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Investigating the effects of cryogenic treatment On Engineering Coatings

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① Introduction

The purpose of performing cryogenic treatment on a material is to improve the mechanical properties e.g. toughness, hardness by causing permanent microstructural changes with little or no adverse effect within and as cast sample. Cryogenic treatment is a one-time treatment that involves lowering the cast to temperature typically below 193 K (-80° C). Then soaked for a length of time, before raising back to the atmosphere – fig 1.1 [1 - 3].

In the literature, cryogenic treatments have been shown to be of great benefit for industry, though not limited to e.g. improving cutting tool life, stopping power and life span of automobile brakes in high stress concentration. Nevertheless, for some applications, cryogenic treated materials are also coated as they offer protection (e.g. corrosion and wear resistance) in turn lead to significant cost savings for wide range applications (e.g. improved tool life about from 65% to 343%) [2].

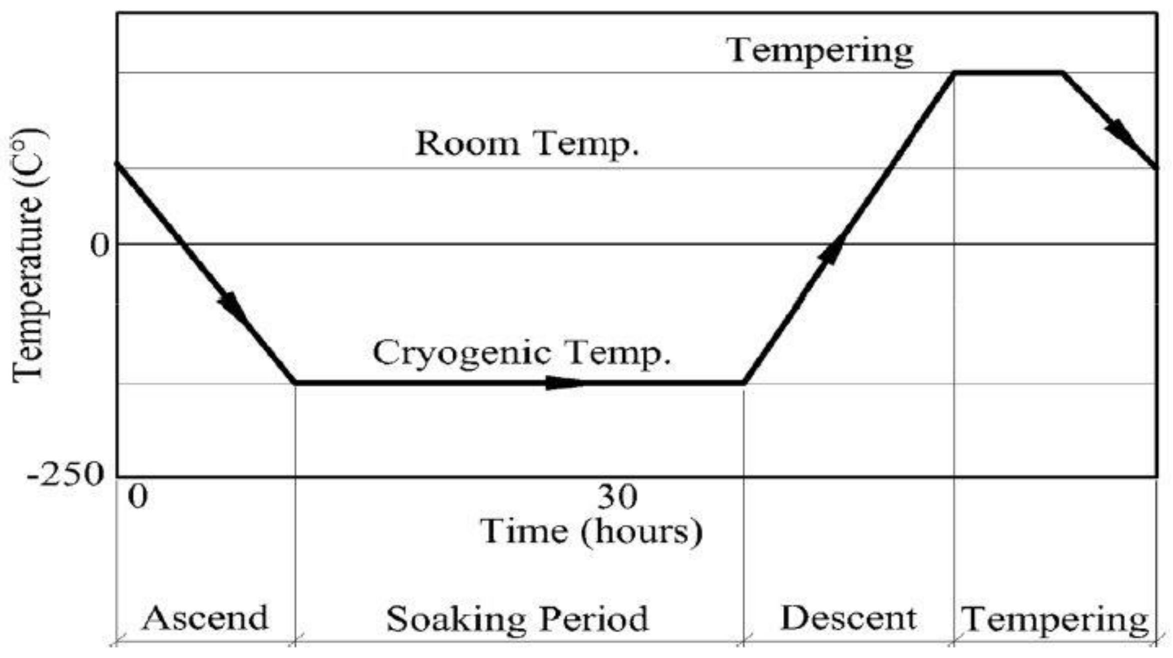

Fig. 1.1 – Cryogenic treatment process [3]

② Aims & Objectives

The aim of this project is to investigate the effects of cryogenic treatment on engineering coating – substrate systems. A deeper understanding could potentially lead to answering fundamental questions such as:

- Can cryogenic treatment enhance the performance of coating-substrate systems without causing damage (e.g. at the coating-substrate interface)?
- What are the mechanism(s) responsible for improved mechanical properties after cryogenic treatment (e.g. hardness, wear resistance)?
- What factors effect the consistency of changes due to cryogenic treatment?

③ Methods

- Manufacturing & heat treatment routes – M2 high speed steel of Ø10.4mm & Ø37.5mm (Fig 3.1a) was chosen and prepared for study. Fig 3.1b shows the treatment routes followed before mechanical and materials characterisation. Typical composition of the specimen is tabulated in Table 3.1.

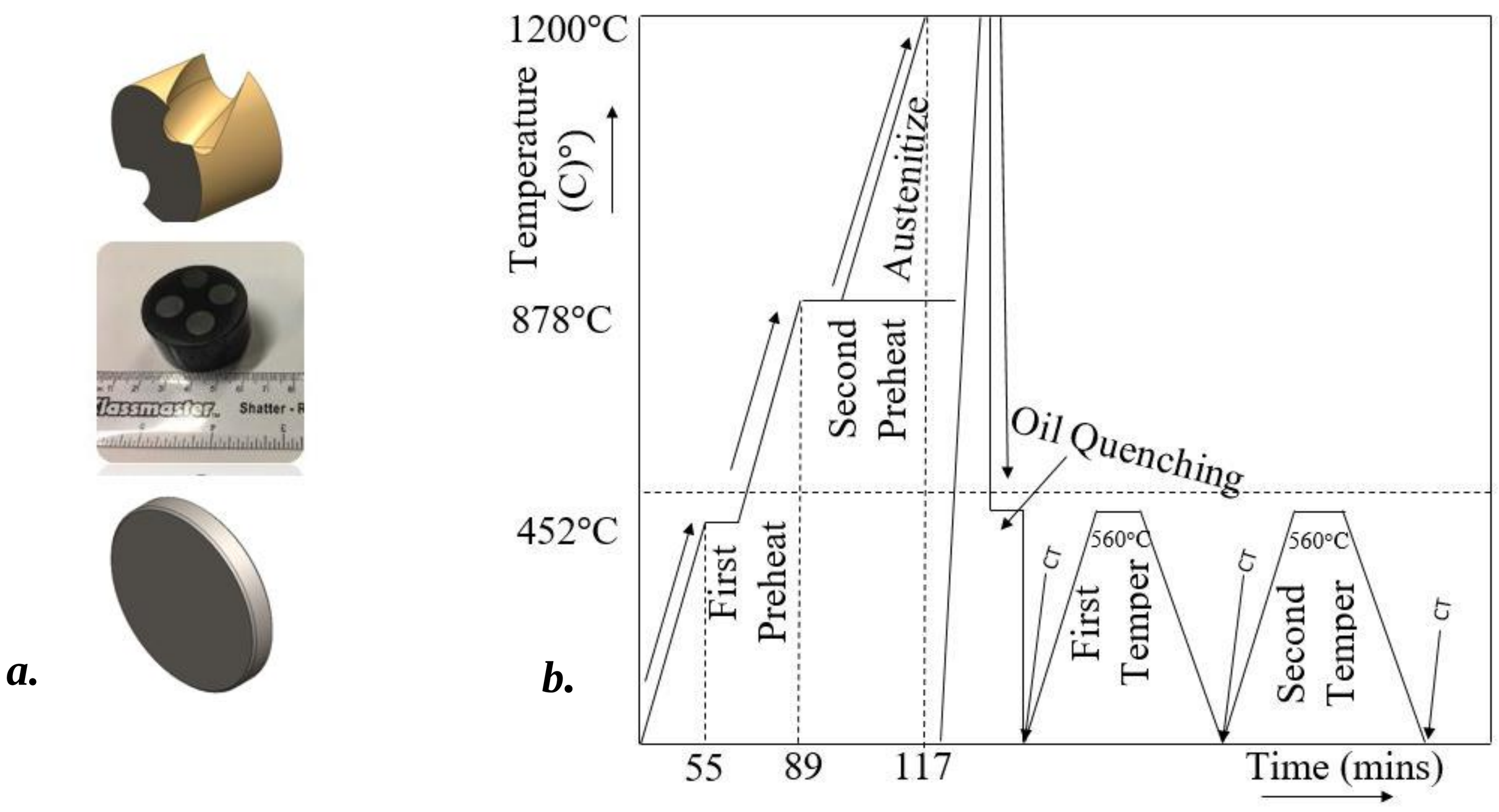

Fig. 3.1 – a.) Samples for study b.) Thermal treatment routes

Table 3.1 – Typical composition of M2 High Speed steel [4]

C	Mo	Cr	V	W
0.85%	5.00%	4.1%	1.8%	6.4%

- Micro hardness values were obtained for cryo treated and non-cryo treated samples. Results from test were processed to get the hardness values in the bulk of the sample. Average data and coefficient of variation reported (Table 4.1).

④ The story so far

- SEM observations - Finer carbides and distribution – Fig. 4.1

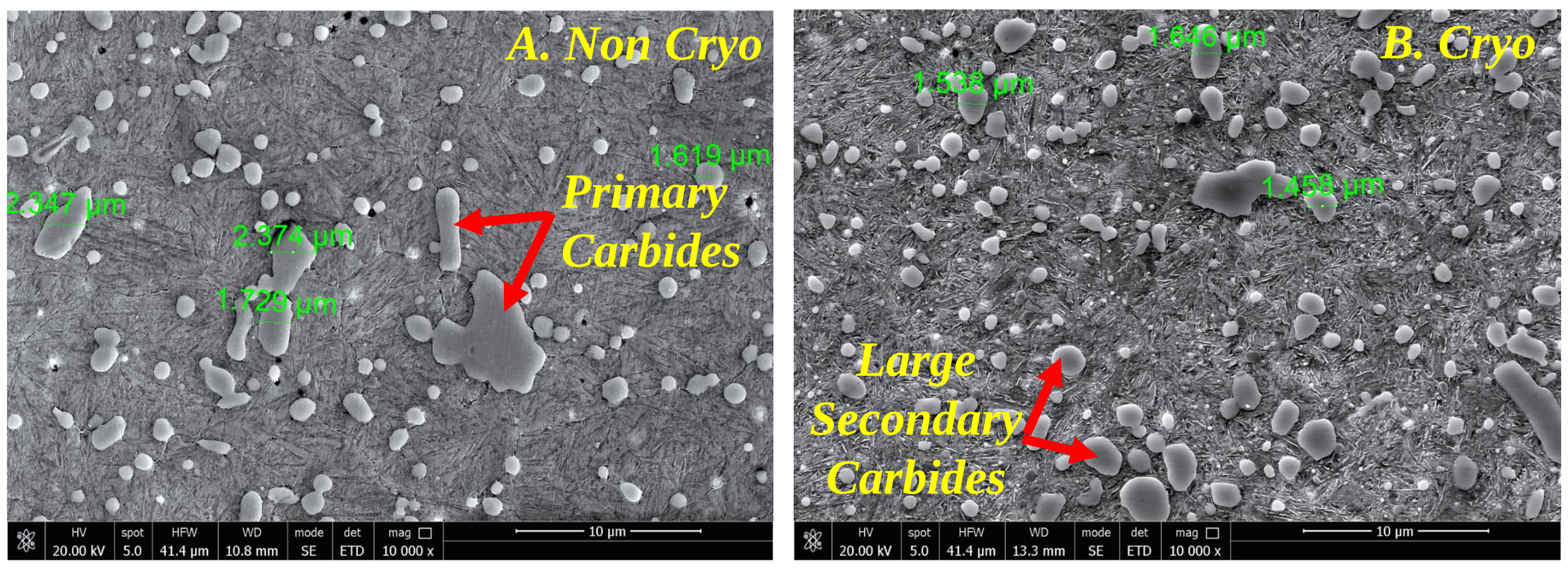

Fig. 4.1 – Carbide distribution

- Carbide sizes & grain boundaries – Fig 4.2

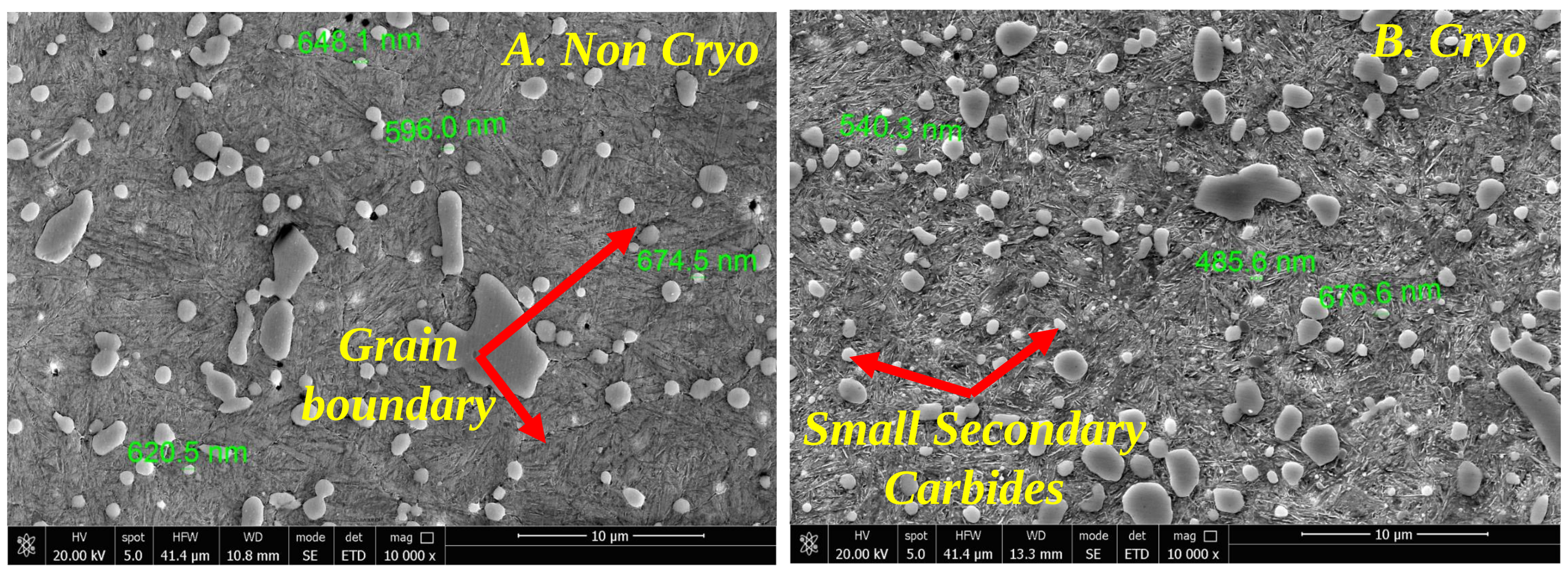

Fig. 4.2 – Carbide Sizes & boundaries

- Bulk hardness measurement before and after DCT – Table 4.1

Table 4.1 – Result from bulk hardness measurement

Material Type	Classification	$HV_{0.1}$	Coeff. Of variation
Ø10.4 mm M2 HSS	Non Cryo treated	997	11.0%
	Cryo treated	1522 (%52.7)	11.9%
Ø37.5 mm M2 HSS	Q	1312	7.7%
	Q + CT	1436 (+9.5%)	9.1%
Ø37.5 mm M2 HSS	Q + T + T	392	12.9%
	Q + T + T + CT	391 (-0.3%)	5.5%

Nomenclature:
DCT – Deep cryogenic treatment
Q – Quenched
T – Tempered
CT - Cryotreatment

⑥ Conclusion

- Cryo sample - Microstructure revealed more enhanced and homogenously dispersed carbides on a black needle like martensitic structure.
- Non cryo sample – distribution was non homogeneous and localised.
- Hardness for Q + CT, increased compared to Q + T + T + CT. It can be inferred from this that for the more better results, CT should be introduced before tempering.

⑦ Future Direction

- Characterise the effect defects, voids and effect on the coating-substrate.
- Characterise the amounts of carbide increased before and after cryo treatment

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