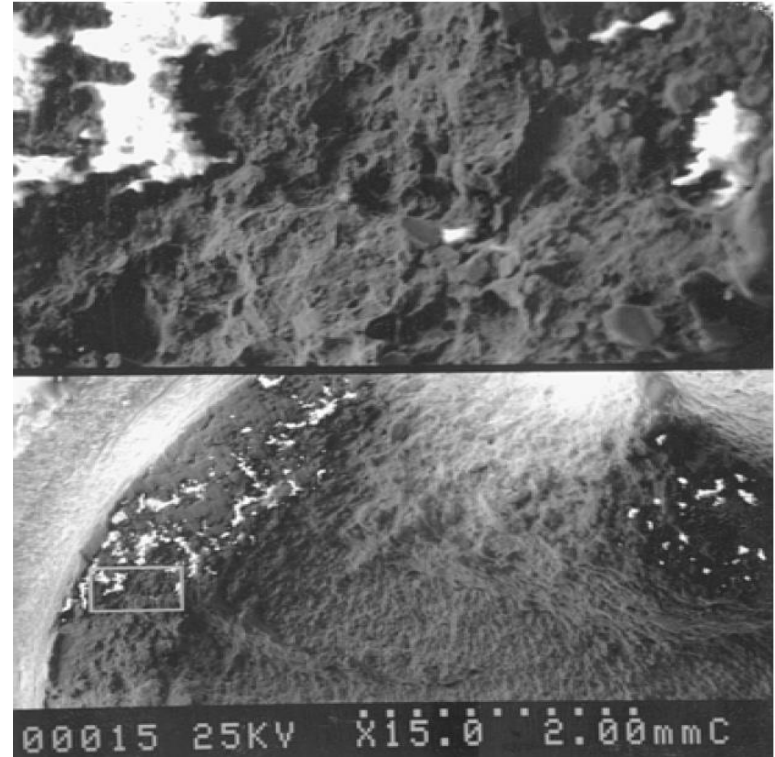


Medium-carbon AISI/SAE 1040 Steel

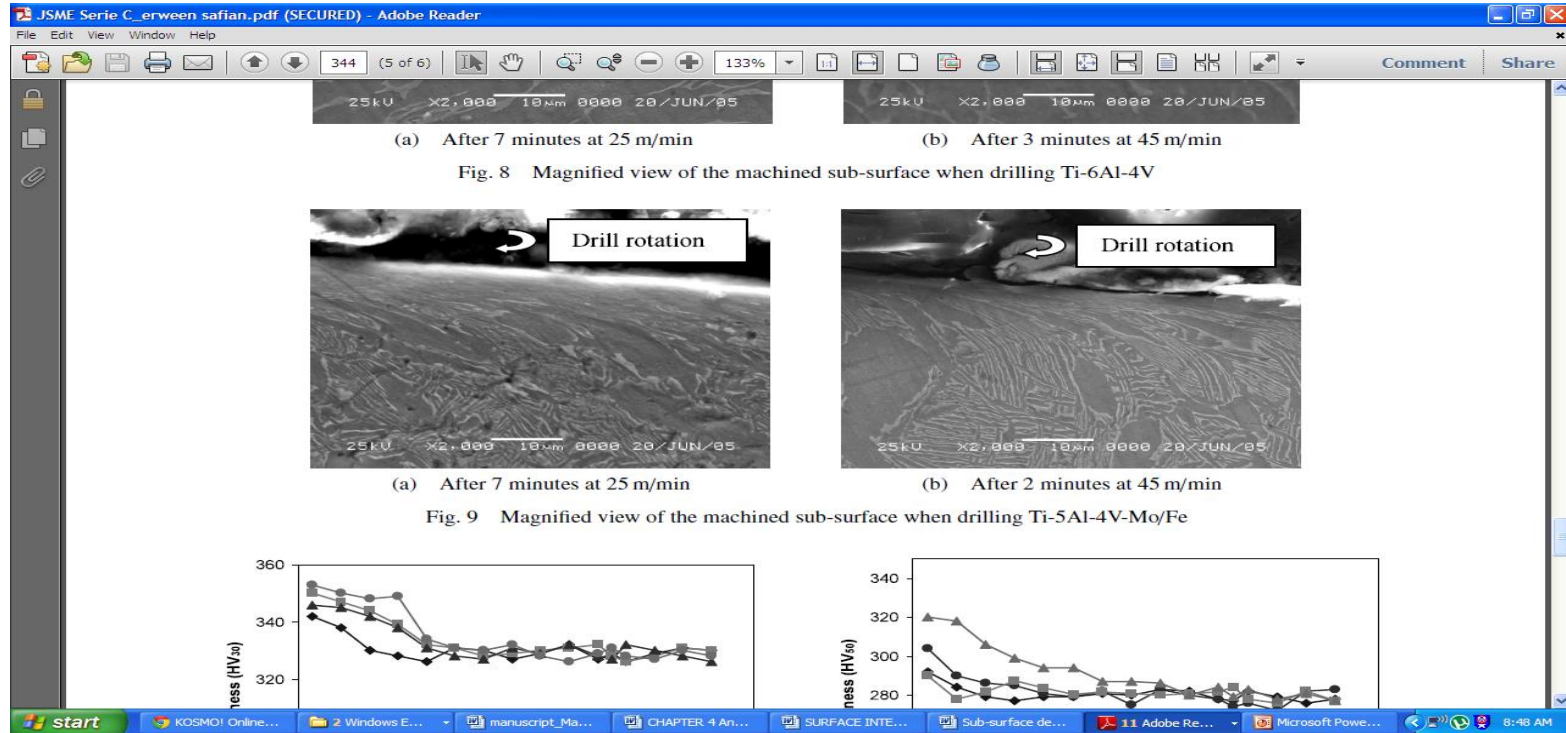
Segregation



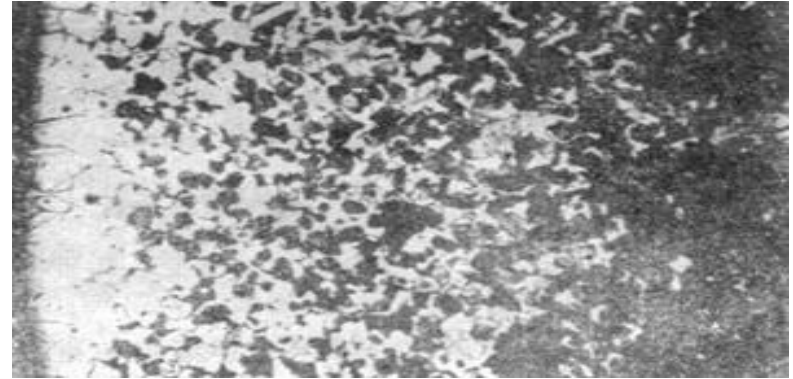
Segregation



Sub-surface deformation



Decarburization



Overheating and carburization

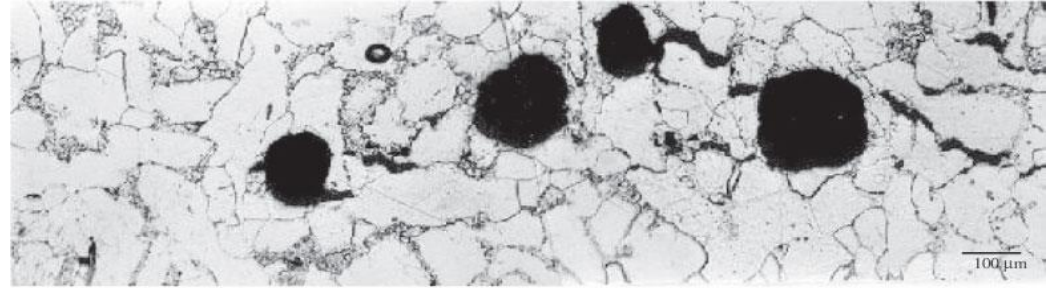


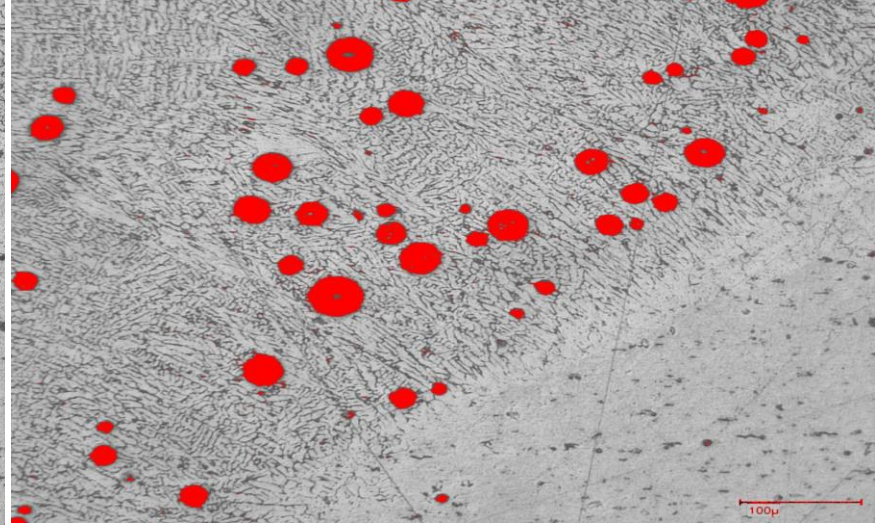
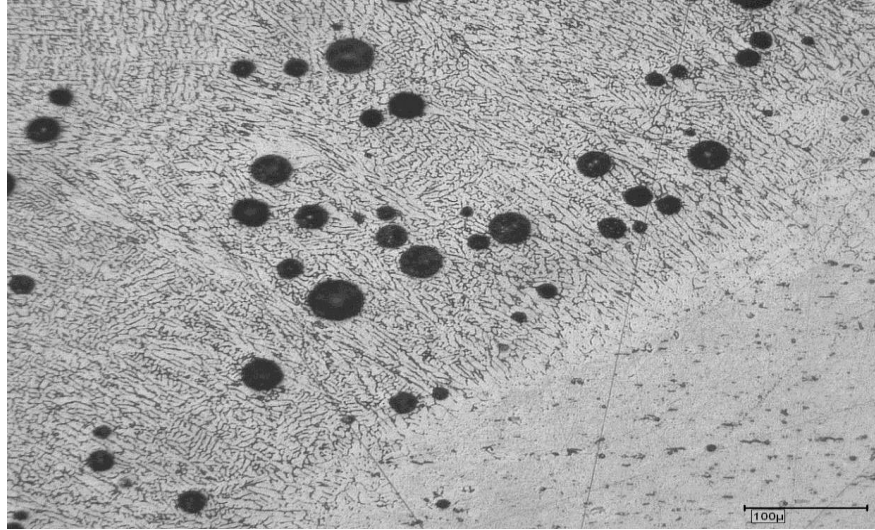
Figure 5. Voids formed by methane in a carbon steel exposed to a hydrogen atmosphere at high temperature. The carbides in the pearlite have been eliminated by reaction with the hydrogen. Photograph courtesy of T.L. da Silva.

Microstructure

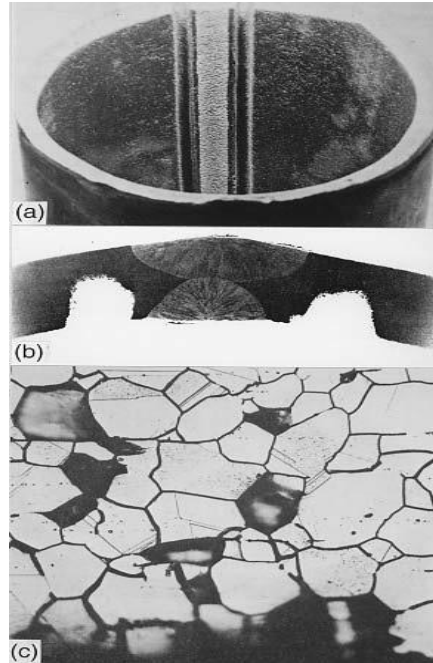
- Grain structure
 - Size
 - Shape
 - Distribution
- Phase structure
 - Type of phases
 - Relative amounts
 - Distribution



Porosity measurement



Weld failure AISI 304 in HNO₃



Typical microstructures

