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The importance of heat treatment in the high precision bearing rings

Dortmund, Germany 10.10.2017

PROSINO

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Our company helps (since 1946) the producers of super precision and custom made bearings by supplying them high quality rings (mostly black rings).

We are located in Italy and we employ 92 workers

Every year we machine roughly 1.000 Tons of 100Cr6 steel

In the last 25 years we have supplied >100.000.000 rings to some of the most important EU producers such as FAG-INA, SKF, GMN, NTN-SNR.

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The purpose of my speech today is to draw your attention on the importance of the correct heat treatment of the rings used later by our customer to produce HPBB.

I will show some real cases that happened during my career that made me understood the importance of this production step.

The cases that I will show are related to 100Cr6 steel (SAE 52100 – Din 1.3505)

Topics that we will face today

1. HT: some highlights
2. The hardness level
3. The correct steel structure after HT
4. The issue of residual austenite
5. Residual stresses
6. A possibile action line

What is the heat treament ?

By HT of steel we define a process that **alter** its physical characteristics**.**

Infact HT provides an efficient way to **manipulate** the properties of the metal by controlling the rate of diffusion

and the rate of cooling within the microstructure.

Proper heat treating requires precise control over temperature, time held at a certain temperature and cooling rate **(TTT curves).**

The importance of heat treatment in the high precision bearing application

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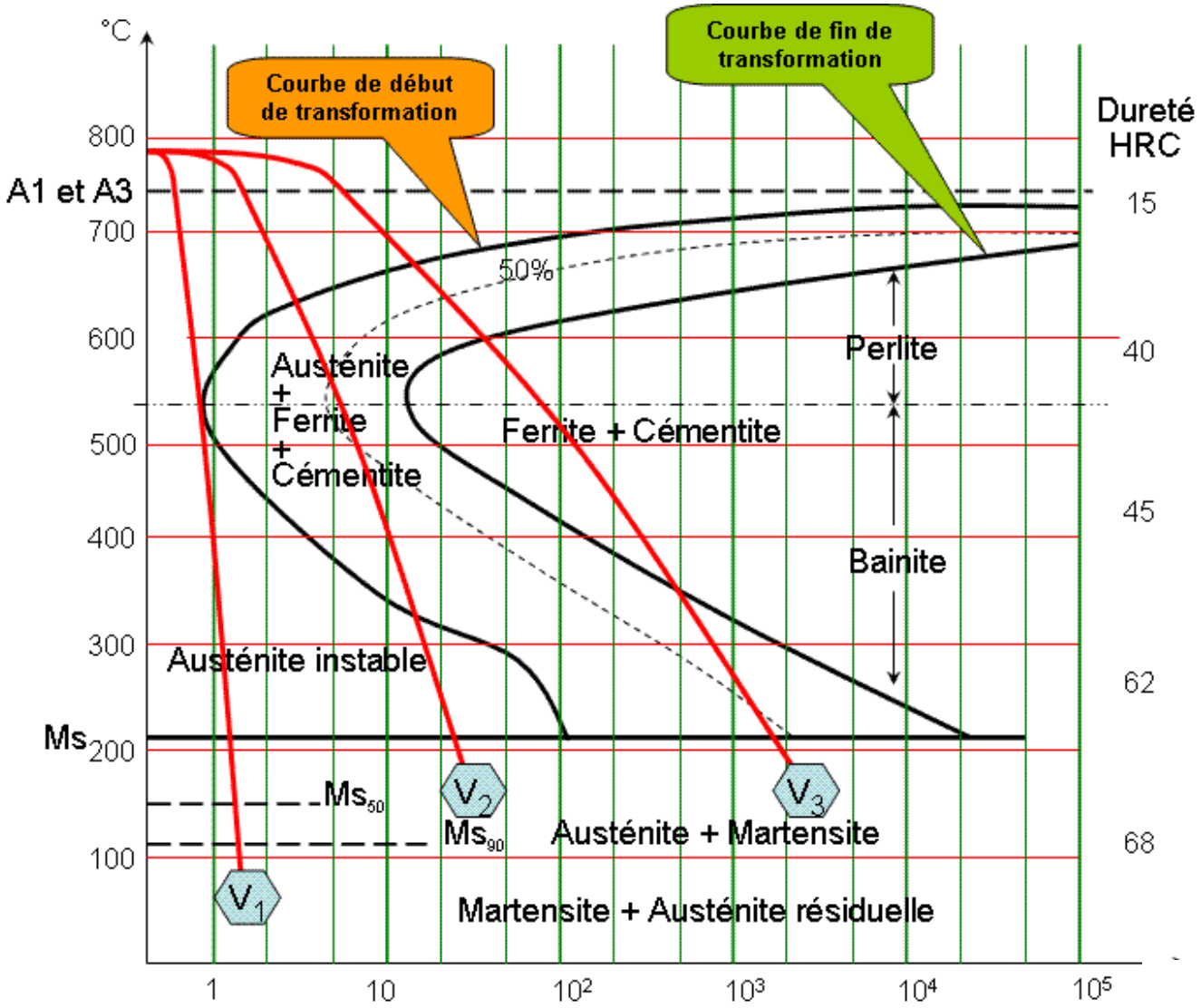

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What is the heat treament (2)

During HT, a particular steel structure which is soft and with coarse and irregular grain structure called **austenite** is transformed in **martensite**

Martensite is harder, resistant to wear and with a much more regular structure.

Unfortunately austenite won't trasform completely in martensite leaving always a **certain % in the heat treated part.** This is the root cause for **residual stresses** within the heat treated part.

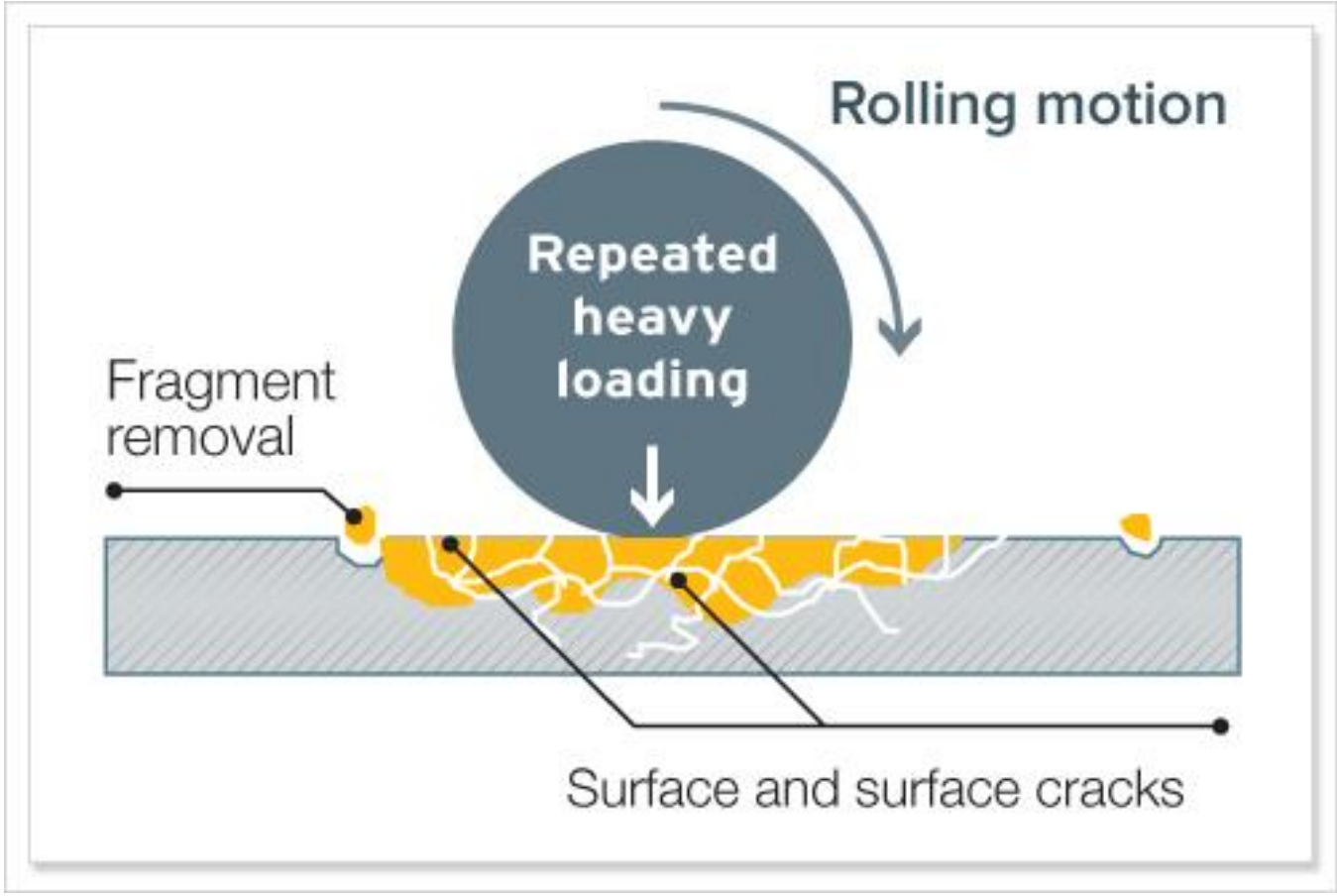
1. The hardness level

The heat treatment has the main purpose to create a structure that resist to **friction** and to **fatigue** (which are minor loads that occur within a fixed frequency).

Every bearing producers has his own technical spec about the hardness level. We have 2 hardness level request from our customer: **HRC 58-62** and **HRC 60-64.**

The hardness level is achieved by applying different temperature level during final anhealing.

What is fatigue ?



The HT is typically described in 3 phases**:**

1. **AUSTENITIZATION 860˚**
2. **QUENCHING 105˚**
3. **STRESS RELEASE – ANNHEALING 180-240˚**

A typical HT cycle is described by the following curve (our process B-05)

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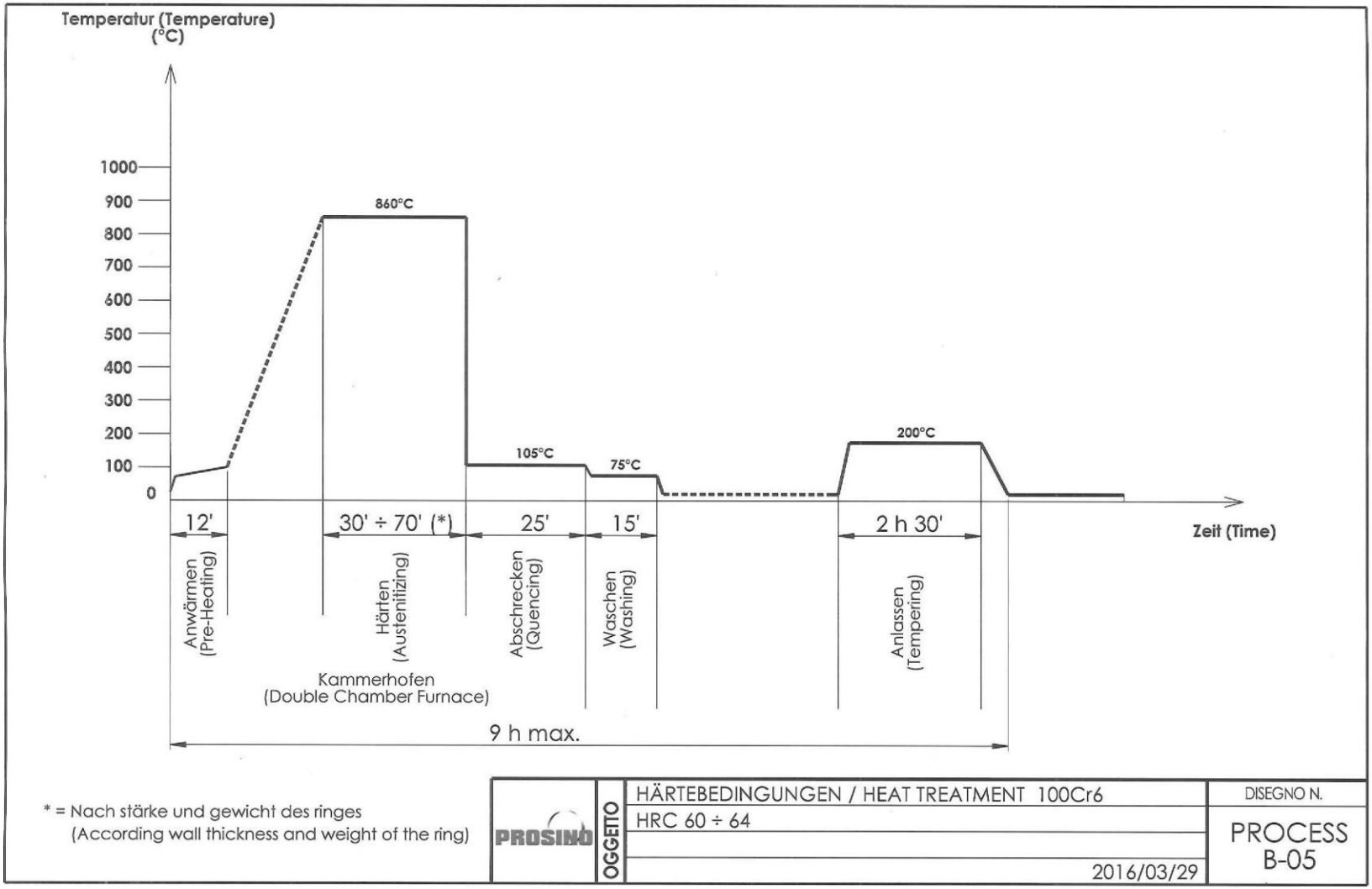

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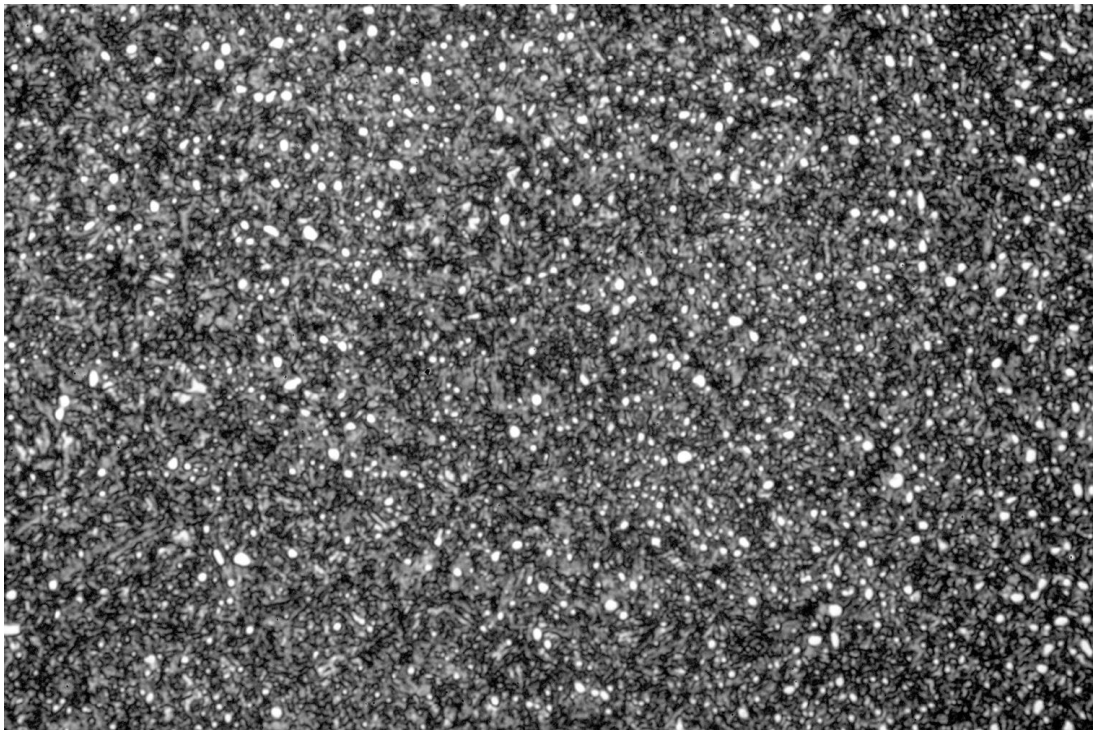
2. The correct steel structure after HT



The heat treated structure must show carbides with a **roundish shape** and **evenly distributed** (= no concentation).

When we see this structure we can be sure that the HT has been done **correctly**

During Austenization the main problems that could occur are:

1. **Decarburization.** It represent a lack of carbon content. It can be detrimental to surface properties (mechanical characteristics will not matching to the standard).
2. **Excessive growth of austenitic grain**, due to excessive permanence of the parts in this phase. It also weaken the mechanical characteristics

3. The issue of residual austenite

Retained austenite is a something that is unavoidable when there is a heat treatment of steel with a high level of alloy elements, that is typical for bearing rings for special application**. There are two main problem related to the retained austenite that have the same origin.**

1. Retained austenite is not stable at room temperature and, for this reason, if there are some kind of stresses (mechanical, thermal...), it can be transformed during work of the bearing**.** This trasformation involves a **volume variation** that generates also a **dimensional variation** of the bearing itself and a internal stress that can be trigger the propagations of a crack and then drastically reduce the bearing fatigue resistance.

To reduce as much as possible the retained austenite there must be careful control of the hardening parameters. The first elements is the austenitization temperature, because a **too high temperature** increases the quantity and stability of the retained austenite during the quenching**.**

One other parameter is **the time between quenching and stress release**, because more time pass between the two operation, more the retained austenite tends to stabilize**. Furthermore the stress release temperature is important, not only for the hardness of the steel,** but also for the reduction of residual austenite. **The higher is the temperature, more residual austenite is reduced**.

Residual Stresses

Residual Stresse **is that which remains in bearing ring after having completed the heat treatment.** We can simply define it like **steel portion with different physical & chemical characteristics. In particular with different volumes**. They generate tensions that could get free during subsequent machining operation like grinding.

Certainly one of the goal of the HT is to produce a ring free of residual stresses that can influence its dimensional stability over time.

What we want to achieve ?

A hard ring with the lowest possible level of residual stresses and maximum dimensional stability

Lowest possible level of residual stresses and dimensional stability can be achieved with the adoption of a special heat treatment with double annhealing and subfreezing (S0)

The importance of raw material purity and cleanliness requirements, for precision bearing rings

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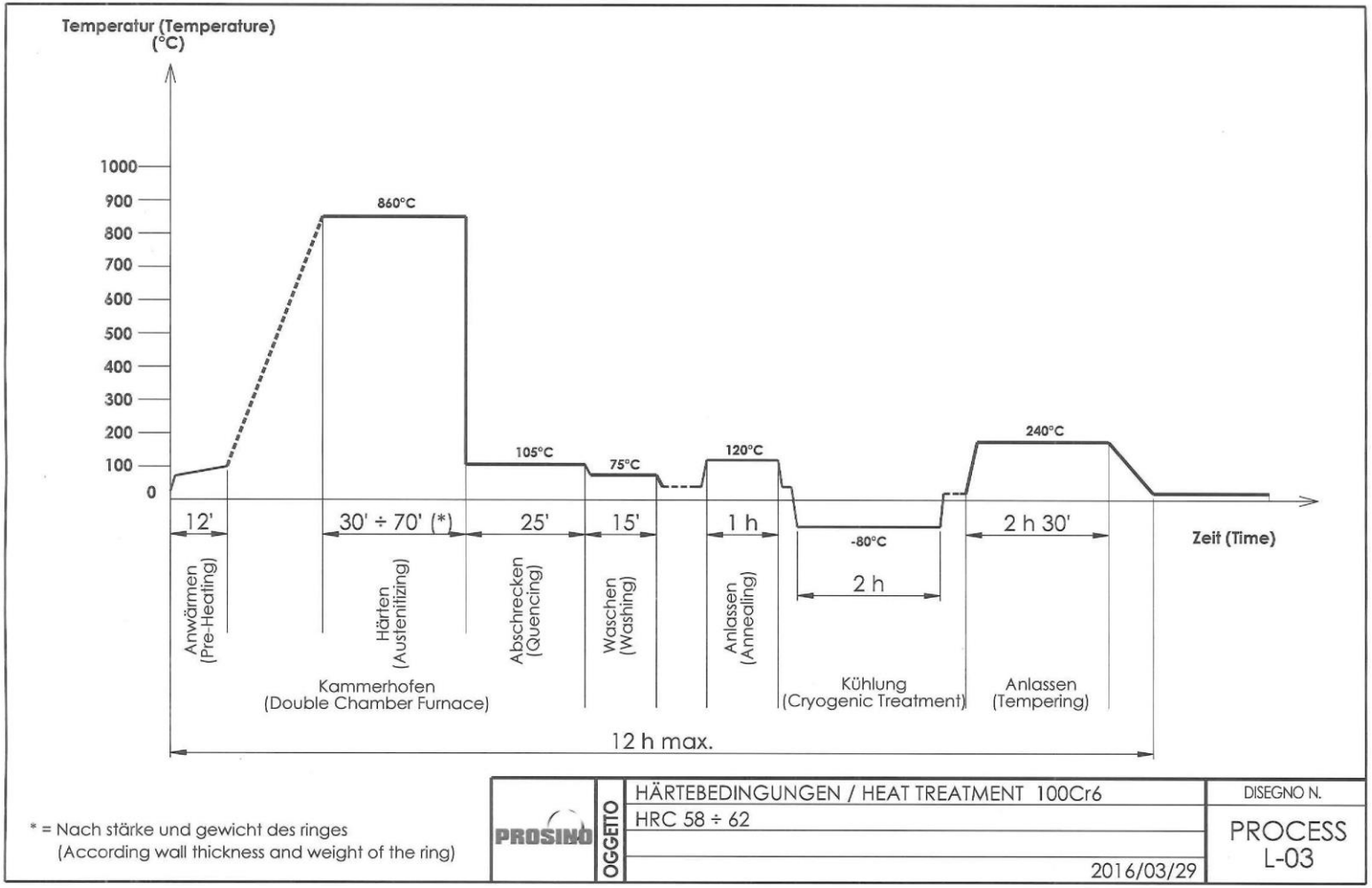

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As you can see we have introduced a cryogenic step after the first stress release.

The permanence of the rings at -80° is allowing the complete transformation of the residual austenite in martensite.

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Results of customer lab on the steel structure

4. Ergebnisse

	Soll S0	**Ist AR 71912 gleit-geschliffen**	**Ist AR 71912 sandgestrahlt**	**Ist AR 7008 gleit-geschliffen**	**Ist AR 7008 sandgestrahlt**	**Ist AR 71913 gleit-geschliffen**	**Ist AR 71913 sandgestrahlt**
Kernhärte	60,5 ± 2 HRC	702 –705 - 703 HV30 → **60,3 HRC**	707 – 703 – 703 HV30 → **60,4 HRC**	698 – 699 – 700 HV30 → **60,1 HRC**	699 – 702 – 698 HV30 → **60,4 HRC**	707 – 703 – 703 HV30 → **60,1 HRC**	698 – 699 – 696 HV30 → **60,0 HRC**
Restaustenit	max. 5 %	1 %	1 %	1 %	1 %	1 %	1 %
Gefüge	max. nadeliger Martensit	feinnadeliger Martensit					
Mischgefüge	Rand: ≤ 1 % bis 0,07xDW Abstand in den Funktions-flächen Kern: ≤ 5 %	nicht festgestellt					
Randanomalien (Randoxiation)	≤ 20 µm	5 µm	10 µm	5 µm	5 µm	5 µm	5 µm

Thank you for your attention !

Who is interested in these topics can meet me at my booth in the hall