element

MICROSTRUCTURE ANALYSIS

STUDYING MATERIALS STRUCTURE SUPPORTS PROPER SELECTION AND UTILIZATION

BACKGROUND

The successful application of materials in industrial practice is dependent on the material properties, which are intimately connected to the material structure.

The structure of a material is the result of its composition and processing history, including heat treatment, forging, extrusion, and rolling. Changes in the structure have an impact on material properties, which in turn can affect the performance of a product.

Microstructure analysis is a valuable tool to gain information on how the material was made and the quality of the resulting material. Through a microstructural examination, one can determine if a component was made from specified material and if the material received the proper processing treatment.

Whether you are in research and development (R&D) or quality control (QC), microstructure analysis helps you understand if the material you are incorporating into your project is suitable for its intended purpose. It determines if the structural parameters of a material are within certain specification, and is, therefore, employed as a criterion for acceptance or rejection.

Studying the structure of a material under magnification is also an important part of failure analysis, allowing investigation of components and products that fail during service or do not operate as intended.

CONTENTS

CASE STUDY

MICROSTRUCTURE EXAMINATION OF FOUR CROSS-SECTIONS OF STAINLESS STEEL TUBES

This case study involves four transverse cross-sections of AISI 430 stainless steel tubes having a wall thickness of 0.031" and an outside diameter (OD) of 0.312".

Some of these tubes cracked during forming. It was suspected that a difference in microstructure existed and that this would be the reason why they failed.

A microstructural examination of the tubes for each of the four cross-sections was therefore performed to study the structure of the tube and determine the cause of failure.

The four samples were identified as follows:

- Sample 1 - Vibe tested sample
- Sample 2 - Fractured sample
- Sample 3 - Cracked sample
- Sample 4 - Second vibe sample

MICROSTRUCTURE ANALYSIS

To ensure accurate observation and interpretation of the microstructure, specimens were appropriately prepared.

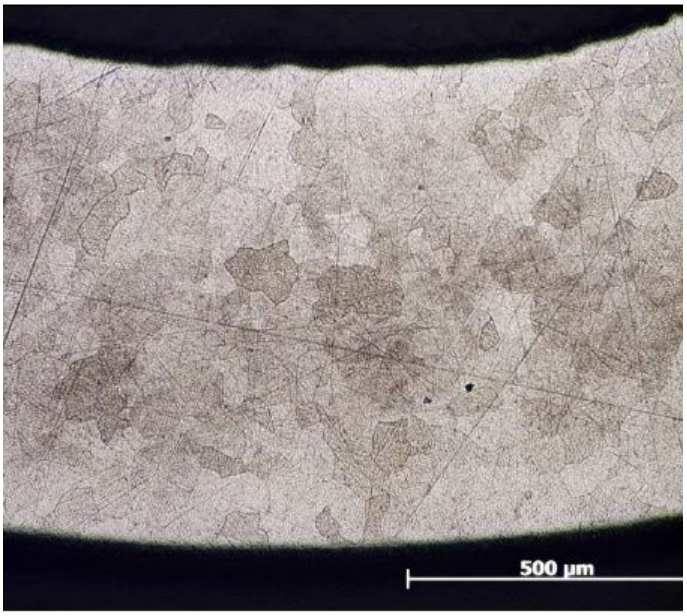
The first steps performed were grinding and re-polishing of the four as-received transverse cross-sections that were mounted in an acrylic-type clear medium in accordance with the standard practices of the current revision of ASTM E3.

The finished cross-sections were examined in the etched conditions using a metallurgical microscope at magnifications up to 500X.

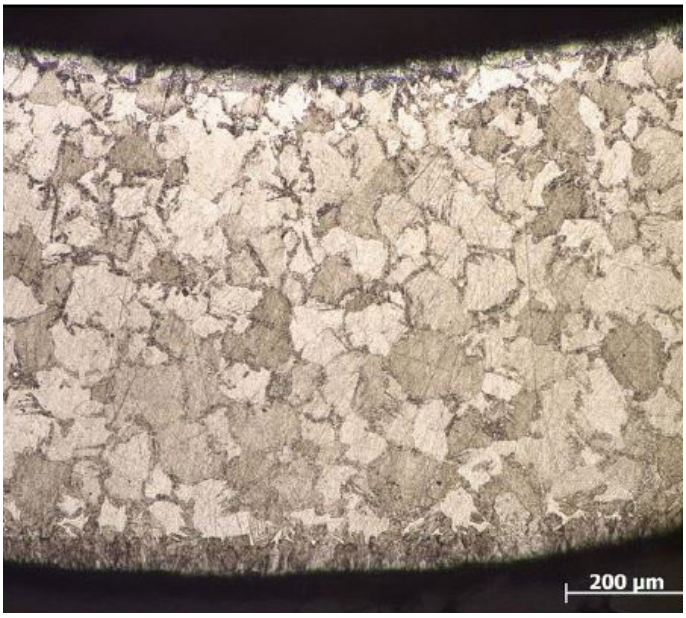
LOW MAGNIFICATION

The microstructural examination started out with a low magnification of the four samples at 100X. Photographs 1 to 4 are a low magnification view of the transverse cross-section of the tube wall as seen in the etched condition.

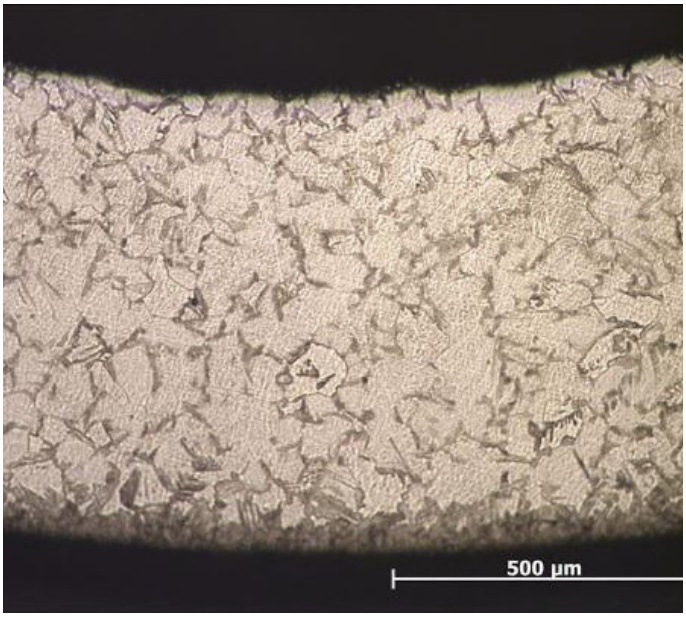
All four photographs show ferrite grains with a grain size of 3 per ASTM E112. Samples 2 and 3 also show a network of tempered martensite along the ferrite grain boundaries and on the OD surface of the tube.



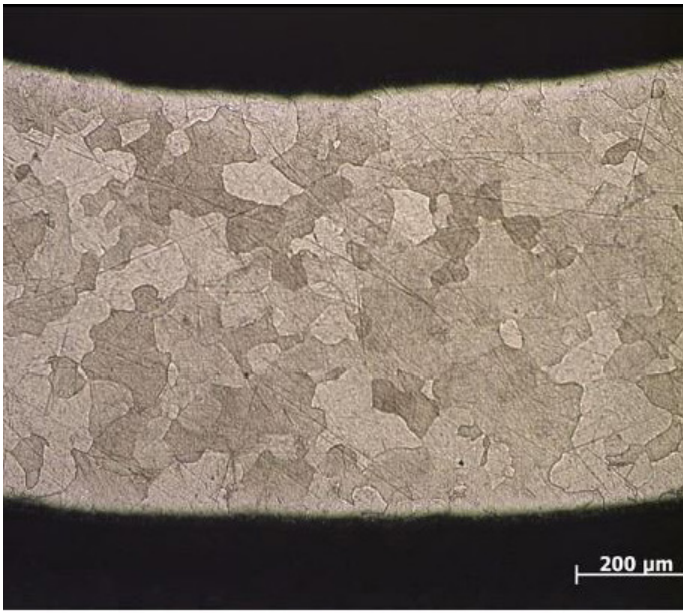
Photograph 1: low magnification of sample 1



Photograph 2: low magnification of sample 2



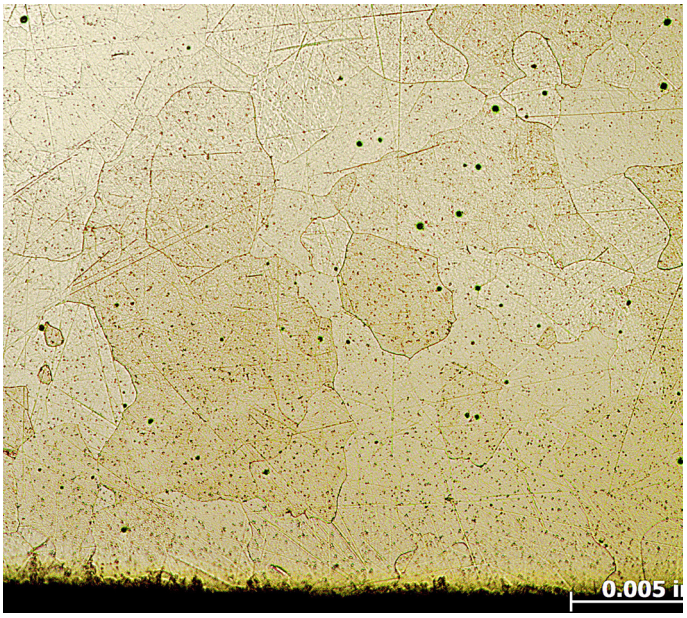
Photograph 3: low magnification of sample 3



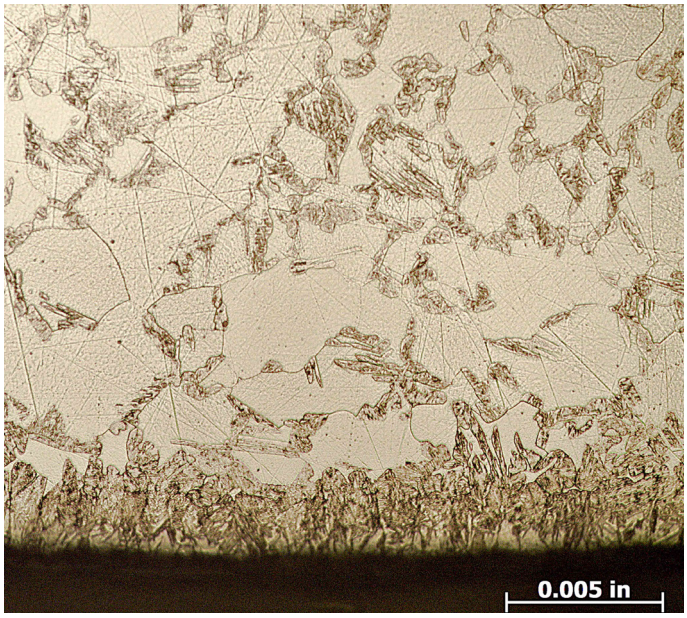
Photograph 4: low magnification of sample 4

INTERMEDIATE MAGNIFICATION

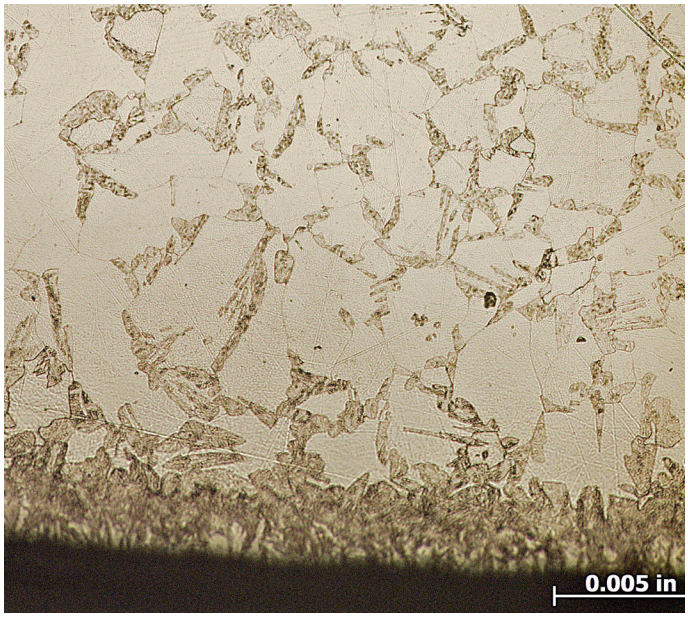
The samples were subsequently analyzed at 200X. This intermediate magnification ensured a clearer examination of the samples and allowed focusing in on the tempered martensite exhibited on samples 2 and 3.



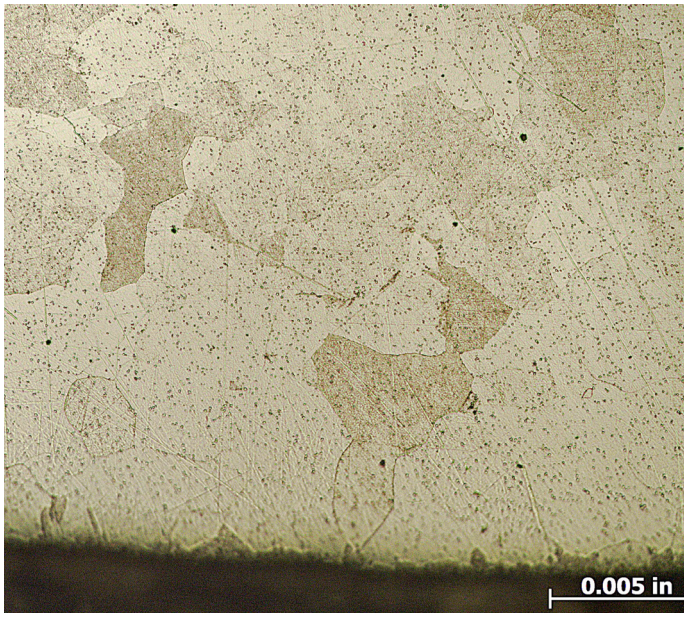
Photograph 5: intermediate magnification of sample 1



Photograph 6: intermediate magnification of sample 2



Photograph 7: intermediate magnification of sample 3



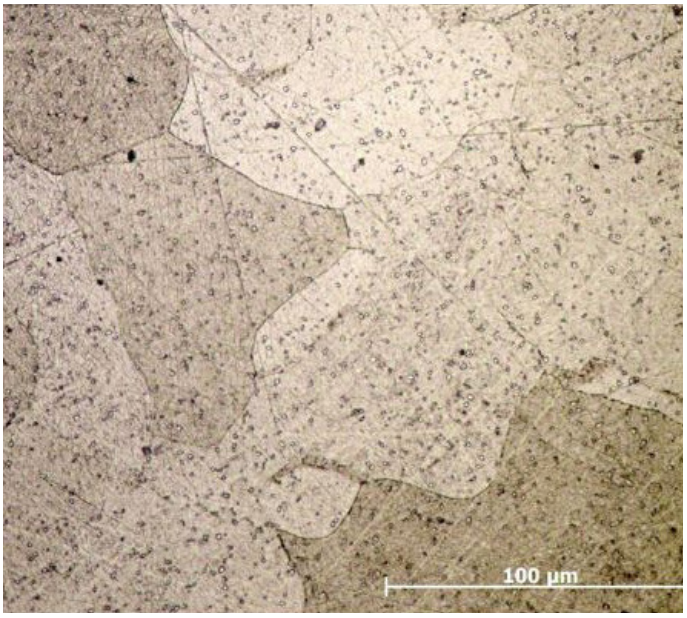
Photograph 8: intermediate magnification of sample 4

HIGH MAGNIFICATION

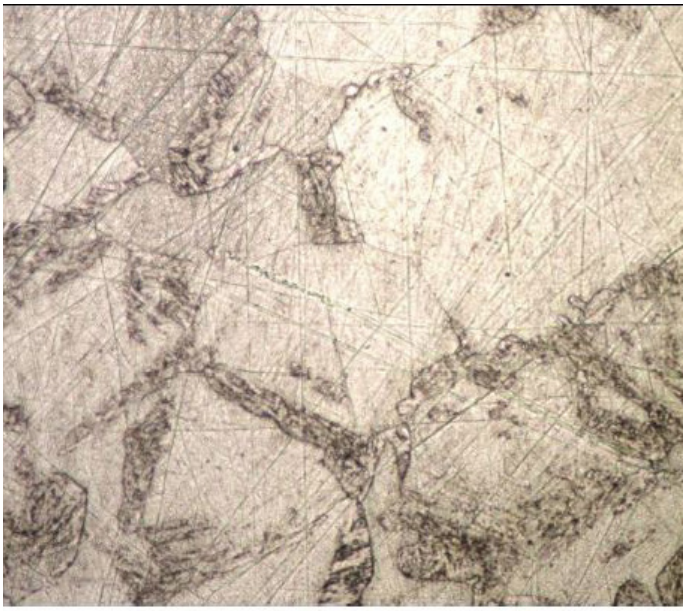
The examination moved up to a higher magnification at 500X to see the structure of the tubeeven closer up.

Photographs 9 to 12 are a high magnification view of the transverse cross-section of the tube wall as seen in the etched condition.

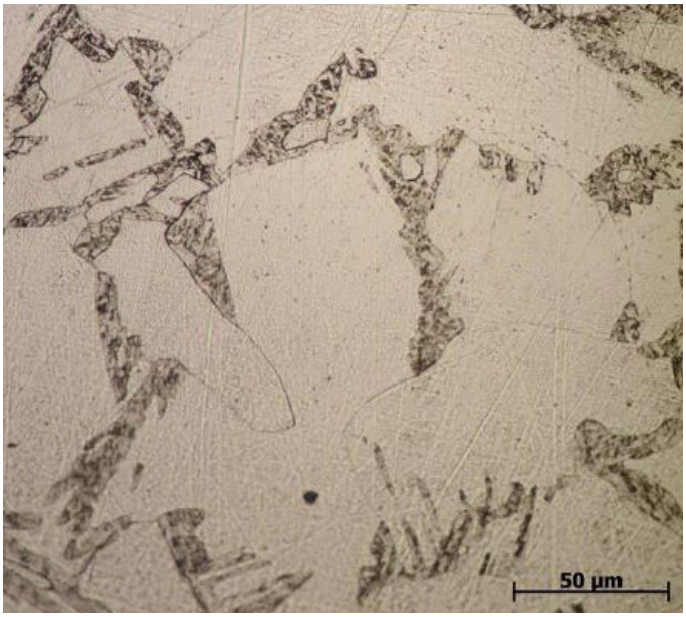
Examining the samples at a higher magnification confirmed the presence of white ferrite grains on all samples, and a network of tempered martensite along the ferrite grain boundaries on samples 2 and 3.



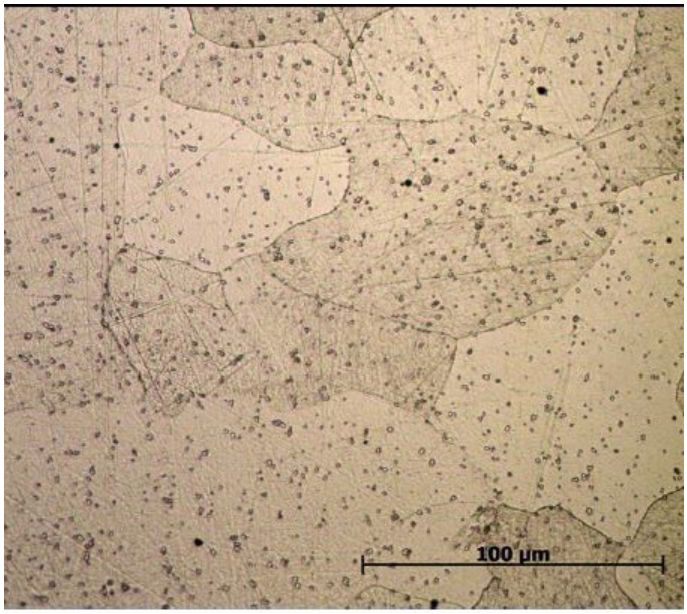
Photograph 9: high magnification of sample 1



Photograph 10: high magnification of sample 2



Photograph 11: high magnification of sample 3



Photograph 12: high magnification of sample 4

ANALYSIS RESULTS

Samples 1 and 4 have a microstructure that consists of a dispersion of fine carbide particles in a matrix of ferrite grains.

The microstructure in samples 2 and 3 shows the presence of a network of tempered martensite around the ferrite grains and at the tube OD surface.

The difference in microstructure explains why some tubes, specifically 2 and 3, cracked during forming.

CONCLUSION

The microstructure of materials can strongly influence materials properties, which in turn affect their suitability for different uses. Selecting and applying proper materials in any engineering design plays a vital role in ensuring the quality and safety of your project.

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Contact.us@element.com Europe: **+44 (0) 808 234 1667** Germany: **+49 800 000 5137** Americas: **+1 888 786 7555 - www.element.com**