ADVANCED MATERIALOGRAPHY

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Sample Preparation of Heat-Treated Materials

Introduction

Originating in the Bronze Age, heat treatment was further developed to process iron (blacksmithing) around 800 B.C., reaching a first peak with the production of Damascus steel in the beginning of the 10th century A.D (see Figure 1).

Figure 1: Modern Damascus steel knife

Iron was converted into steel by adding carbon, thus giving the alloy new properties like increased hardness. A large number of iron alloys and various elements have been investigated resulting in the development of new steel types suitable for many different applications. Another way to change the properties of steel is heat treatment, like annealing. As time plays a crucial role in this process, temperature-time diagrams have been developed. Today, many temperature-time diagrams have been evaluated to manufacture the best steel for a specific application. These diagrams show the correlation between time and heat and the respective structure (austenite, martensite, bainite) of the treated steel. Heat treatment is primarily performed in hardening shops.

The materials treated in hardening plants are mostly the same and reproducible, reliable, and comparable results are mandatory. For effective process control a large number of samples has to be tested. Due to this high throughput, the sample preparation process should be simple and fast. Moreover, the preparation must result in excellent sample flatness to ensure easy and error-free surface inspection.

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Materialographic Preparation Process

As a consequence of all these requirements, the preparation method should include:

- fast and gentle sectioning of samples
- fast mounting yielding plane surface
- fast and gentle grinding/polishing

Figure 2: Wet abrasive cutting machine Brillant 240.

Using ATM's **wet abrasive cutting machine Brillant 240** offers the advantage of fast and gentle cutting by choosing the CareCut feature which reduces the heat during cutting and keeps the deformation at a low mass. This facilitates fast subsequent preparation of the sample with only a low degree of deformation and no or minimal structural changes.

To obtain a plane surface and a high edge retention, our **modular hot mounting press Opal X-Press** used with Epo black as a mounting compound meets the requirements of high throughput, good edge retention, and a plane surface.

Several grinding and polishing methods can be applied for samples from the industrial field and the preparation methods discussed here will give an overview of methods used in this field.

Method 1

This method has been well established for a long time. Due to the hardness of the heat-treated samples, the lifetime of the SiC Paper is quite short, resulting in relatively high costs for consumable consumption.

The preparation is as follows:

Step	Medium	Lubricant/ suspension	Speed platen	Direction sample holder	Single load	Time
Grinding	SiC, P180	Water	300 rpm	Clockwise	30 N	Until plane
Grinding	SiC P320	Water	300 rpm	Clockwise	30 N	1:00 min
Grinding	SiC P600	Water	300 rpm	Clockwise	30 N	1:00 min
Grinding	SiC P1200	Water	300 rpm	Clockwise	30 N	1:00 min
Polishing	IOTA	Dia Com-plete, 3µm	150 rpm	Clockwise	30 N	5:00 min

Method 2

Planar grinding with a stone offers the advantage of a fast and cost-efficient preparation. But this involves an investment for a special machine. Nevertheless, the overall preparation time is reduced as no SiC papers need to be changed. Additionally, diamond lapping discs can be used, which have a long lifetime.

Step	Medium	Lubricant/ suspension	Speed platen	Direction sample holder	Single load	Time
Grinding	Stone, P100	Water	fixed	Clockwise	30 N	Until plane
Pre-polish-ing	Galaxy Con-tero H	Dia Com-plete, 9µm	150 rpm	Counter Clockwise	30 N	4:00 min
Polishing	IOTA	Dia Com-plete, 3µm	150 rpm	Clockwise	30 N	4:00 min

To avoid the investment for a new machine, diamond grinding discs for planar grinding may be utilized offering the advantage of using standard grinding and polishing equipment.

Method 3

The Galaxy grinding disc is very stiff and yields plane surfaces even if the hardness of the sample surface varies.

Step	Medium	Lubricant/ suspension	Speed platen	Direction sample holder	Single load	Time
Grinding	Galaxy red	Water	300 rpm	Clockwise	30 N	Until plane
Pre-polishing	Galaxy Contero H	Dia Complete, 9µm	150 rpm	Clockwise	30 N	5:00 min
Polishing	IOTA	Dia Complete, 3µm	150 rpm	Clockwise	30 N	4:00 min

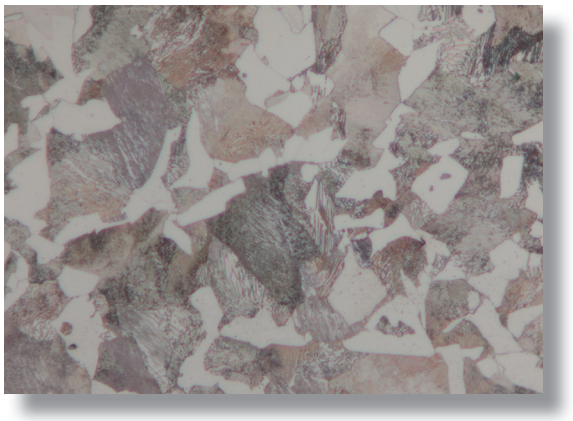

Figure 3: Ferrite-Pearlite, etched with 3% Nital, brightfield 20x

Figure 4: Martenitic structure after heat treatment, etched with 3% Nital, brightfield 20x

Conclusion

In hardening shops, the requirements of the samples preparation include short preparation time, high throughput, reliable results with good sample flatness for hardness testing or surface examinations. The preparation method using SiC paper involves relatively high costs, using a grinding stone requires investment in a special machine. The lapping discs method offers the advantage of using existing machines and a long consumables lifetime, providing best cost efficiency and meeting all necessary preparation requirements.