



Modern tool steels for hot stamping – requirements and properties

Bilbao, November 29, 2018

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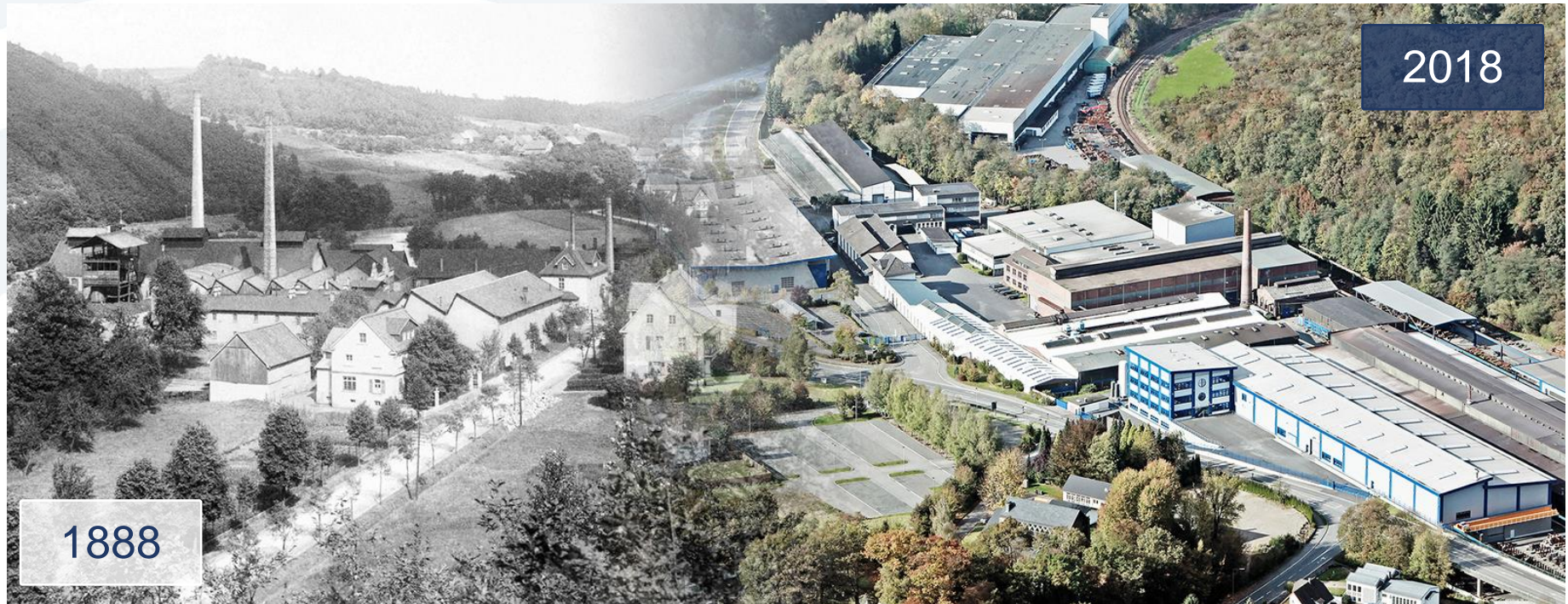


Globally operating hot-work
tool steel specialist

Brief profile of the KIND&CO Group

- Tradition and modernity
- Kind&Co in a nutshell
- Integrated production process

Tradition and modernity: The best of both worlds!



Tradition

- Experience and know-how
- Sustainability
- Commitment and respect in cooperation
- Linked with our home region

Modernity

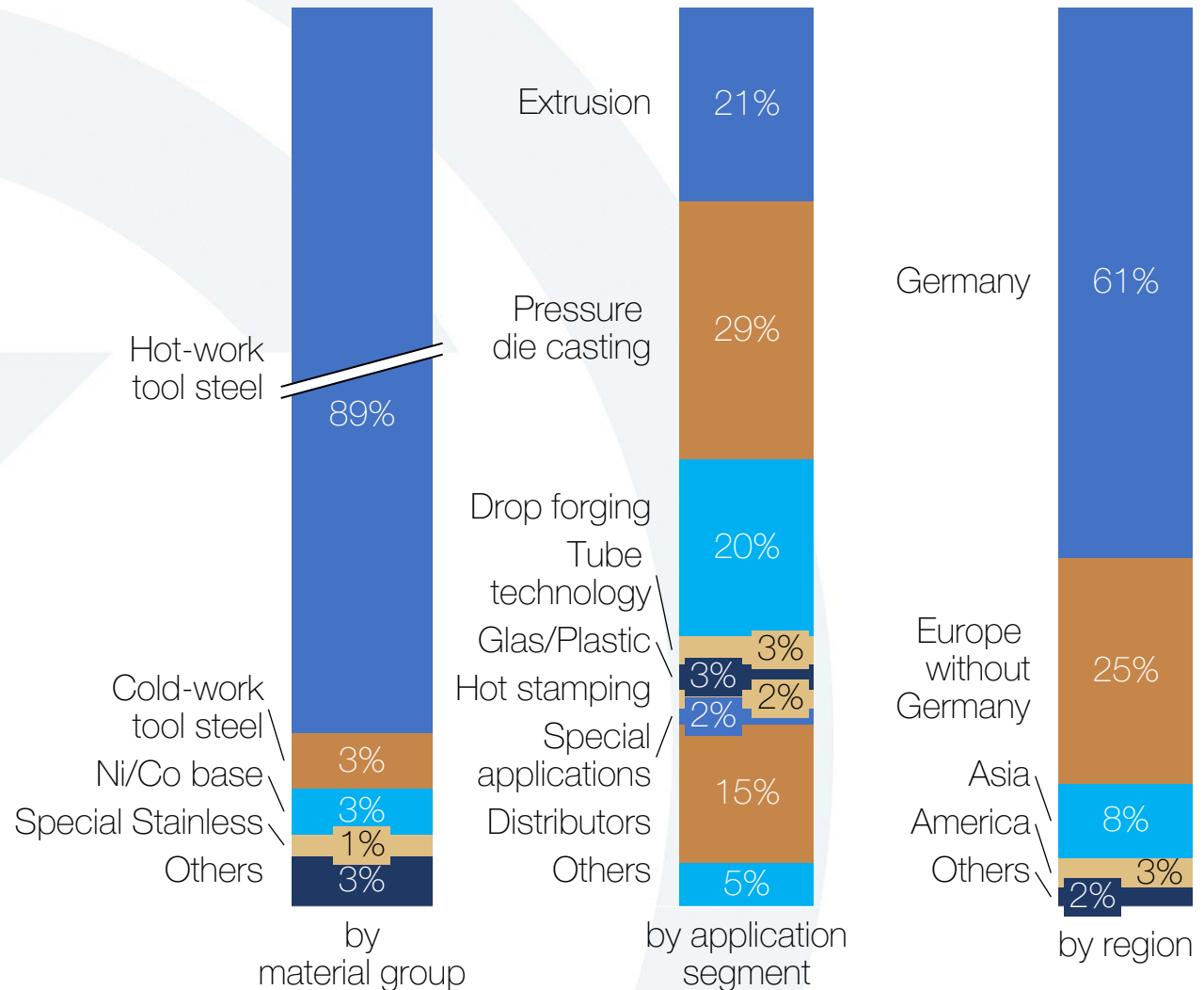
- Up to date production technology
 - Professionalism in service
 - Quick decision processes
 - Internationality

Kind&Co in a nutshell: Hot-work tool steel specialist in close proximity to the end customer

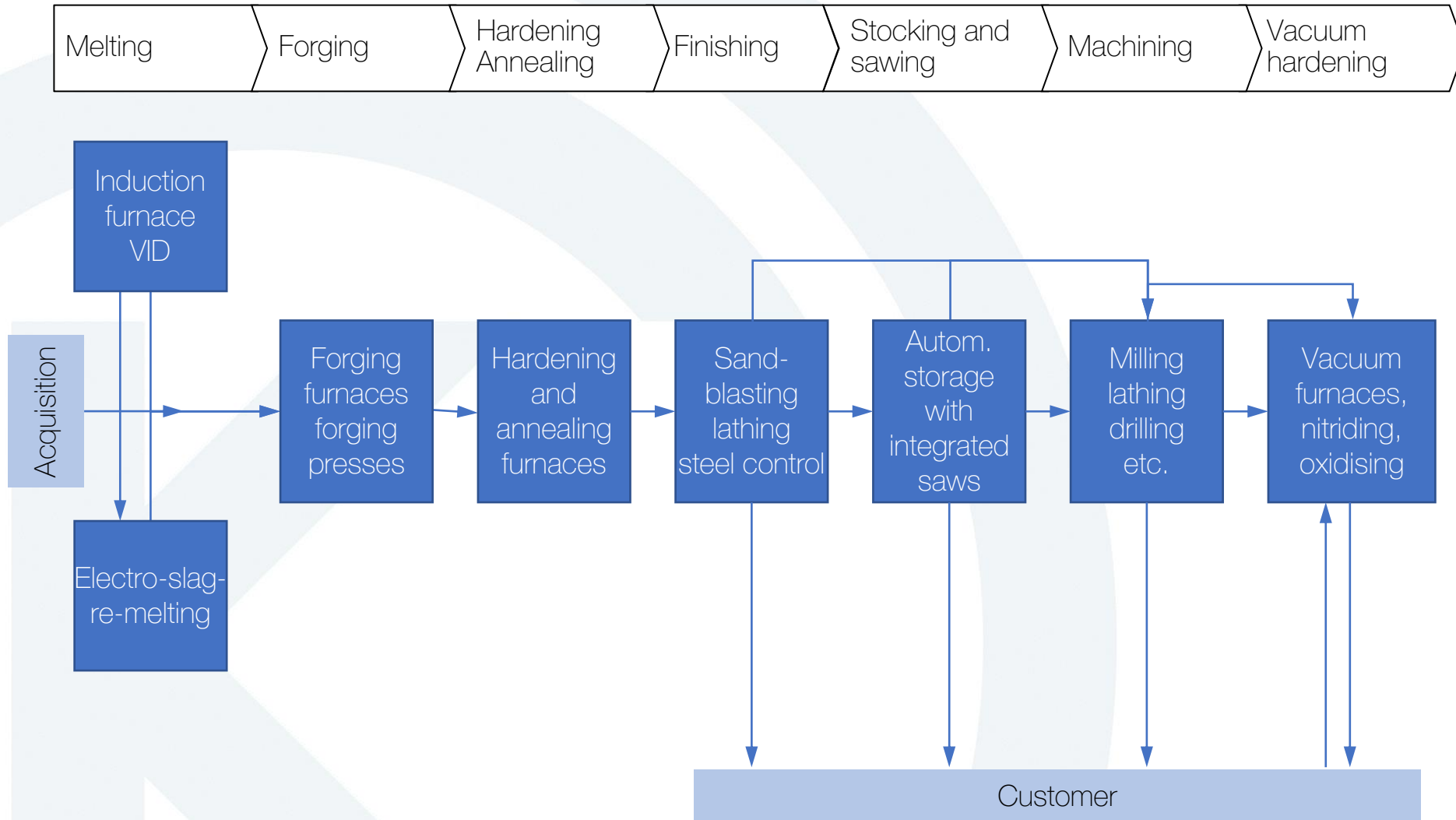
The Kind & Co Group

- A family company since 1888
- Only hot-work tool steel specialist worldwide
- Fully integrated mill in Bielstein/Germany
- Strong application expertise and close proximity to the end customer:
 - Extrusion
 - Pressure die casting
 - Drop forging
- Strong market leader in domestic market, growing presence in international markets

Revenue distribution, 2017, in %



Integrated production process: Expertise in every step of the value chain





Hot stamping permits an economical weight reduction of cars

Motivation

- Trends in automotive light weight
- Requirements, development and impacts

Motivation:

- Economic and legal requirements to reduce exhaust gas emissions
- Reduction of car weight by 100 kg
=> Reduction of fuel consumption by 0.3 – 0.5 l / 100 km
- Different strategies are developed based on forging, die casting, extrusion and hot stamping
- Decisive is economic efficiency of the produced part
=> Only possible by smoothly operating tools with good durability



A successful hot stamping requires different aspects

- Hot stamping tools are extremely expensive and therefore require a reliable performance of some 100.000 pieces.
- Economic hot stamping production requires short cycle times and highly effective cooling of the produced components.
- Premature tool failures or unexpected repair work due to excessive wear need to be avoided.
- The performance of hot-stamping tools depends to a high degree on an analysis of the loads of the tools, an appropriate tool steel selection and proper heat treatment.

Tool design has changed for efficient cooling



Constant change in design from straightforward design to rather complex due to:

- Segmented tools.
- Cooling channels closer to the surface increasing the heat transport.

Impacts on the hot stamping tools are complex

Impacts:

- High temperature in contact zone tool ↔ sheet
- Compression stresses
- Thermal cycles
- Abrasive as well as adhesive wear

General requirements:

- Suitable high-temperature strength
- High thermal fatigue resistance
- High hardness and tempering resistance
- High abrasive wear resistance
- High toughness and ductility

A full-page background image showing a worker in a hot environment. The worker is wearing a silver helmet, a clear face shield, and a grey and yellow protective suit. They are holding a long, dark metal rod or tool, which is positioned over a glowing, molten metal surface. The background is dark and industrial.

Hot stamping requires an adequate choice of the tool material

Suitable hot work tool steels

- Chemical composition
- Quality improvement due to ESR
- Tempering behaviour
- Wear resistance
- Design vs. thermal conductivity?
- Tailored tempering

Special steel CR7V-L shows an outstanding combination of properties for hot stamping application

Kind & Co. CR7V-L

„The Wear Resistant One“

Steel Designation			Mass Content in %						Hardness Recommendation HRC
Brand	Mat.-No.	AISI	C	Si	Mn	Cr	Mo	V	
USD	1.2344	H13	0.40	1.00	0.40	5.20	1.30	1.00	50 – 52
RPU	1.2367	---	0.38	0.40	0.40	5.00	2.80	0.60	50 – 52
CR7V-L	---	---	0.42	0.50	0.40	6.50	1.30	0.80	52 – 54

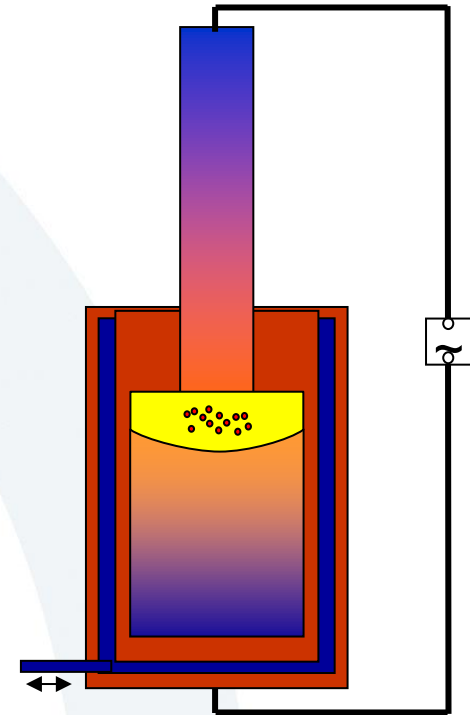
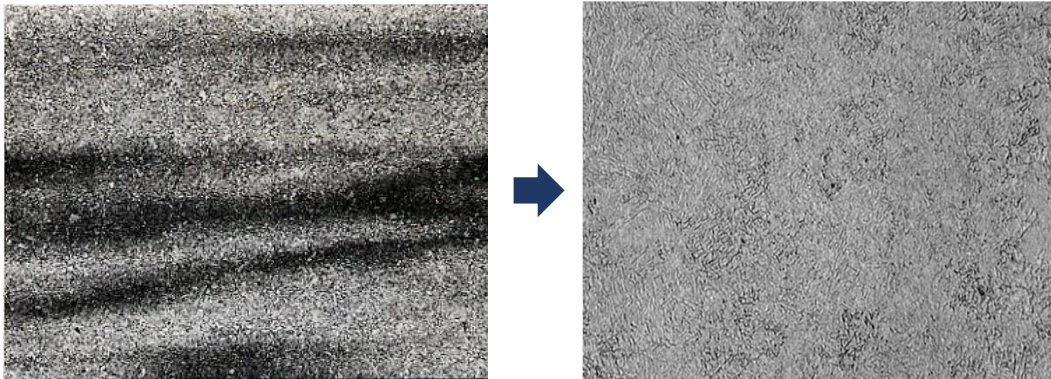
- For USD and RPU, the alloying content range is standardized, however, the execution by Kind&Co is excellent („good standard“).
- CR7V-L is a proprietary development by Kind&Co with a property combination particularly well suited for hot stamping applications.
- For high toughness requirements CR7V-L is available as an Electro-Slag-Remelted (ESR) special steel providing significantly improved purity and homogeneity.

Electro-Slag-Remelting for highest purity and homogeneity

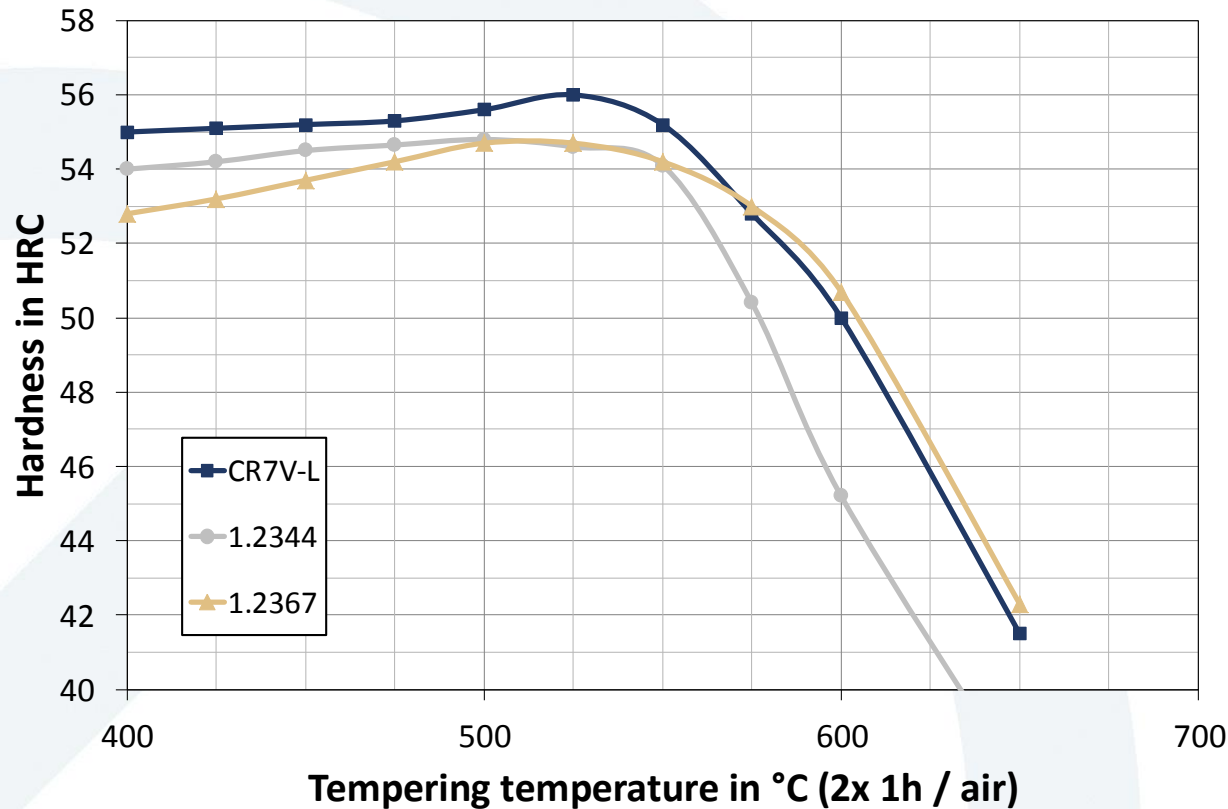
The ESR Process:

- Purifies the steel,
- Improves the steel's homogeneity macroscopically and microscopically,
- Improves toughness considerably,
- Allows for higher hardness values and wear resistance.

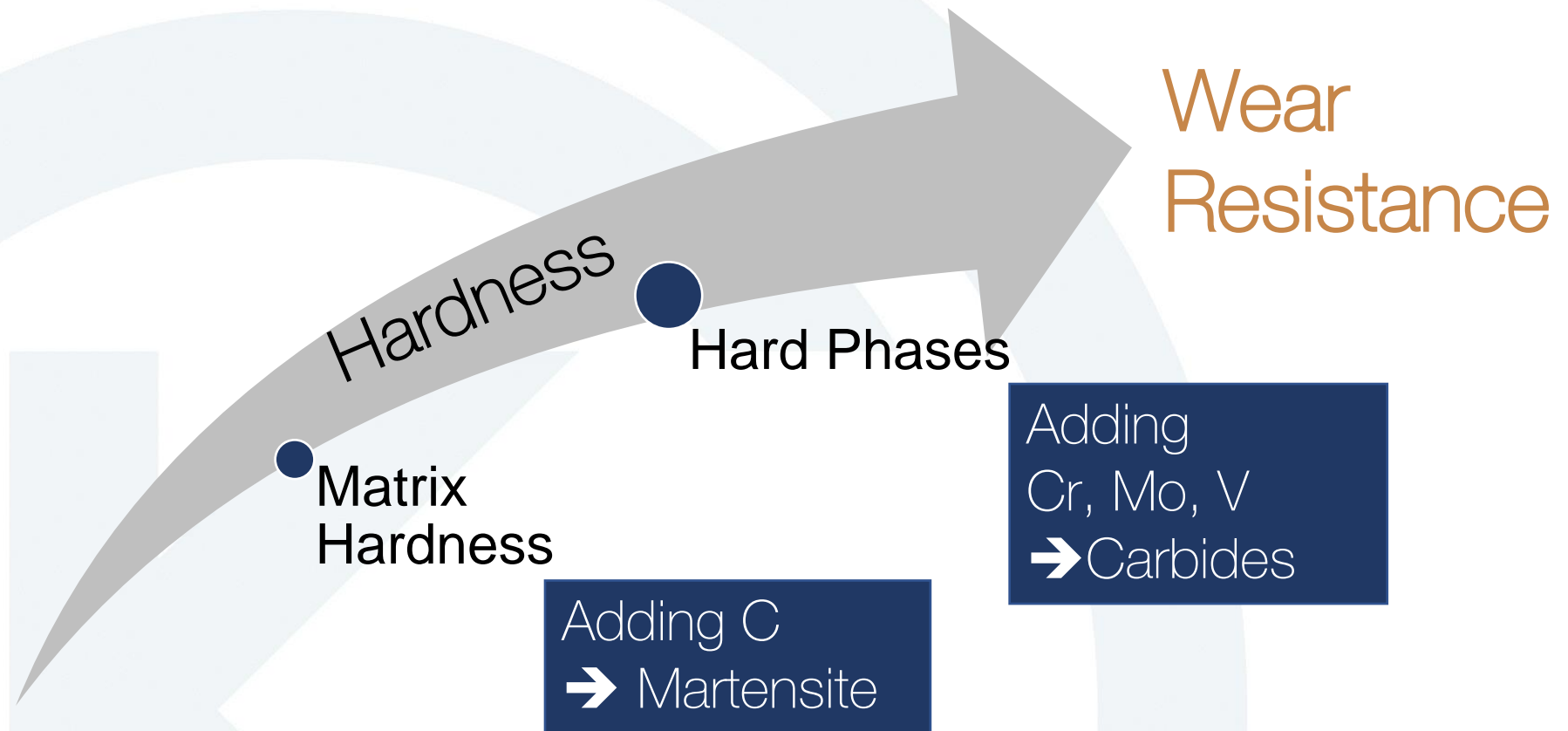
Improvement of the microhomogeneity due to the remelting process:



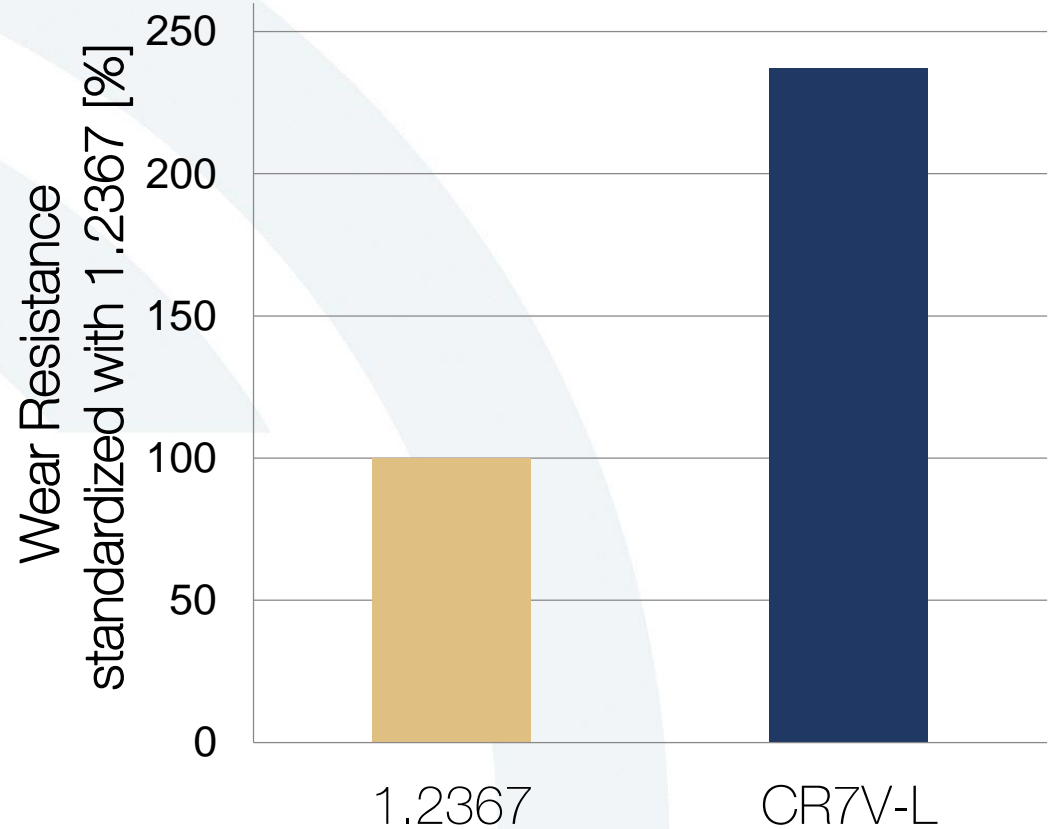
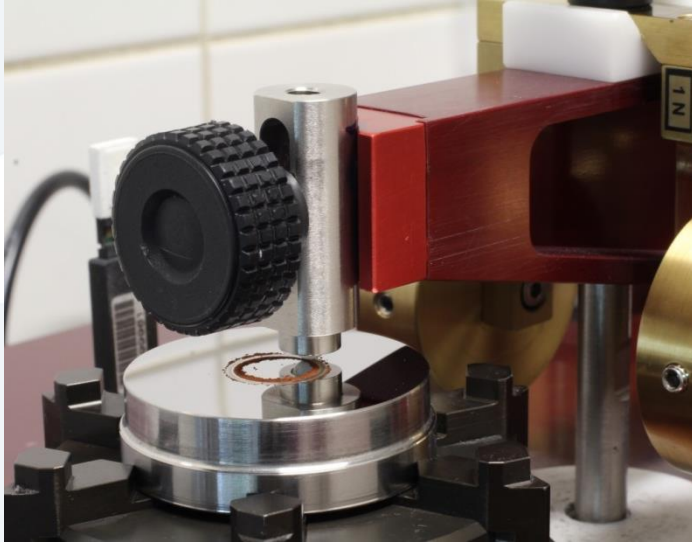
CR7V-L is characterized by a high hardness and an excellent tempering resistance



- The three tool steels show a secondary hardness maximum.
- CR7V-L develops the highest achievable hardness combined with an excellent tempering resistance.

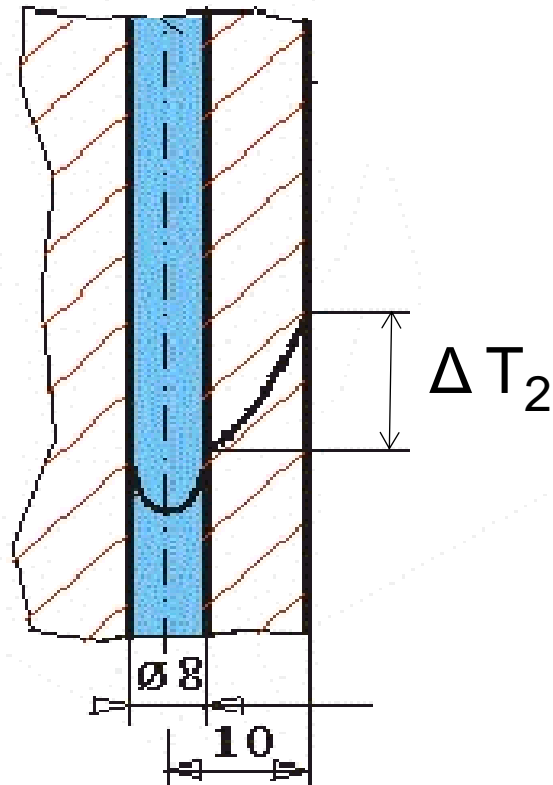
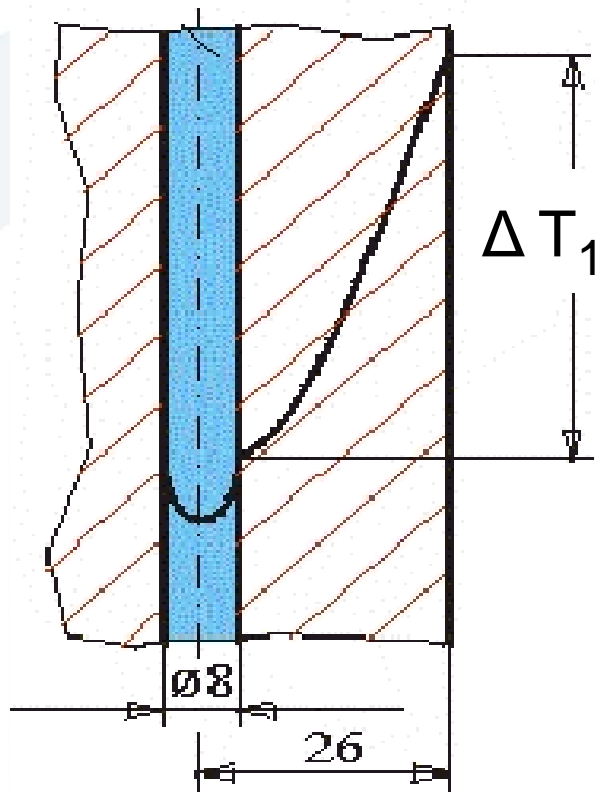


Better wear resistance of CR7V-L in comparison with RPU is confirmed



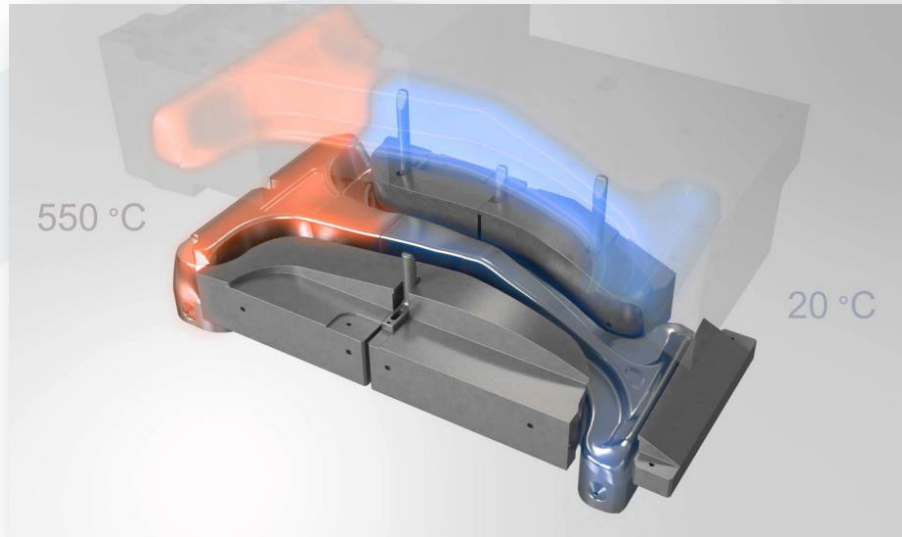
- Standardized with 1.2367
- The abrasive resistance of CR7V-L outperforms the standard grade 1.2367.

Design is much more effective lever for heat transfer than thermal conductivity

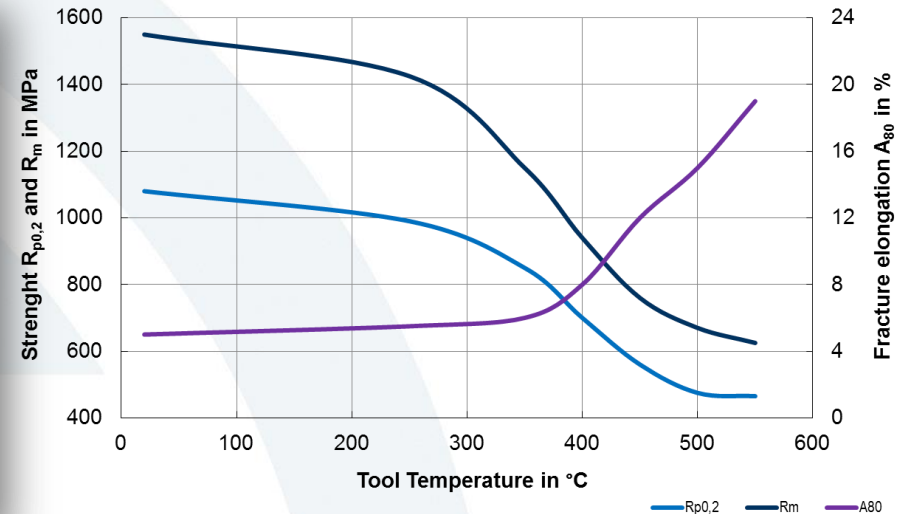


- The thermal conductivity of the different steels is very similar
- Small distance of cooling channels to the working surface, large diameters, and heavy cooling are more effective in influencing heat transfer compared to slightly higher thermal conductivity of the steel used

Tailored tempering allows for different strengths in the same part in one process



Thyssenkrupp



S. Sikora a.o. "Tailored Tempering- adjustment of local mechanical properties in hot formed parts
HTM Heat treatm. Mat. 66 (2011)

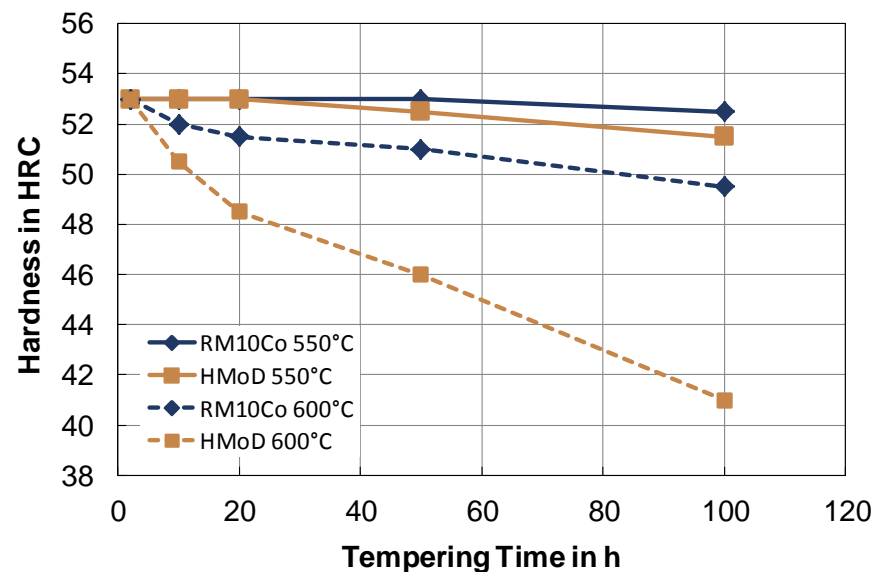
Aims:


- Press Hardened monolithic body parts with partially different material properties within the component.
- improved crash behavior combining lightweight.

Tailored tempering demands a tool steel providing excellent long-time tempering resistance

Steel Designation		Mass Content in %								Hardness Recommendation HRC
Brand	Mat.-No.	C	Si	Mn	Cr	Mo	V	W	Co	
RM10Co	1.2888	0.20	0.20	0.50	9.50	2.00	-	5.50	10.00	50 – 52
HMoD	1.2889	0.45	0.30	0.40	4.50	3.00	2.00	-	4.50	50 – 52

- Co-alloyed hot work tool steels
- Both steels have an excellent high temperature strength
- Outstanding long-time tempering resistance





Corrosion is more and more present

Hot stamping and corrosion

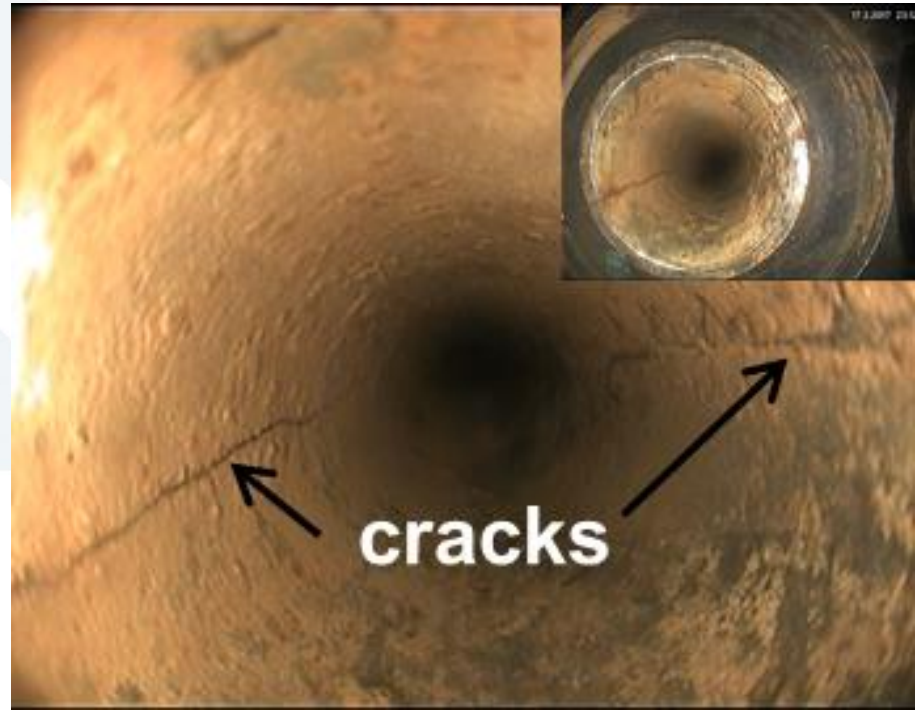
- Industrial experience
- Test setup and results
- Influence of hardness
- Recommendations

Cracks in cooling channels have become a serious failure mode



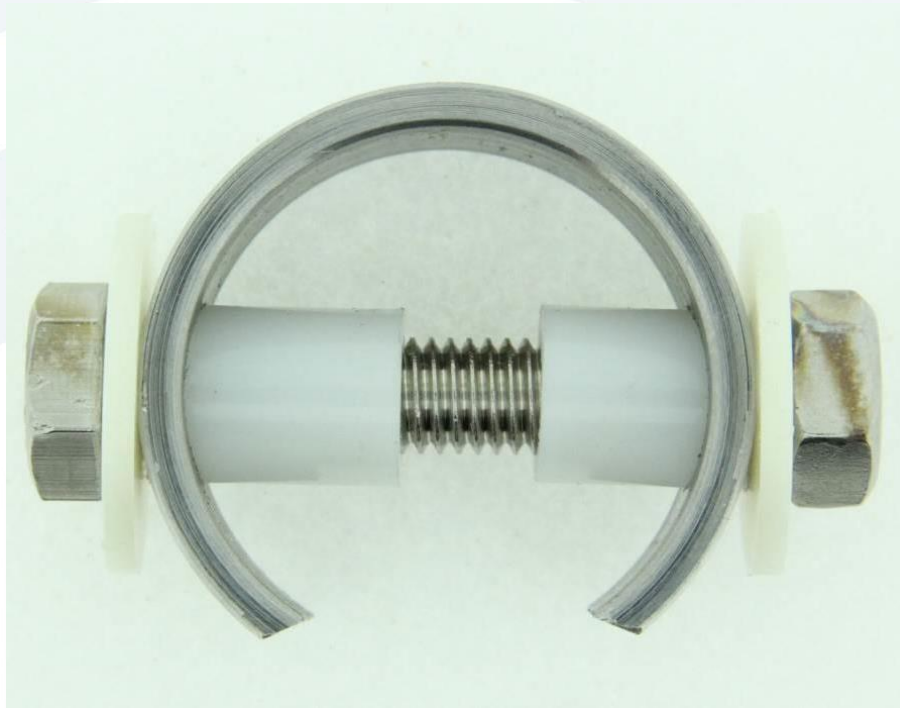
Water leakage from cooling channels:

- Favoured by critical trends in the industry:
 - Using highest hardness for the tools to reduce abrasive wear.
 - Reduced distances between cooling channels and working surface.



Cooling channel inspection by using a borescope:

- Formation of the crack in the cooling channels.
- Crack formation favoured by corrosion.



- Ring-shaped samples acc. to NACE Standard TM0177-2005
- Dimensions: ID 34 mm, OD 40 mm, width 3 mm, length 20 mm

- Tested tool steels

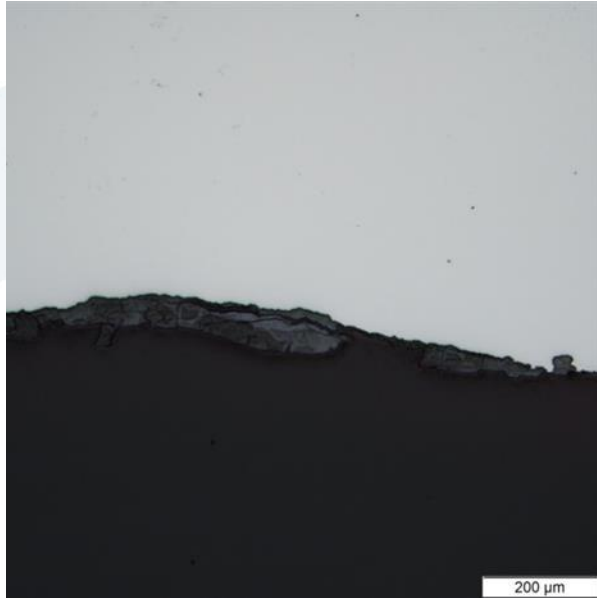
Brand	Hardness (HRC)			Metallurgy
RPU	41	45	53	ESR
CR7V-L	40	47	53	Not ESR

- Test parameters

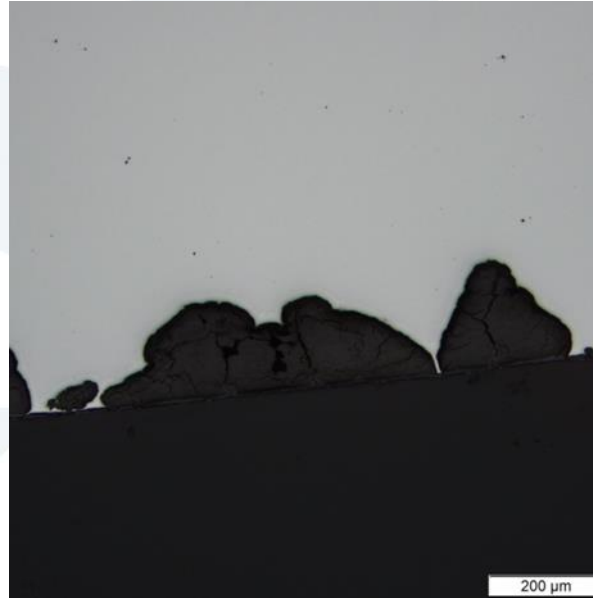
Test No.	[Cl ⁻] (ppm)	T (°C)	Time (h)
1	250	30	504
2	250	50	504
3	1250	30	336

- 250 ppm corresponds to the highest tolerable concentration of chloride in german drinking water.
- Chloride concentration in industrial cooling water is assumed to be higher than 250 ppm.

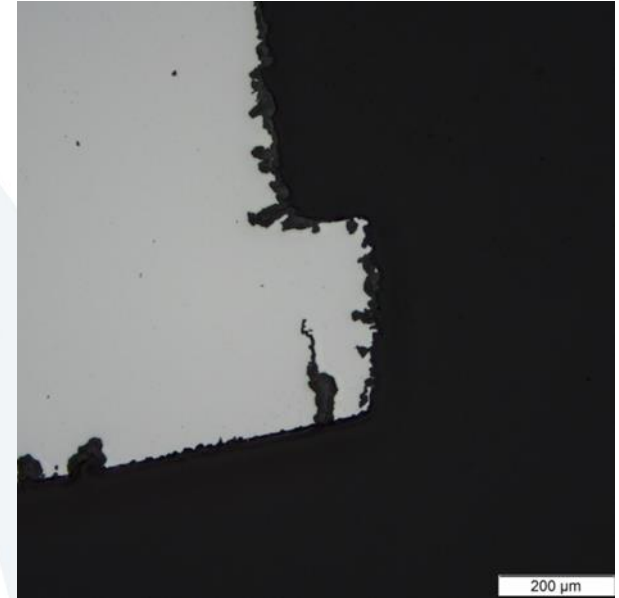
Three types of corrosion are observed



General corrosion



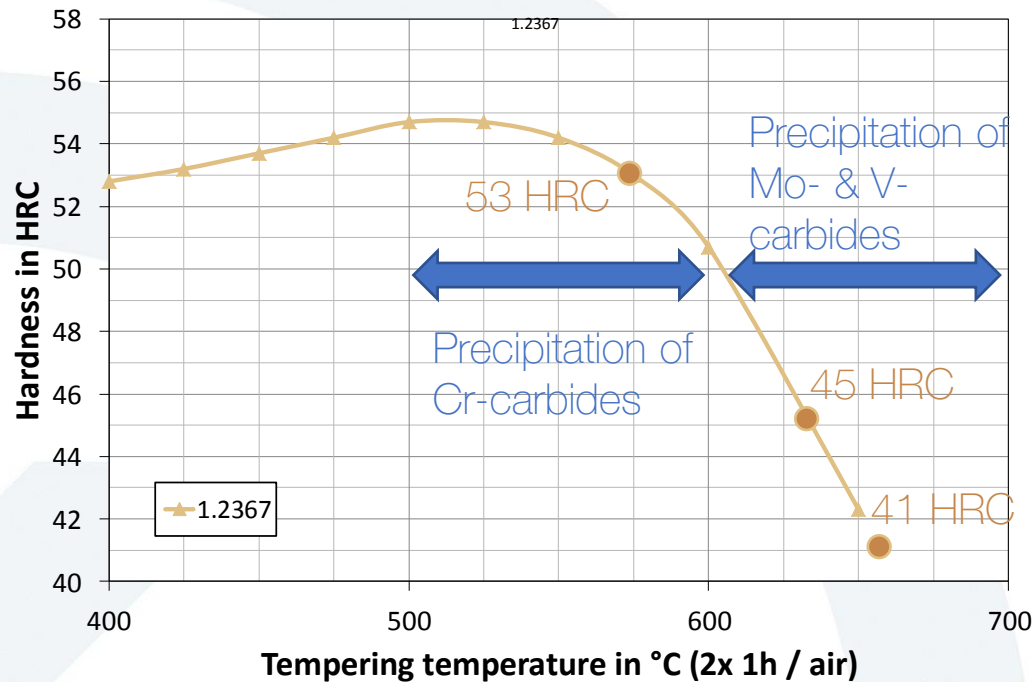
Localized corrosion



Stress corrosion cracking

- Both tested steels show a very similar corrosion pattern.
- Good resistance against general corrosion.
- The higher the hardness, the more sensitive to corrosion are the steels.
- The higher the concentration of chloride, the more widespread are the localized corrosion and the stress corrosion cracking.
- A higher temperature leads to more corrosion.

By choosing the tempering temperature/working hardness the corrosion behaviour is influenced



- The tempering at temperature near the secondary hardness maximum leads to the precipitation of Cr-carbides.
- Less Cr-atoms available for the corrosion resistance, chromium depleted zones are formed around the carbides.
- Local corrosion attack can start more easy.
- Furthermore the toughness potential is lower after tempering at the secondary hardness maximum, the stress corrosion cracks propagate faster.

- Do not expect corrosion resistance from 5% Cr- hot-work tool steels.
- Use, whenever available, the ESR version of the selected steel (better homogeneity, higher cleanliness).
- Avoid tempering tools of these hot-work tool steels to the secondary maximum hardness.
- Provide a smooth surface of the cooling channels (use sharp drills).
- Check cooling water regularly.
- Use closed cooling water circuits.
- Consider the use of corrosion inhibiting additives to the cooling water.

Conclusion



- Hot stamping is a modern and efficient process to produce steel components with extremely high tensile strength and light weight.
- Kind & Co. recommends the special grade CR7V-L for quenched hot-stamping tools. The special steel CR7V-L provides all necessary properties for a successful application in the hot stamping technology:
 - High abrasive wear resistance.
 - High hardness.
 - Excellent tempering resistance.
- CR7V-L is available as Electro-Slag-Remelted steel for highest toughness requirements, particularly in presence of intense cooling close to the working surface.
- For tailored tempering Kind & Co. recommends to use tool steels with an outstanding long-time tempering resistance such as RM10Co and HMoD.
- Kind & Co. recommends to avoid a tempering at temperatures corresponding to the maximum secondary hardness , as this is the condition of lowest toughness and highest sensitive to corrosion.

**Thank you for
your attention!**

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