COURSE NAME: MME – 102 **GROUP NO.**: A1
EXPERIMENT NO.: 02

NAME OF THE EXPERIMENT:

INTRODUCTION TO METALLOGRAPHY
(Introduction to metallography-Familiarization with the metallurgical optical microscope and observation of etched and unetched samples under optical microscope)

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Introduction

Metallography is the process of seeing the internal structure of metals. It is a part of Materialography– the same observation which can be conducted over any material. We use a metallurgic microscope to see the structure in an enhanced form of a metal. Metallography offers us to see the physical structure of metals inside, its grains, grain boundaries, other or extra materials co-existing with the metal, crystal structure, to see the phases of metals such as Pearlite, Cementite, Ferrite etc and to observe the impurities and so on. Metallography has enabled us to determine the quality of a metallic structure and to understand its characterisation. Moreover, metallography is heavily used in education and research purposes and to do failure analysis of metallic objects. Hardness and ductility can be directly measured using metallography.

Materials Used

1. A metal sample
2. Emery paper (Abrasive; of six different kinds)
3. Grinding machine and polishing wheels
4. Alumina powder (Al_2O_3)
5. Acetone
6. Nital (2% HNO_3, 98% $Alcohol$)
7. Water
8. Metallurgical microscope'

Procedure

1. **Sectioning:** A sample of appropriate size and alignment is cut off from mother metal by hacksaw or abrasive cut-off wheel.
2. **Rough Grinding:** Surface deposits are detached, and rough surfaces are leveled.
3. **Mounting:** If the sample is too small or too unsuitable shape or delicate nature mounting is required. Bulk samples generally do not need mounting. It is also done to avoid damage or rounding during grinding or polishing.
4. **Grinding:** The sample is grinded on a series of emery papers of gradually finer grade starting from no 320 CW, 600 CW, 800 CW, 1200 CW and 1500 CW. When all the marks on the surface being polished are running in one direction then next emery paper is used. Sample is polished in such a way that the finer set of scratches will be perpendicular to the present set of scratches until grinding on the finest paper (4/0) is completed.
5. **Polishing**: Alumina (Al_2O_3) or diamond powders are used abrasives in polishing. The polishing media are used as suspension in water or as pastes. Then remaining scratches are detached producing a smooth shiny surface for microscopic examination.

6. **Cleaning:** Impurities, oil, dust and grease are cleaned from the metal by water or ultrasonic cleaner.
7. **Etching:** Mainly aqueous or alcoholic solutions of acids, bases or salts serve as etching mediums. The surface is wiped with moist cotton. Time taken for etching is short. Etchant is rinsed off immediately after etching has made the surface of the specimen slightly cloudy. The section of the appropriate etching reagent is determined by metal or alloys & the specific structure desired for viewing

Table: Different types of etchants and their significance.

Types of Etchants	**Composition**	**Features and uses**
Nital	$HNO3$ (2 ml) Alcohol (96 ml)	General etchant for irons and steels. For pure iron and wrought iron the conc. HNO3 may be increased to 5 ml. Also, right for ferritic gray cast irons and black-heart malleable irons.
Picryl	Picric acid(4g) Alcohol (96ml)	The most appropriate reagent for all cast irons, with an exception for alloys and completely ferritic cast irons
Alkaline sodium picrate	Picric acid(2g) NaOH (25g) Water (100 ml)	Its main use is to differentiate between ferrite and cementite. The latter is stained black, but ferrite is not attacked.

8. **Microscopy:** The sample's microstructure was overlooked, examined and noted as an image with the help of a microscope.

Observation

The microscopic image of the sample was overlooked twice– once before etching and again after etching. We could see the internal basic composition, but it was not evident. In the sample, we expect to observe pearlite or ferrite and nodular graphite. Before etching, we could not differentiate between them. But after etching, we could clearly see the inert nodular graphite. As pearlite and ferrite are more reactive to the etchants, some of it got distinguished. From the metallographic images, we could determine the mechanical properties of the sample.

Result

The given sample was 'Ductile Cast Iron'.

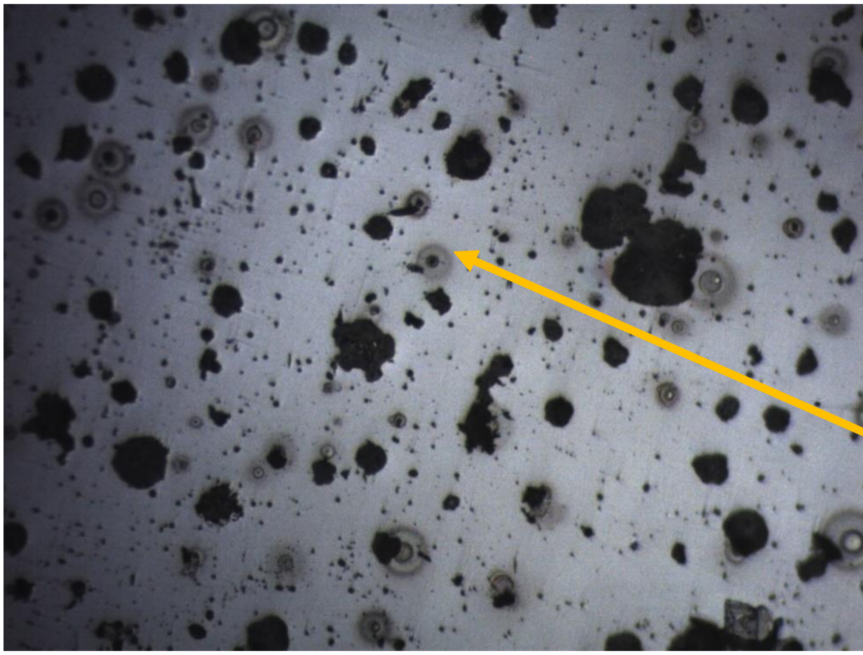

Fig 01: Microscopic structure of the sample (before etching)

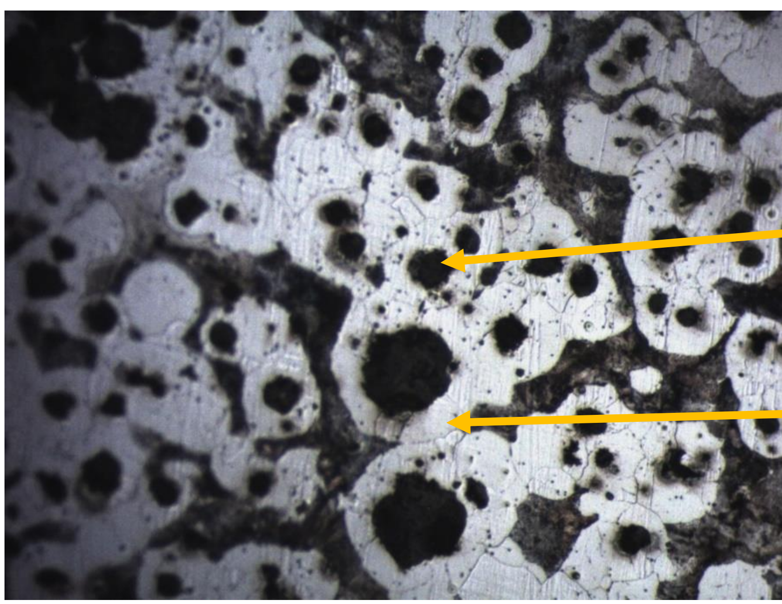

Fig 02: Microscopic structure of the sample (after etching)

Properties

Ductile cast iron is a versatile material known for its excellent combination of strength, toughness, and machinability. Its unique microstructure, characterized by nodular graphite inclusions, imparts these desirable properties.

Mechanical Properties:

- **High tensile strength:** Ductile cast iron offers good tensile strength, making it suitable for applications requiring structural integrity.
- **Excellent ductility and toughness:** The nodular graphite morphology provides exceptional ductility and toughness, allowing it to absorb energy and resist impact loads.
- **Good machinability:** The soft, pearlitic or ferritic matrix makes ductile cast iron easy to machine, reducing processing costs.
- **Fatigue resistance:** Ductile cast iron exhibits good fatigue resistance, making it suitable for applications involving cyclic loading.

Physical Properties:

- **Density:** Like other cast irons, ductile cast iron has a moderate density.
- **Thermal conductivity:** Ductile cast iron has a moderate thermal conductivity, making it suitable for applications where heat transfer is a consideration.
- **Corrosion resistance:** The presence of graphite inclusions provides some corrosion resistance, particularly in environments where the graphite acts as a sacrificial anode.

Discussion

Metallography is a very significant and a delicate process of identifying or picturing inside microstructure of a metal. That is why the procedure stated above had to be done very carefully and with precision. Specially grinding and polishing was given extra focus. If a single grinding mistake was made, scratches on the metallic surface would have generated, the result would have been an unclear image of the metallic microstructure. As we found our image was clear and the segments were easily identified, we can say that our experiment was a success.