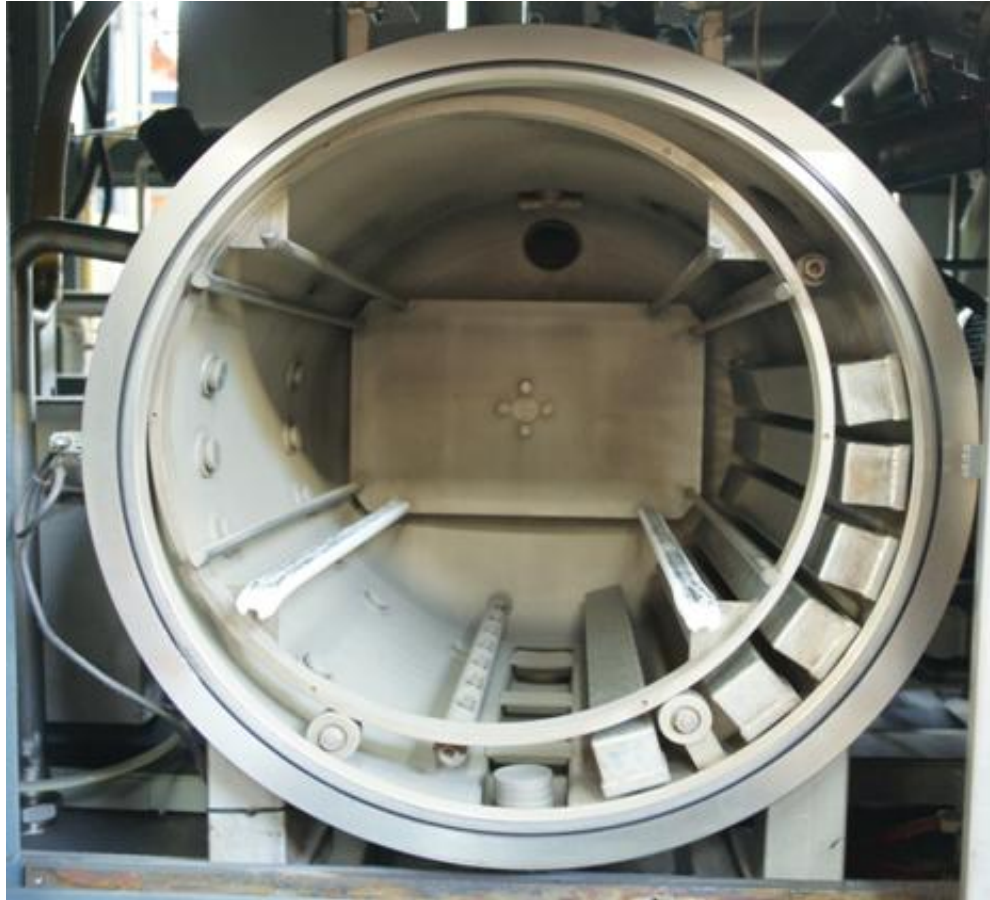


Successful Heat Treatment of precision Tooling



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Heat Treatment Shop – Wu Jii



Some Takeaways

- 為什麼光學模具鋼熱處理很重要?
Why Specifying heat treatment for your tools is important)
- 重要的熱處理工藝?
Which heat treatment parameters are important
- 熱處理後所得硬度代表一切品質嗎?
Hardness alone does not necessary
- 熱處理所得的特性是否符合精要求，機械特性?
Reliability, Mechanical properties

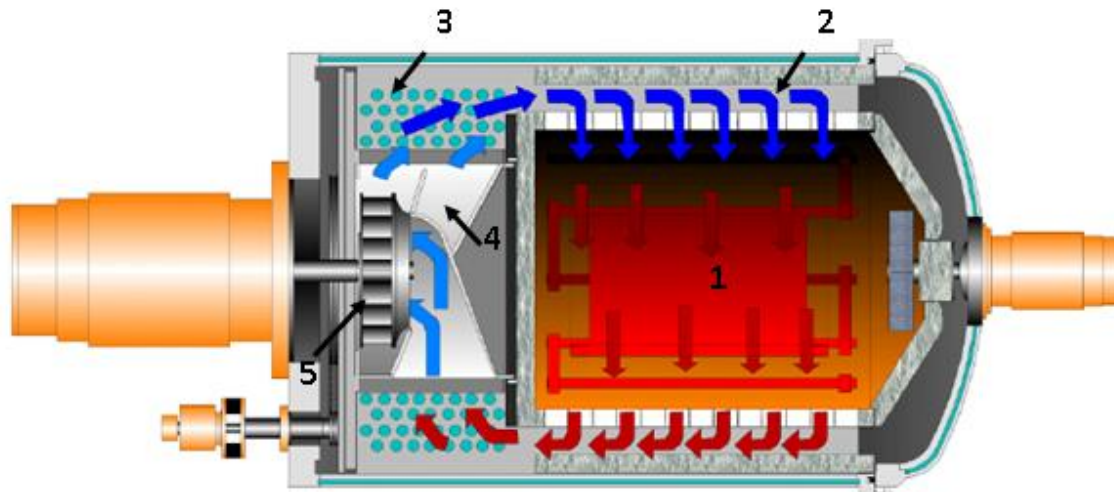
Definition - Heat Treatment

真空熱處理：

有效控制金屬材料的升溫及降溫速率達到所需的金相組織，特性應用。

Definition: Heat Treating

“Heat Treating” is the controlled heating and cooling of a metal to obtain the desired structure and properties for a given application.



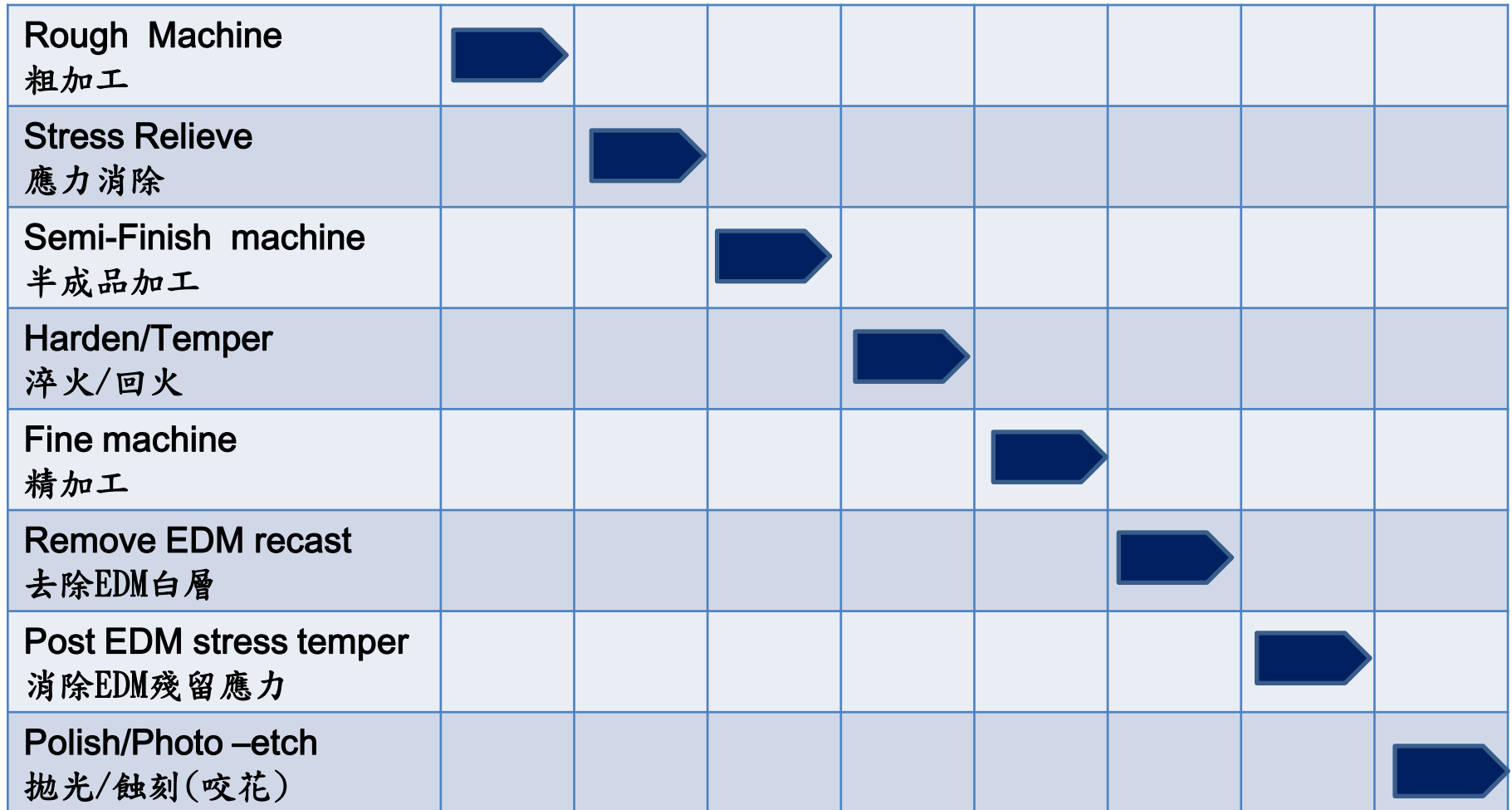
Why do we Heat Treatment ?

為什麼要做熱處理？

1. 調整金屬材料機械特性：
強度、硬度、韌性、機械加工性
(Strength、Hardness、Toughness、Machinability)
2. 達到所需的”**金相組織微結構**”及”**尺寸穩定性**”
(Achieve Structure and Dimension Stability)
3. 消除、減少殘留應力：
加工殘留應力、熱殘留應力、相變化殘留應力
(Machine、Thermal、Transformation stresses)

Recommended Tool Making Sequence

模具加工流程



Specify Heat Treatment

設定依功能導向(韌性、耐蝕性、尺寸穩定性)-熱處理條件



The keys to Successful Heat Treatment

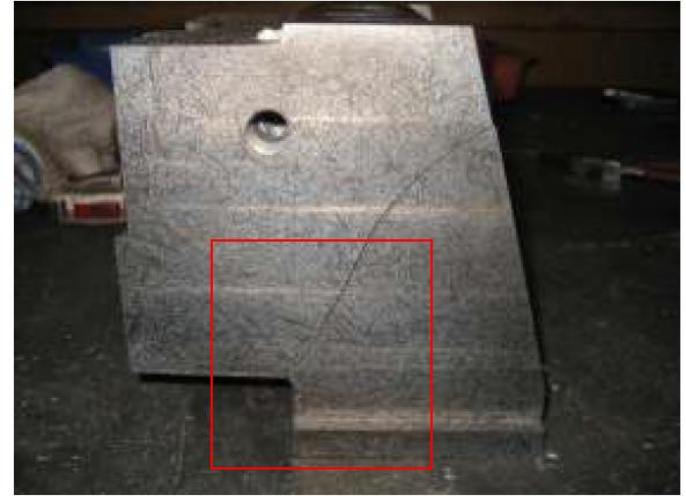
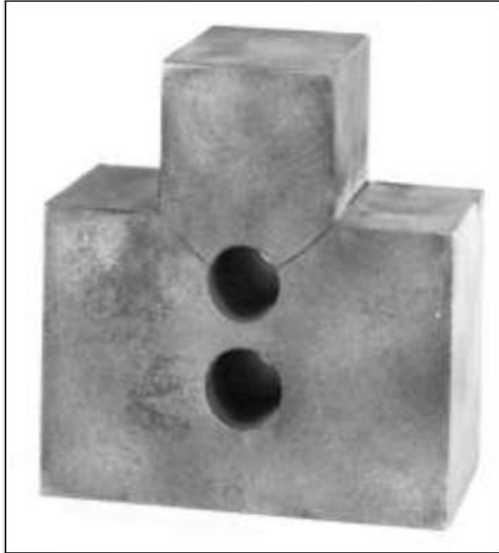
1. 設定依功能導向-熱處理條件
2. 超音波清洗
3. 應力消除
4. 熱處理擺爐方式，位置
5. 淬火溫度，持溫時間
6. 淬火速率，變形量
7. 回火溫度
8. 應力回火
9. 熱處理品保書，製程可追蹤，回朔
10. 品質功能佳的熱處理爐設備

Semi-finish Machine

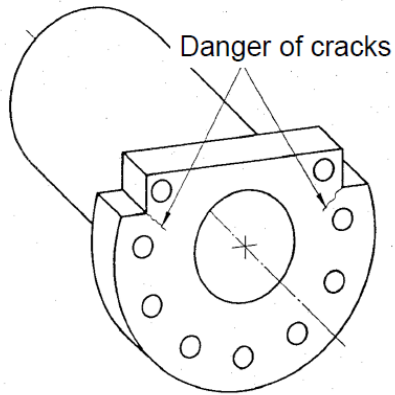
工件形狀，表面狀態對熱處理的風險

- Sharp Corner 直角
- Burrs 毛邊
- Large change in section thickness 高厚薄比例
- Heavy machine marks 殘留重的加工刀痕/應力痕
- EDM recast layer 放電白層
- Pre-existing cracks 粗加工時已產生的微裂痕
- Welds 焊補
- Grease, moisture, dirt, oxides, lubricants, paint, etc.
加工粗糙，髒汙，生鏽，潤滑油等殘漬等

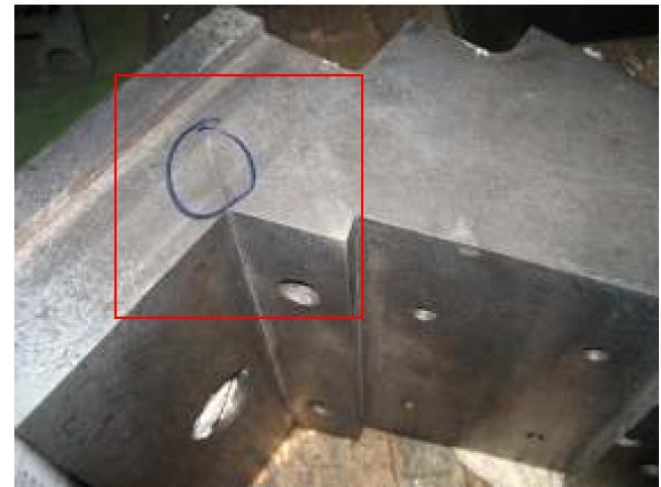
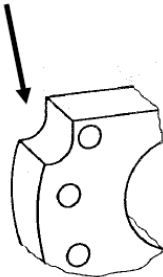
Semi-finish Machine



DIN 17 022



correct

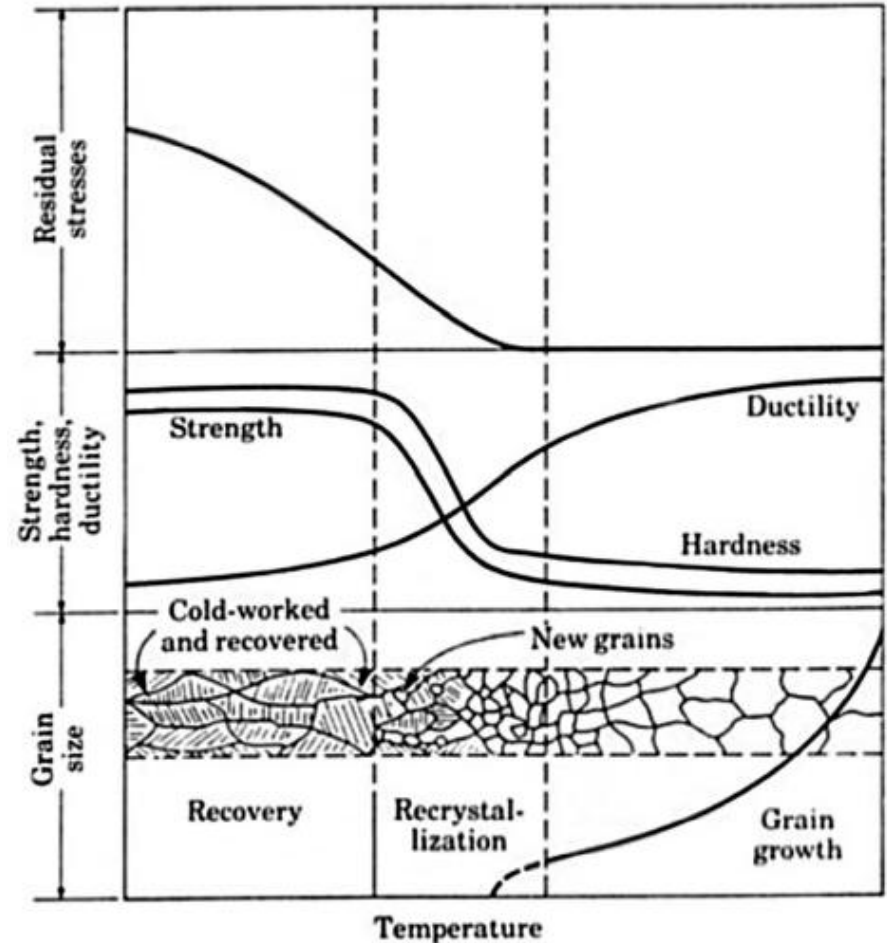


Stress relieving

應力消除：

機械加工殘留應力
焊補後焊接殘留應力(後熱)
相變化殘留應力

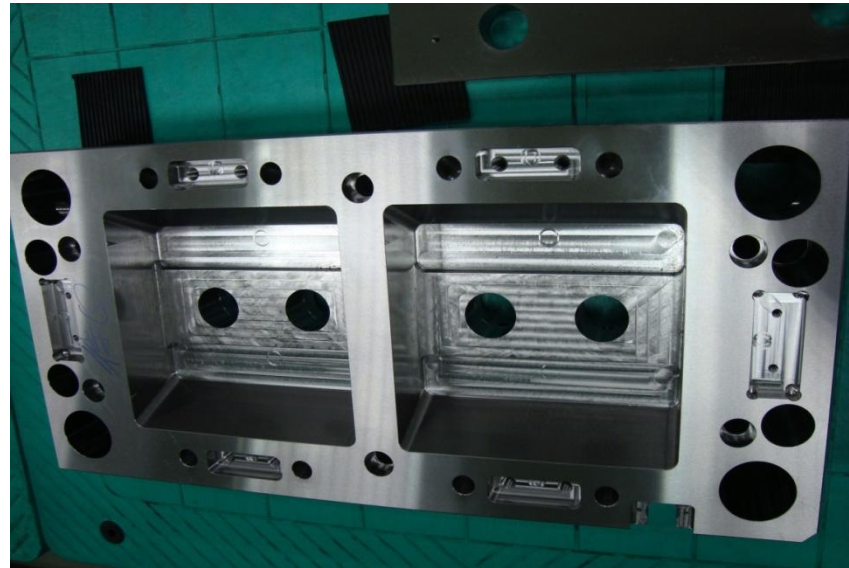
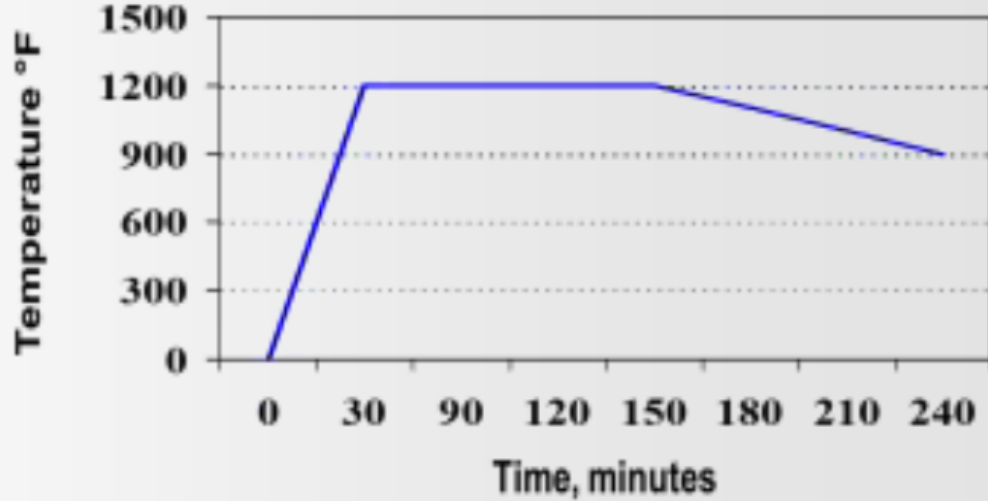
Stress purpose:
to relieve residual stresses introduced



Effects of recovery and recrystallization on grain structure.

Stress relieving

650°C x 2 hrs



Hardening Temperature-Quenching Rate

淬火：

是將鋼加熱到臨界溫度 A_{c3} (亞共析鋼)或 A_{c1} (過共析鋼)以上溫度，保持一段時間，使之達到沃斯田鐵化溫度後，快速冷卻到 M_s 點以下之熱處理。目的：硬度，機械性質(強度，韌性等)

淬火速率：

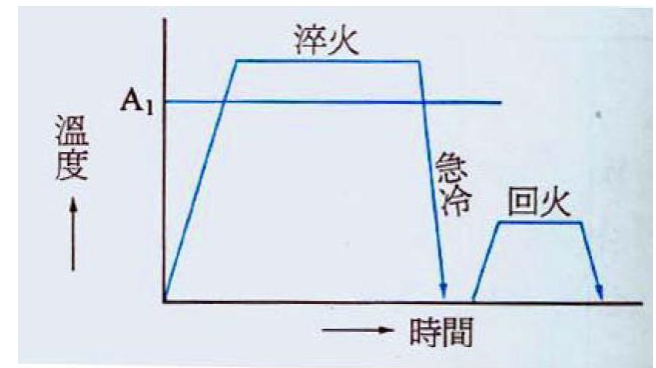
取決於金屬材料合金成份及硬化能，避免產生波來鐵，減少碳化物的析出，減少變韌鐵析出，形成麻田散鐵。

Hardening:

purpose to obtain the mechanical properties required for an application (Strength, hardness, toughness).

Base quench rate on Tooling

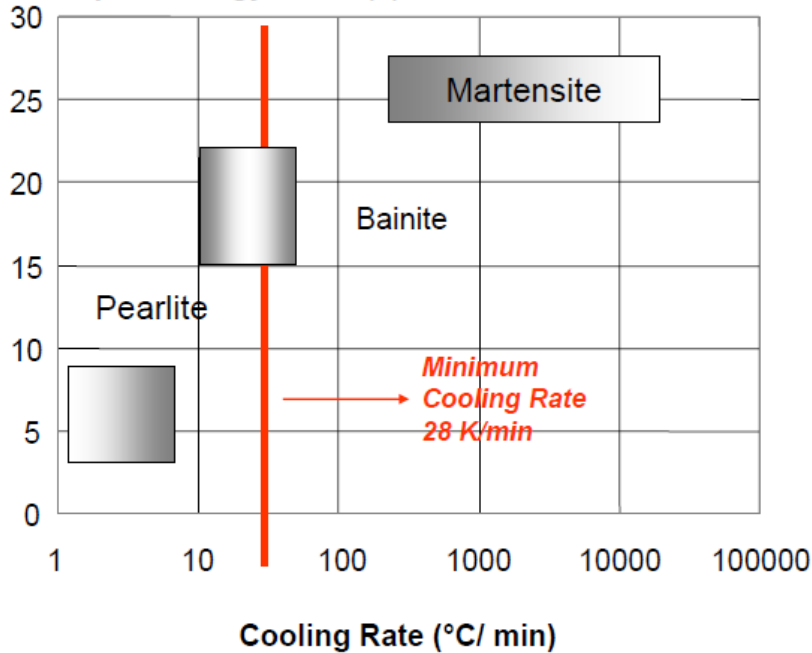
Alloy's Composition/Hardenability. Prevent pearlite precipitation, Minimize carbide and bainite precipitation. Microstructure: Martensite



Hardening Temperature-Quenching Rate

衝擊韌性-冷速 2344(SKD-61)

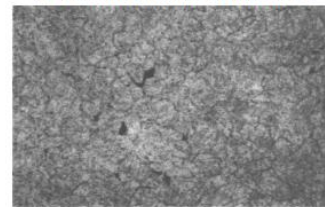
Notched Impact Energy ISO-V (J) at RT



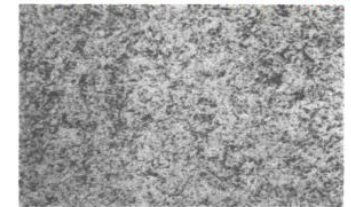
HOT WORK TOOL STEEL AISI H 13

Source: NADCA Rec. Procedures

Quench Rate 5,5°C per minute
30% of Maximum Toughness

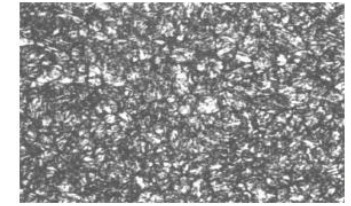
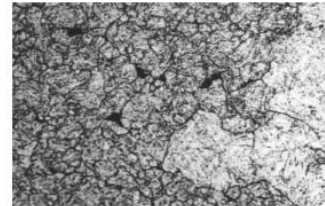


Quench Rate 30°C per minute
60% of Maximum Toughness ($\lambda=6$)



Austenitised at 1875°F (1023°C) – 2% Nital Etch

As Quenched (500x)



Tempered (500x)

Unacceptable Microstructure

Acceptable Microstructure

Quench Rapidly, Minimize Distortion

熱處理冷速與變形量有絕對關係，但爐內擺設位置也是因素，我們力求熱處理工藝品質(得到較穩定麻田散鐵)。最安全的熱處理變形量：

100mm → +0.10mm (單邊預留量，板厚25.4mm)

Cryogenic treatment- Sub-zero

深冷處理：

利用低溫處理程序，將組織微細化，消除殘留加工應力，使結晶組織排列整齊，來改善金屬機械性質。

-60 °C ~ -120 °C，-160 °C - 195 °C

組織安定化

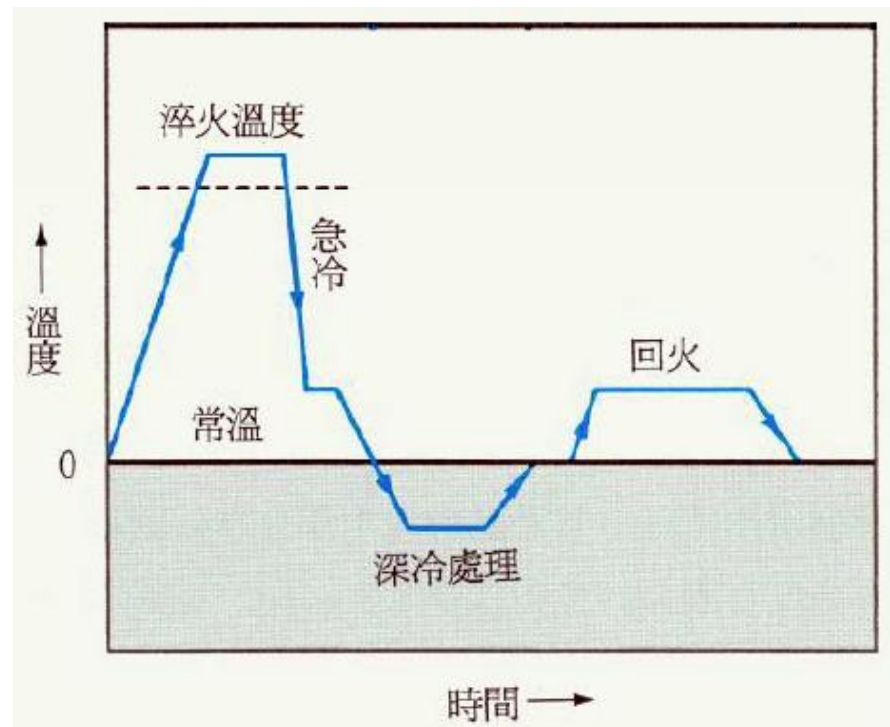
精密尺寸穩定化

消除殘留應力

耐磨耗性能提升

硬度均勻化分佈

消除殘留沃斯田鐵(R/A)



Stress Tempering

應力回火

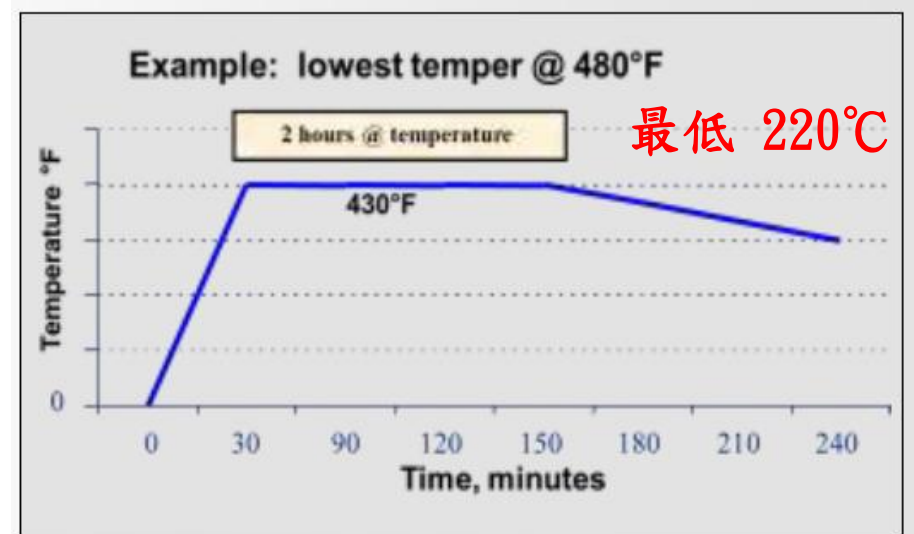
精密尺寸加工影響

- 消除放電加工後應力殘留，白層影響
- 消除模具焊補熱影響區應力殘留
- 消除線切割加工應力殘留，白層影響

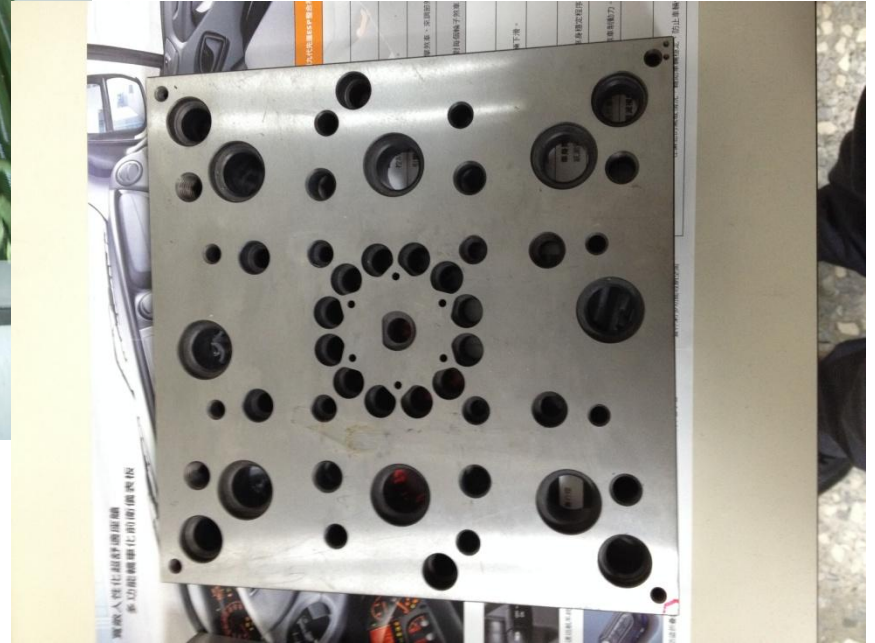
After EDM

After welding of tool

After electroplating operations









Thanks