



Premium Tool Steel – A Pre-Requisite for Efficient Drop Forging Production

Chennai, January 19 - 20, 2019

1. [Brief Profile Kind&Co Group](#)
2. [General Remarks on Suitable Tool Steels](#)
3. [Factors Influencing Tool Life in Forging Operations](#)
4. [Detailed Tool Steel Recommendations](#)
5. [Conclusion](#)



Globally operating hot-work
tool steel specialist

Brief profile of the KIND&CO Group

- Tradition and modernity
- Continuous production process
- Kind&Co Group in a nutshell
- Kind & Co. and Goel Steel

Tradition and Modernity: The Best of Both Worlds!



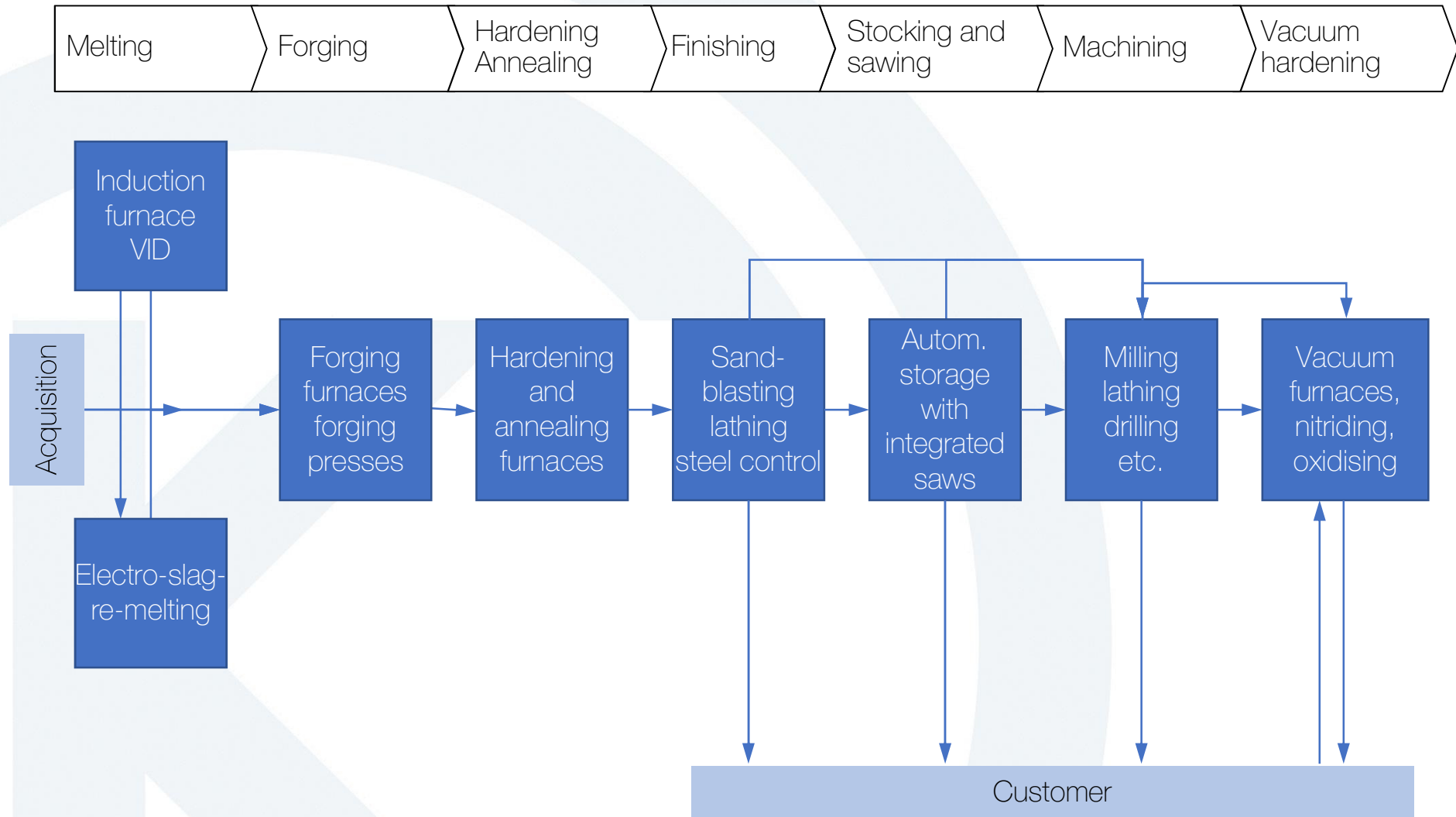
Tradition

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

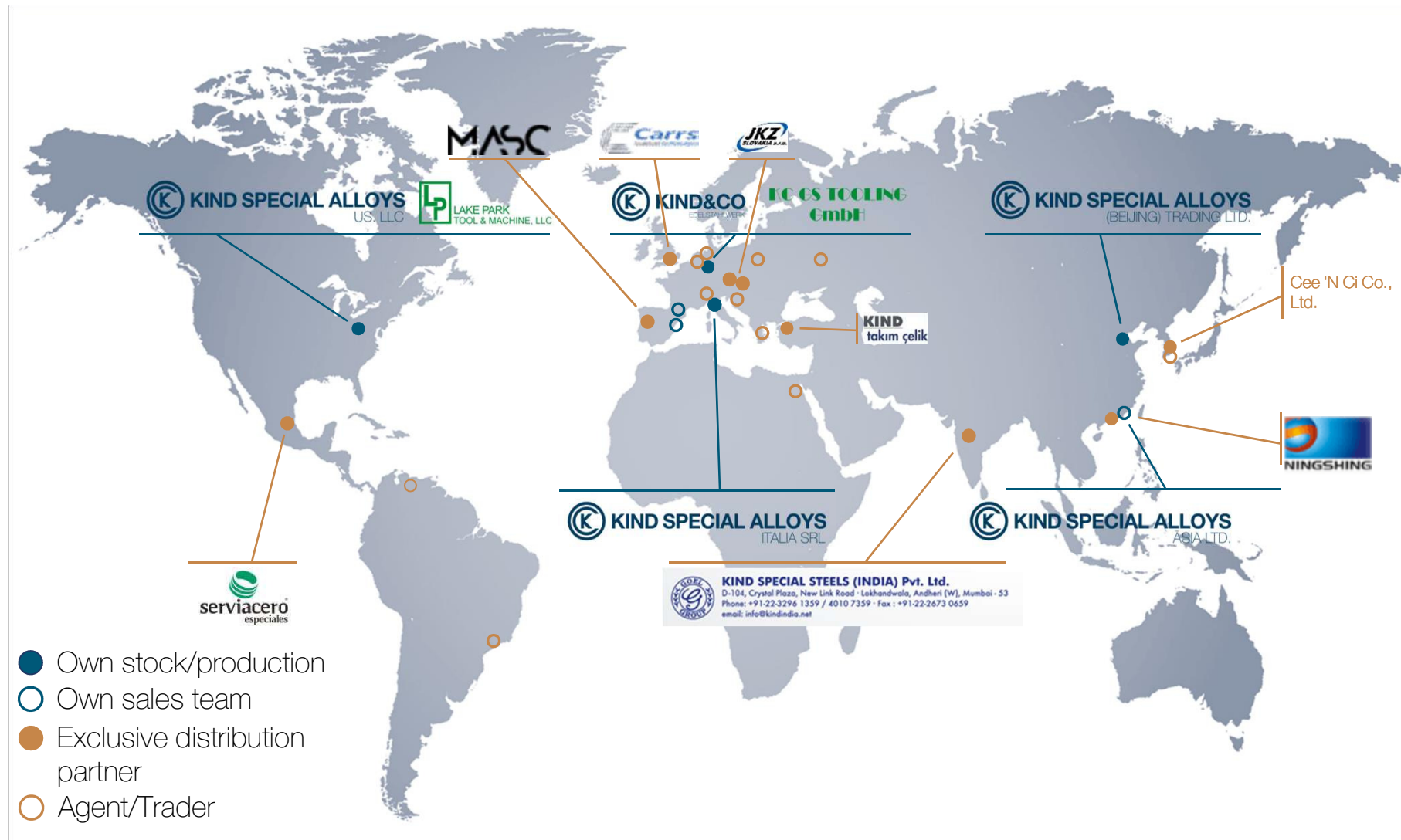
Modernity

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

Continuous Production Process: Expertise in Every Step of the Value Chain



Kind & Co Group in a Nutshell: Global Network with Uniformly High Service Standards



Kind & Co. and Goel Steel – Two Strong Partners for India



Goel Steel Company

SPECIAL STEELS - ENGINEERING SERVICES

www.goelsteel.com



Hot-work tool steels for the forging industry

General remarks on suitable tool steels

- Process of tool steel selection
- Hammer forging
- Press forging




High demands in die forging require reliable and powerful tools



India's forging industry faces a rapidly growing demand in forged products and many challenges:

- High demand of forged products for two-wheelers, passenger cars, and commercial vehicles,
- Permanent necessity to improve the profitability of the forging processes and the precision of the forged products,
- Necessity of automotive light-weight in order to reduce fuel consumption and toxic emissions,
- Substitution of forged materials, e.g. steel by aluminium.
- Furthermore there is a clear trend towards forged components of titanium in turbine applications or medical implants.

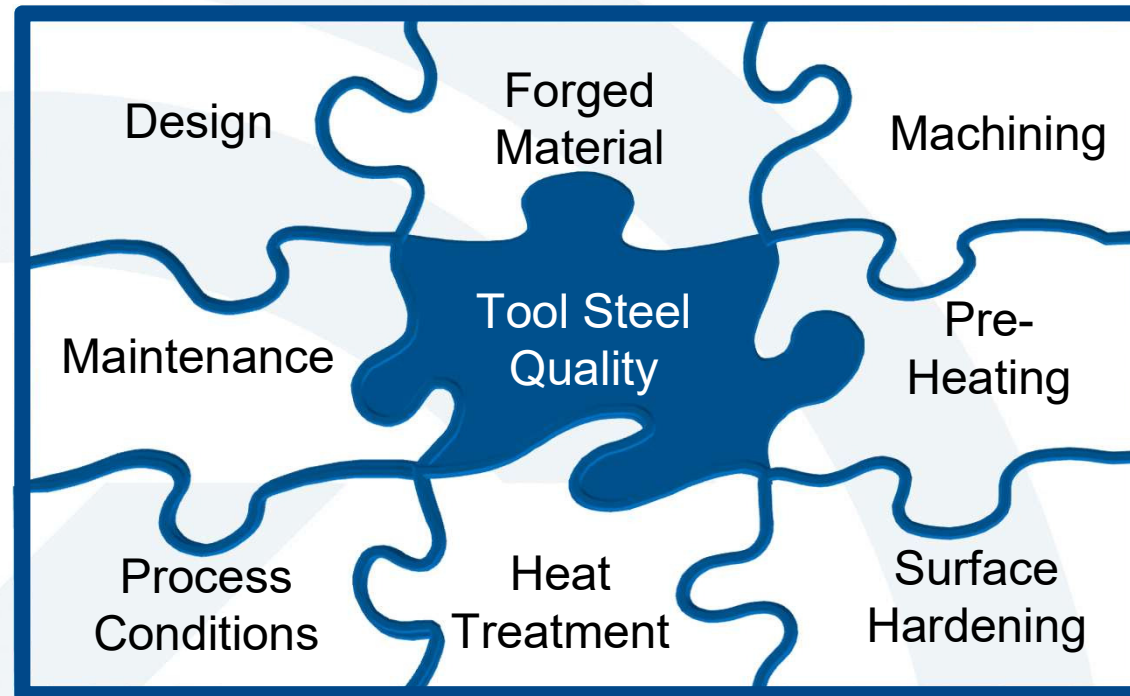
A photograph of a heavy-duty industrial chain and a weight. The chain is made of thick, dark metal links, some of which are coiled together. In the background, a rectangular metal weight is visible, with a white label that reads "600 kg". The scene is set in a workshop or factory environment, with a blurred background showing industrial equipment.

Great tool performance is the result of carefully adjusted parameters

Factors influencing tool life in forging operations

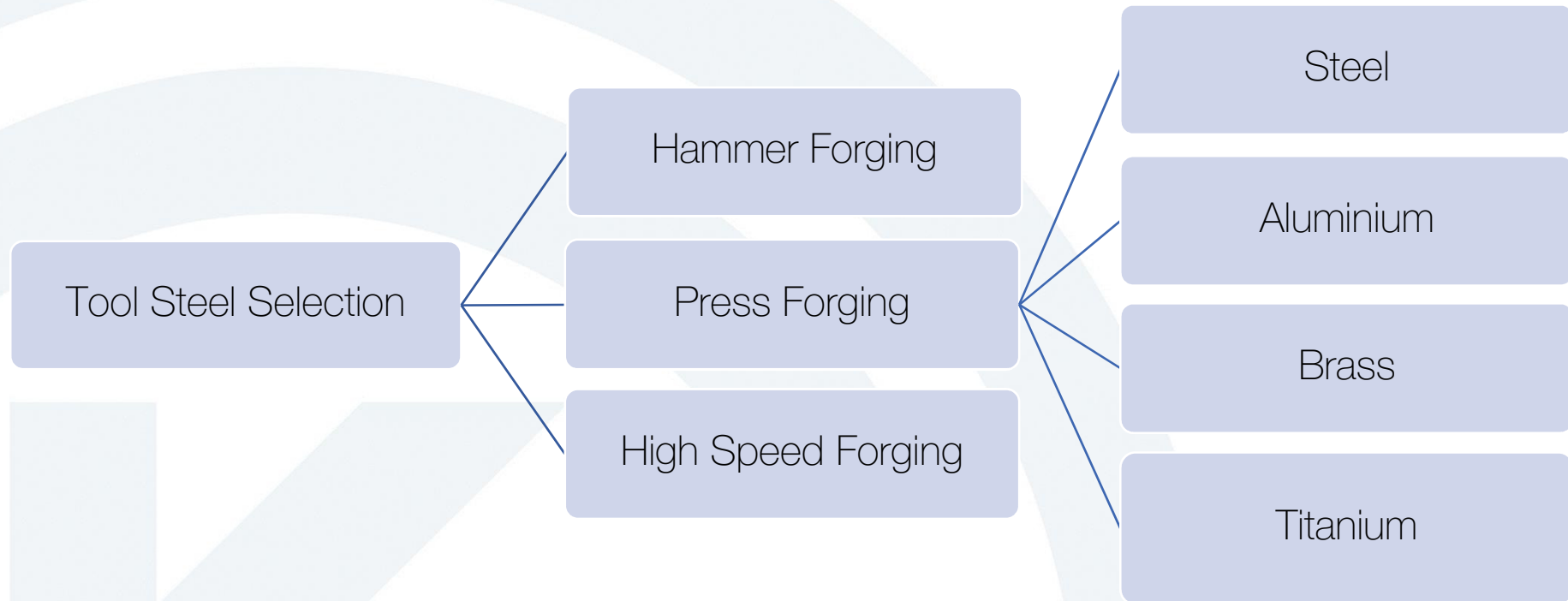
- Influencing factors
- Tool steel selection with respect to forging process and material

Excellent die performance is the result of a proper interaction of many factors



- Many factors influence the performance of forging dies. Tool steel quality is only one of them.
- Kind & Co. is responsible to provide tool materials solutions according to customer's requirements.
- Goel Steel operates a modern vacuum heat treatment company – Sanjay Steel Syndicate – to perform high-class heat treatment.

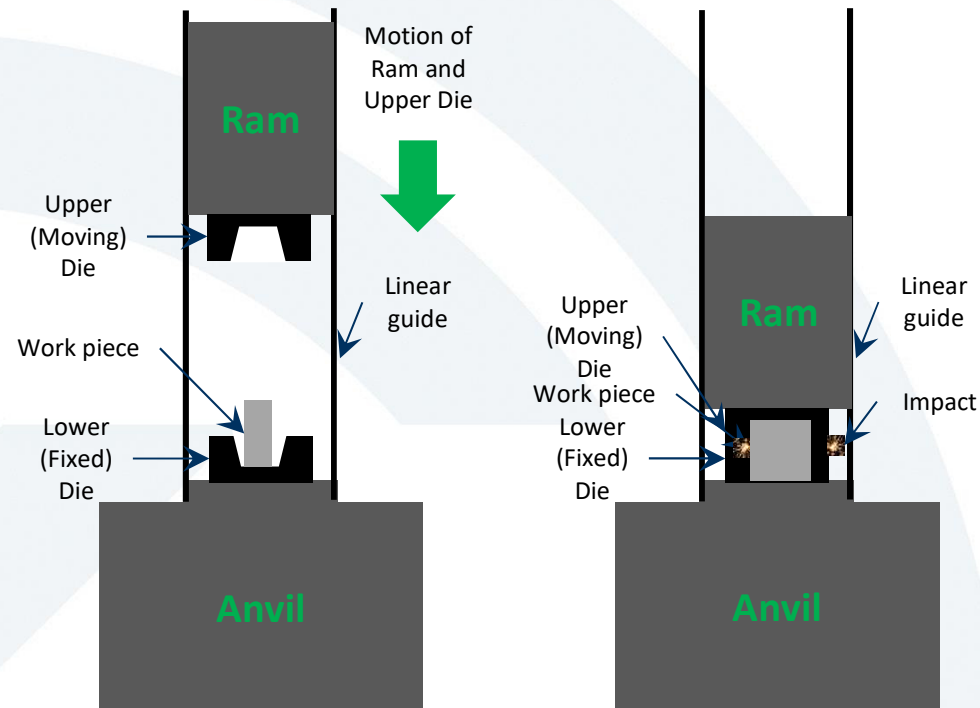
The selection of a suitable die steel has to respect forging equipment and forged material



- The loads on the forging dies differ significantly from hammer to press forging and to high speed forging.
- These differences have to be respected in the selection of a suitable die steel as well as in the design of the forging dies.
- The specific deformation behaviour and range of forging temperatures of each metal has significant influence on the loads on the dies.
- These influences need to be respected in the tool steel selection.

The loads on hammer forging dies are extremely sudden

Forging Hammer



Characteristic loads of hammer forging dies:

- Sudden mechanical impact
- Sudden thermal impact
- Short contact time
- Medium thermal load

Demands for hammer forging dies:

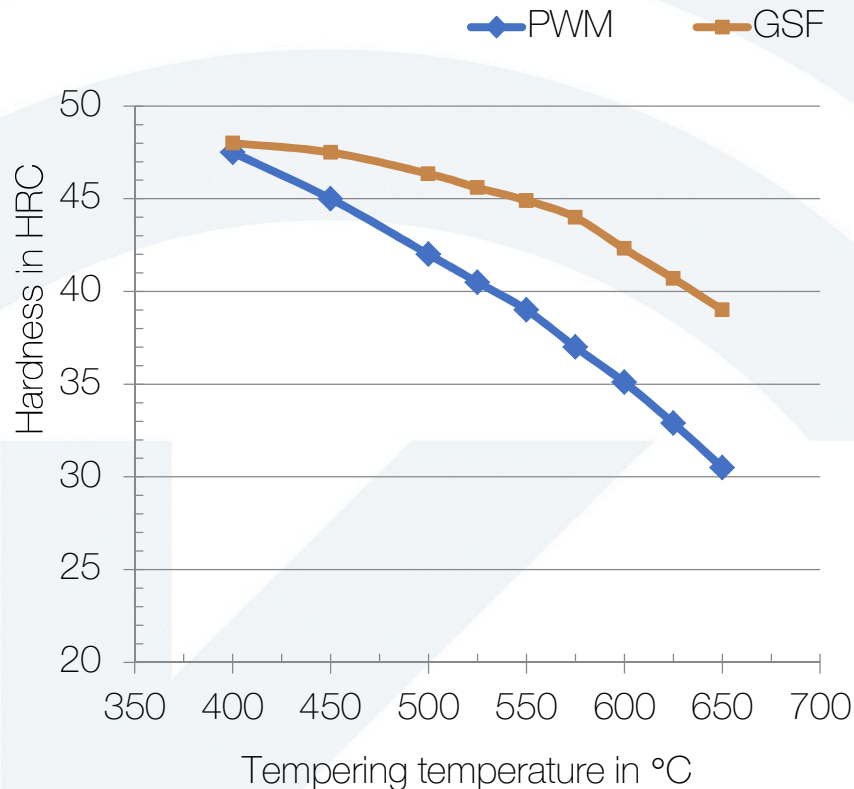
- Excellent toughness
- Good tempering resistance
- Good wear resistance

The alloy concepts of hot-work tool steels for hammer forging dies respect the demand of extreme toughness

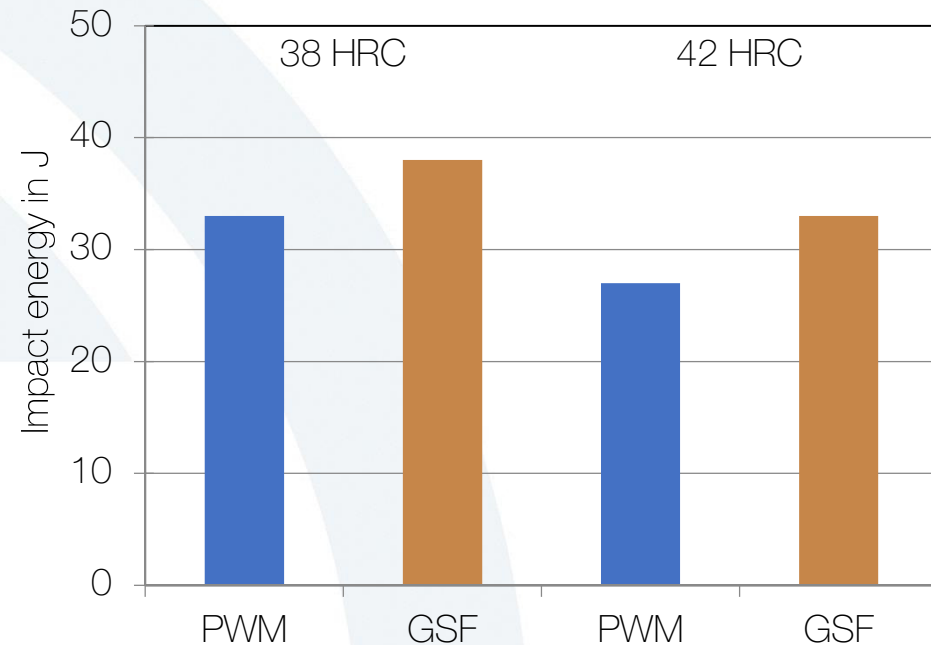
Steel designation		Alloy content in mass-%						
Brand	Mat.-No.	C	Si	Mn	Cr	Mo	Ni	V
PWM	1.2714	0,55	0,30	0,80	1,10	0,50	1,70	0,40
GSF	---	0,28	0,30	0,70	2,80	0,60	1,00	0,40

- The alloy composition of the grade PWM corresponds to the internationally standardized hot-work tool steel 1.2714 which is regarded as the standard hot-work tool steel for hammer forging dies.
- Grade GSF has been designed by Kind & Co. in order to provide a tool steel grade with improved tempering resistance and toughness.

Special hot-work tool steel GSF provides tailored tempering resistance and toughness for hammer forging



- The higher tempering resistance of premium hot-work tool steel GSF protects hammer forging dies better against softening than the „good standard“ grade PWM.



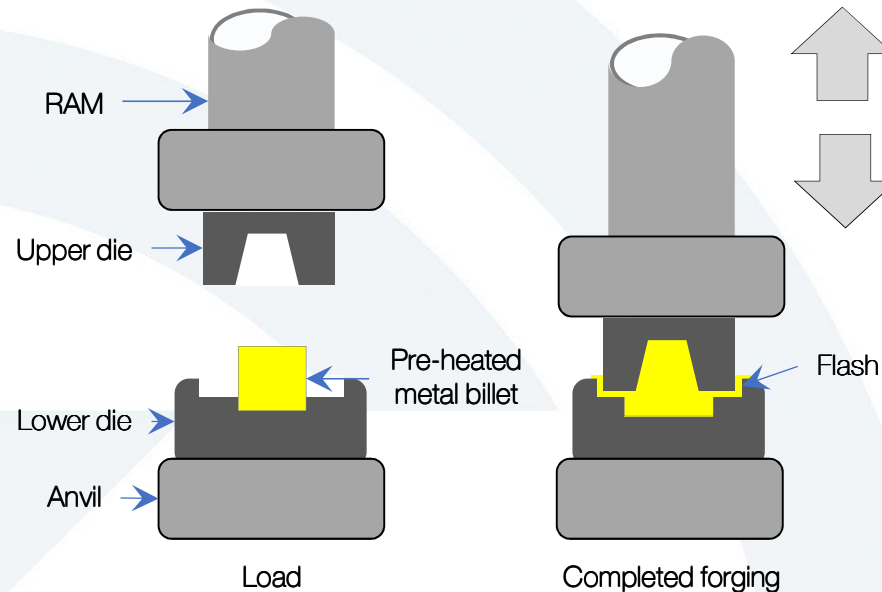
- The higher toughness of premium grade GSF provides a higher resistance against gross cracking of forging dies.
- Measured by ISO-V-notch samples (transverse orientation) at room temperature,

Concluding remarks about hot-work tool steels for hammer forging dies

- The special hot-work tool steel GSF combines improved tempering resistance and toughness.
- The low carbon content makes the steel GSF easily weldable, e.g. for deposition welding of wear resistant alloys.
- These advantages make GSF a powerful alternative to standard grade 1.2714 in hammer forging applications.
- GSF is recommended for dies sensitive to cracks.
- GSF is hardened ex mill:
 - No additional heat treatment is required.
 - Time for the production of dies sets is reduced.
 - No risk of distortion during heat treatment.

Press forging dies are exposed to long heat contact time and less sudden mechanical stress compared to hammer

Forging Press



Characteristic loads of press forging dies:

- Long contact time
- High thermal load
- High abrasive wear

Demands for press forging dies:

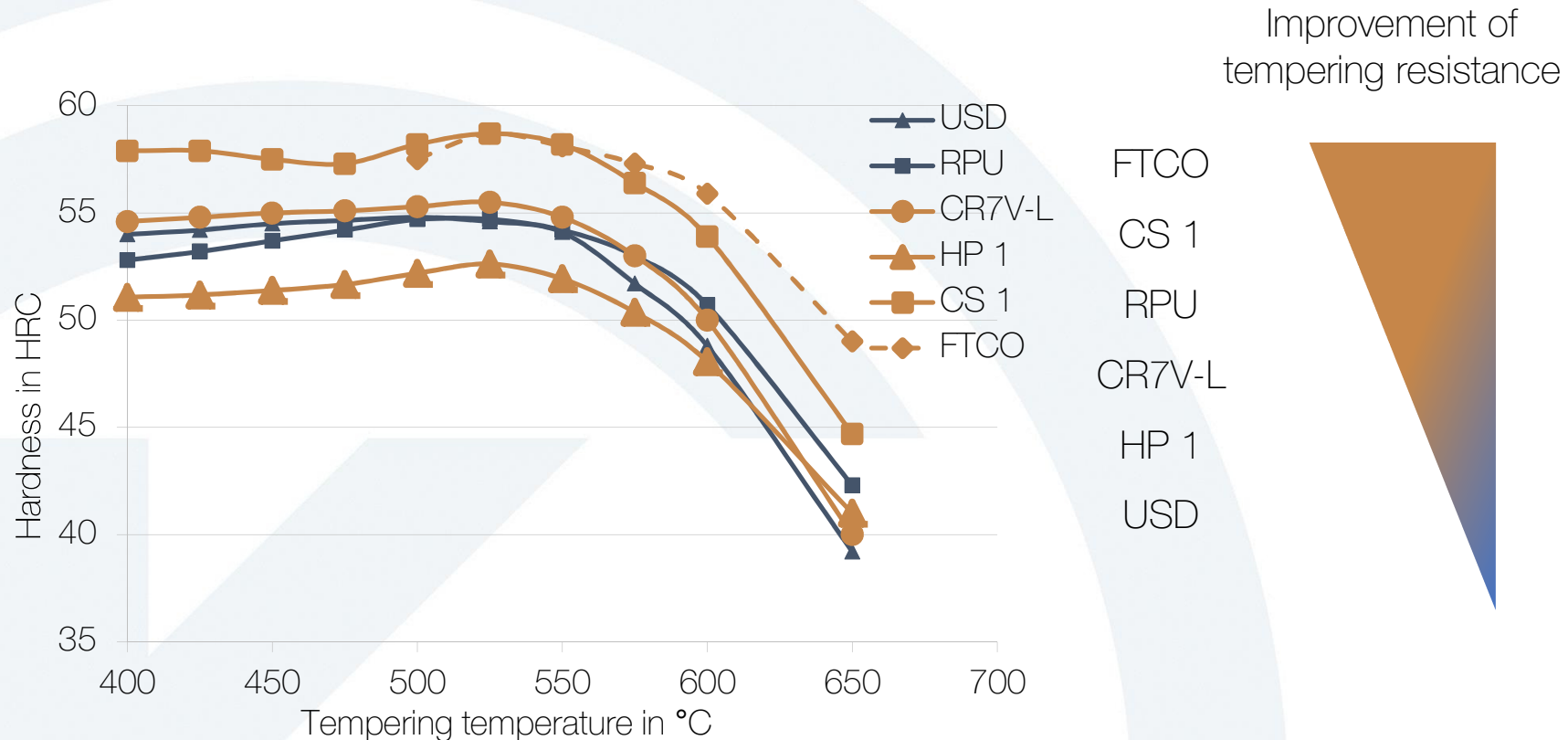
- Good high-temperature strength
- Great high-temperature wear resistance
- Toughness

The alloy concepts of hot-work tool steels for press forging dies respect the demand of the forging process

Steel designation			Alloy content in mass-%								
Brand	Mat.-No.	AISI	C	Si	Mn	Cr	Mo	V	W	Co	Nb
USD	1.2344	H13	0,40	1,00	0,40	5,20	1,30	1,00	-	-	-
RPU	1.2367	---	0,38	0,40	0,40	5,00	300	0,60	-	-	-
CR7V-L	---	---	0,42	0,50	0,40	6,50	1,30	0,80	-	-	-
HP 1	---	---	0,35	0,20	0,30	5,20	1,40	0,55	-	-	+
CS 1	---	---	0,50	0,30	0,40	5,00	1,90	0,55	-	-	+
FTCo	---	---	0,53	0,35	0,40	4,00	2,00	1,00	1,50	0,9	+

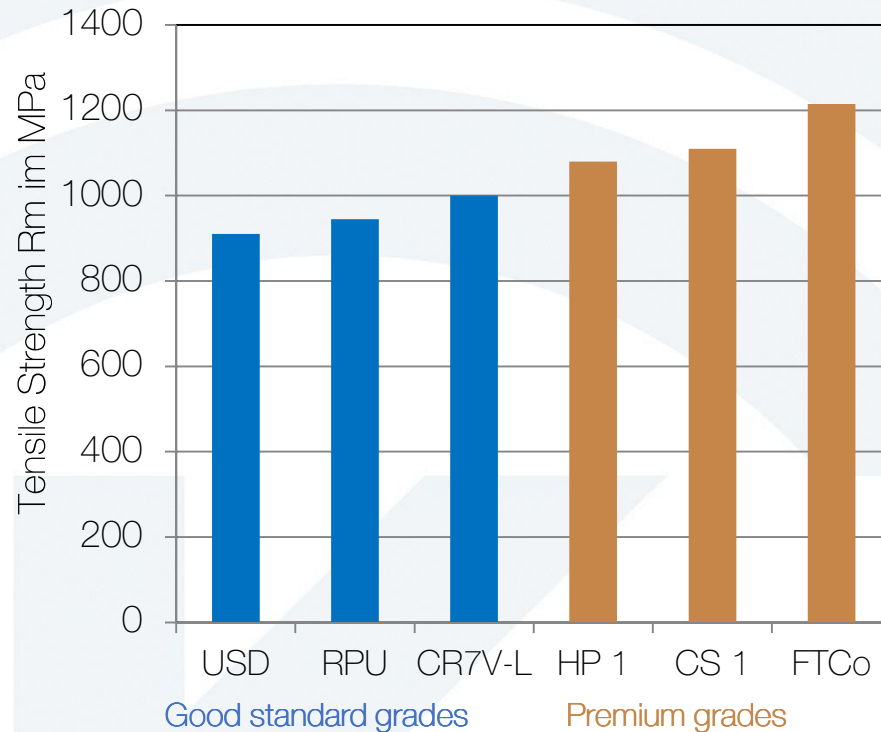
- The alloying composition of grades USD, and RPU correspond to ISO 4957. However, due to the excellent production methods (metallurgy, forging strategy, heat treatment) applied at Kind & Co., these „standard“ grades show better performance than average („good standard“).
- CR7V-L, HP 1, CS 1, and FTCo are specially developed by Kind & Co and show a tailored property combination („premium“)
- The special hot-work tool steel grades HP 1, CS 1, and FTCo are exclusively made via Electro-Slag-Remelting (ESR).
- The addition of Co, W, and Nb provide an outstanding high-temperature strength of FTCo.

Tempering diagrams are an important instrument for the selection and heat treatment of suitable die steels

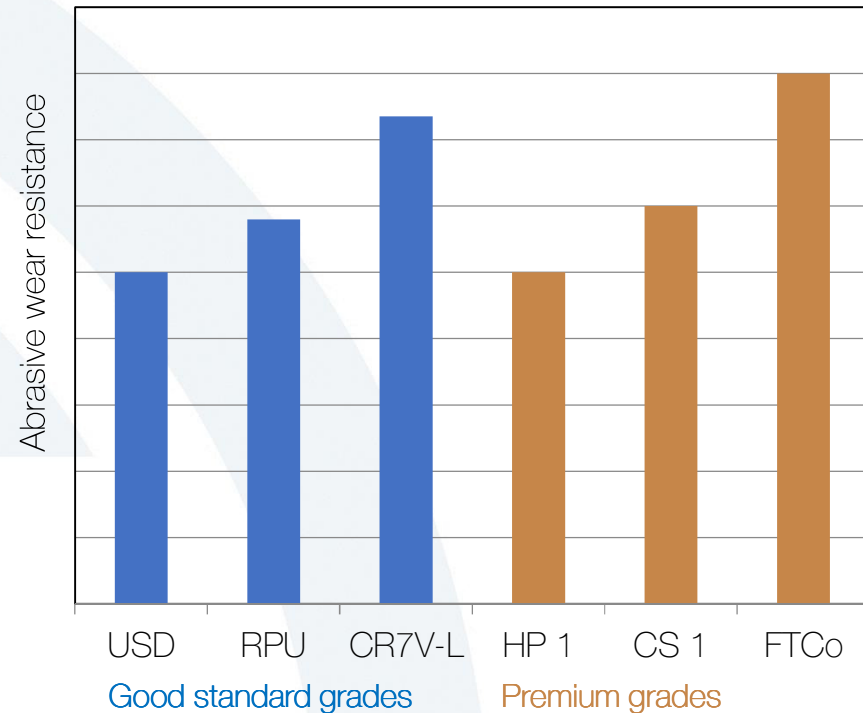


- Tempering curves describe the individual tempering response of each steel and allow the correct adjustment of tempering temperatures during heat treatment of the dies.
- The comparison of these curves allow a differentiation of the steels with respect to tempering resistance.
- High tempering resistance means high resistance against softening due to operational temperatures.

High-temperature strength and abrasive wear resistance strongly influence the performance of forging tools



- High-temperature strength Rm at 550 °C.
- The special hot-work tool steels reveal an improved high-temperature strength.



- Qualitative comparison of abrasive wear resistance.
- Kind & Co. offers a wide range of combinations of abrasive wear resistance and high-temperature strength.

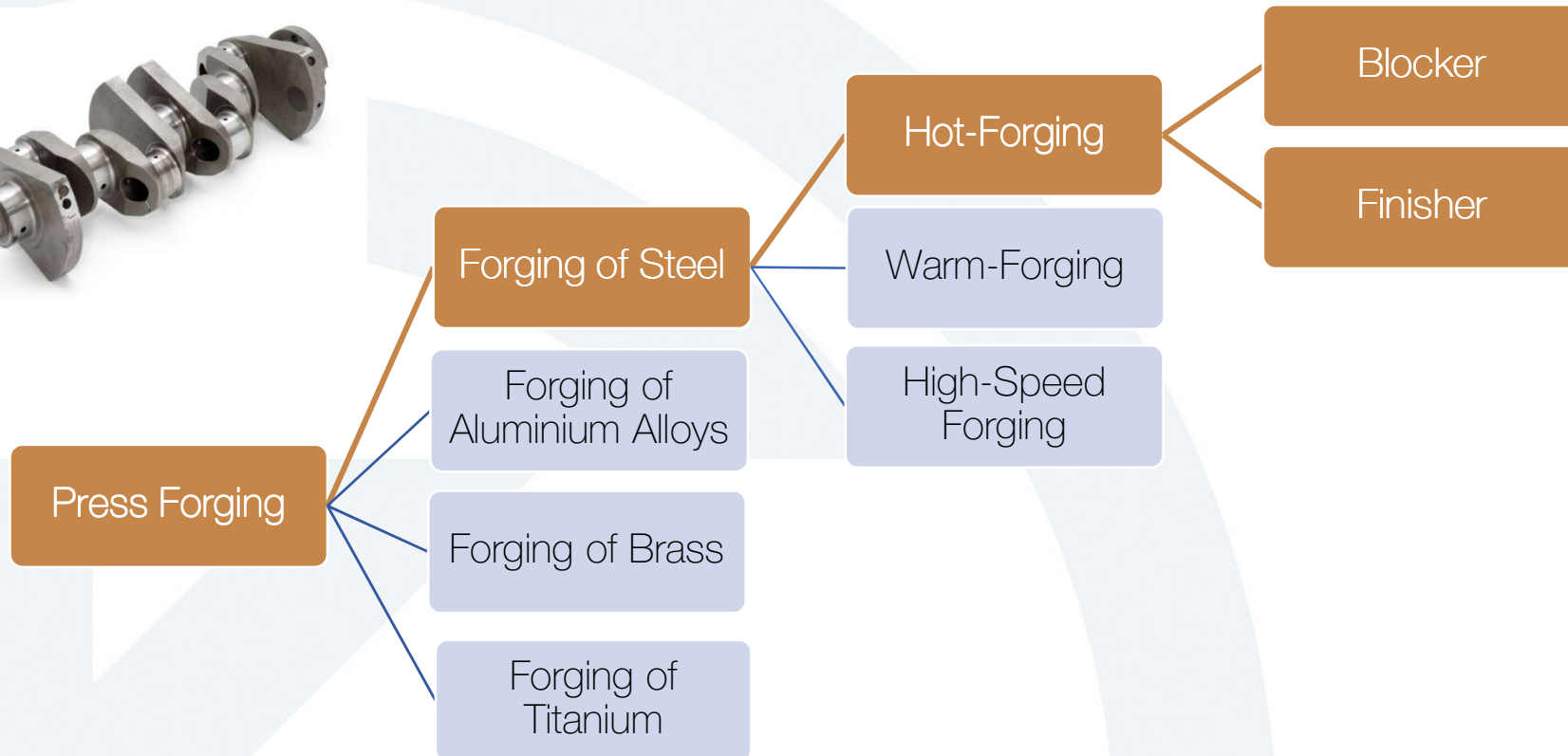


Each forging technology needs specific tool steel recommendations

Detailed tool steel recommendations

- For hot-forging of steel
- For warm-forging of steel
- For high-speed forging

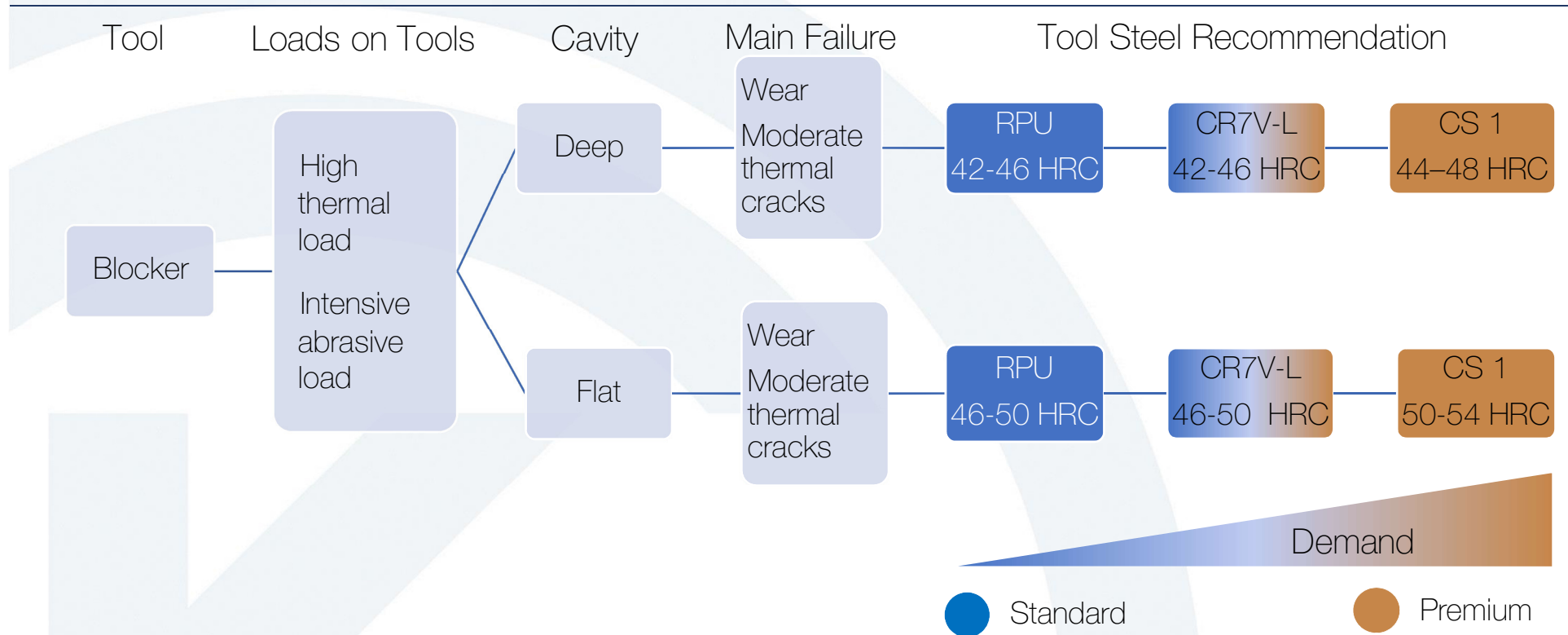
Hot-forging of steel requires a differentiated tool steel recommendation for blockers and finishers



- Tools for hot-forging of steel under forging presses are exposed to high thermal loads and intensive abrasive wear.
- The tool steel selection should respect whether the dies are used as a blocker (first, rough stage of deformation) or as a finisher (final step of deformation).



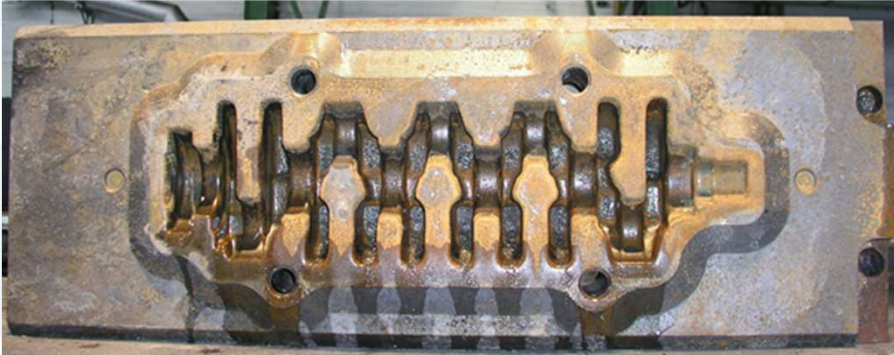
Tool steels for blockers recommended with respect to the type of cavity



- Blockers are exposed to high thermal and abrasive loads.
- Steel grade RPU can be regarded as standard die material, hardness depending on the cavity.
- CR7V-L offers a higher carbide content and is recommended in case of higher wear resistance.
- Grade CS 1 offers high wear resistance in combination with improved toughness and offers further benefits.

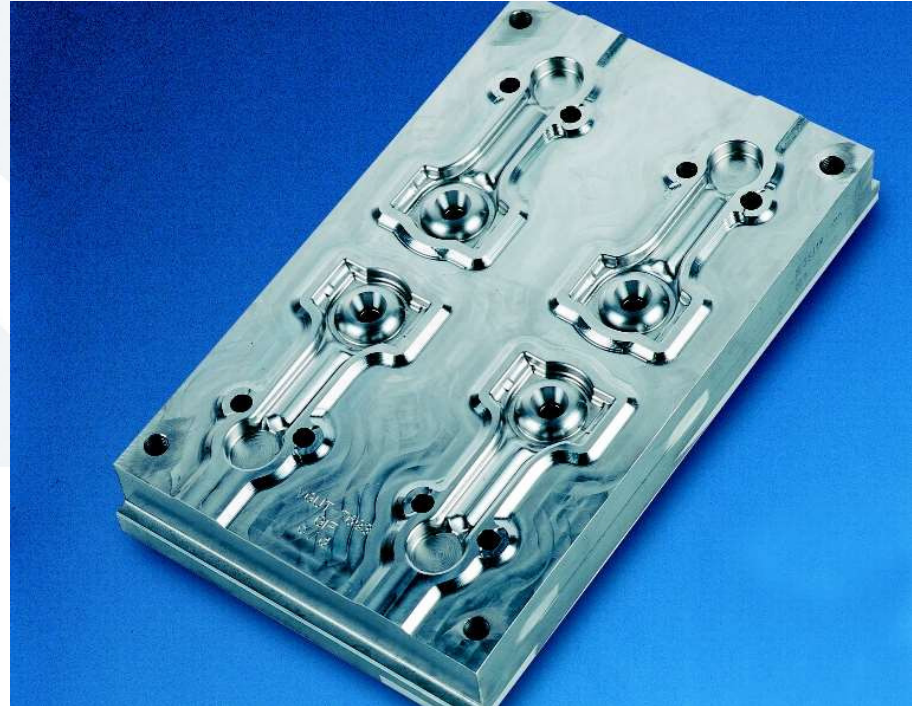


Successful applications of CR7V-L for blocker dies provide 60-70% longer die life



Forging die for a crank shaft

- CR7V-L : 45 HRC
- H11 and H13: 45 HRC
- Increase of performance: 60 %

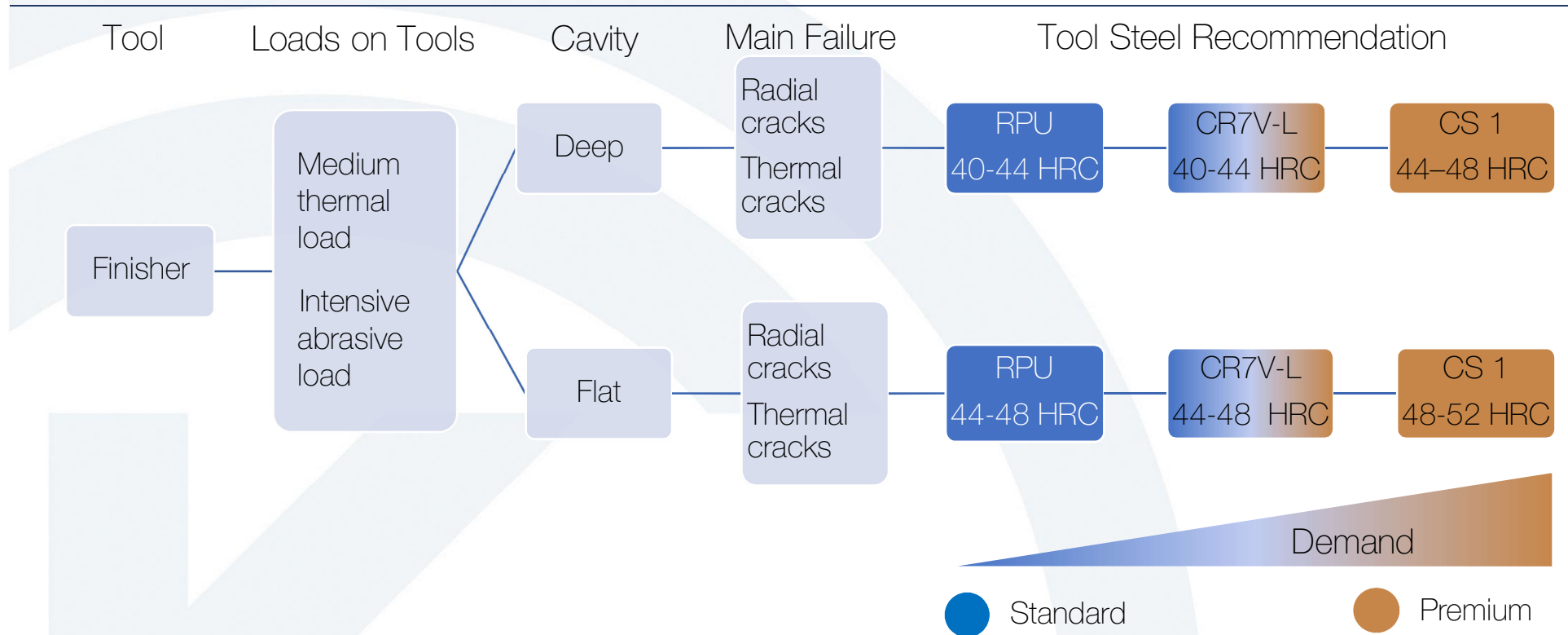


Blocker die for connecting rods
(hydraulic 2,500 tons forging press)

- CR7V-L: 48 HRC
- Improvement in performance:
up to 70 % compared to standard hot-work
tool steel H 13.



Tool steels for finishers recommended with respect to the type of cavity



- Finishers are exposed to slightly lower thermal and abrasive loads than blockers.
- Steel grade RPU can be regarded as standard die material, hardness depending on the cavity.
- CR7V-L offers a higher carbide content and is recommended in case of higher wear resistance.
- Grade CS 1 offers high wear resistance in combination with improved toughness and offers further benefits.



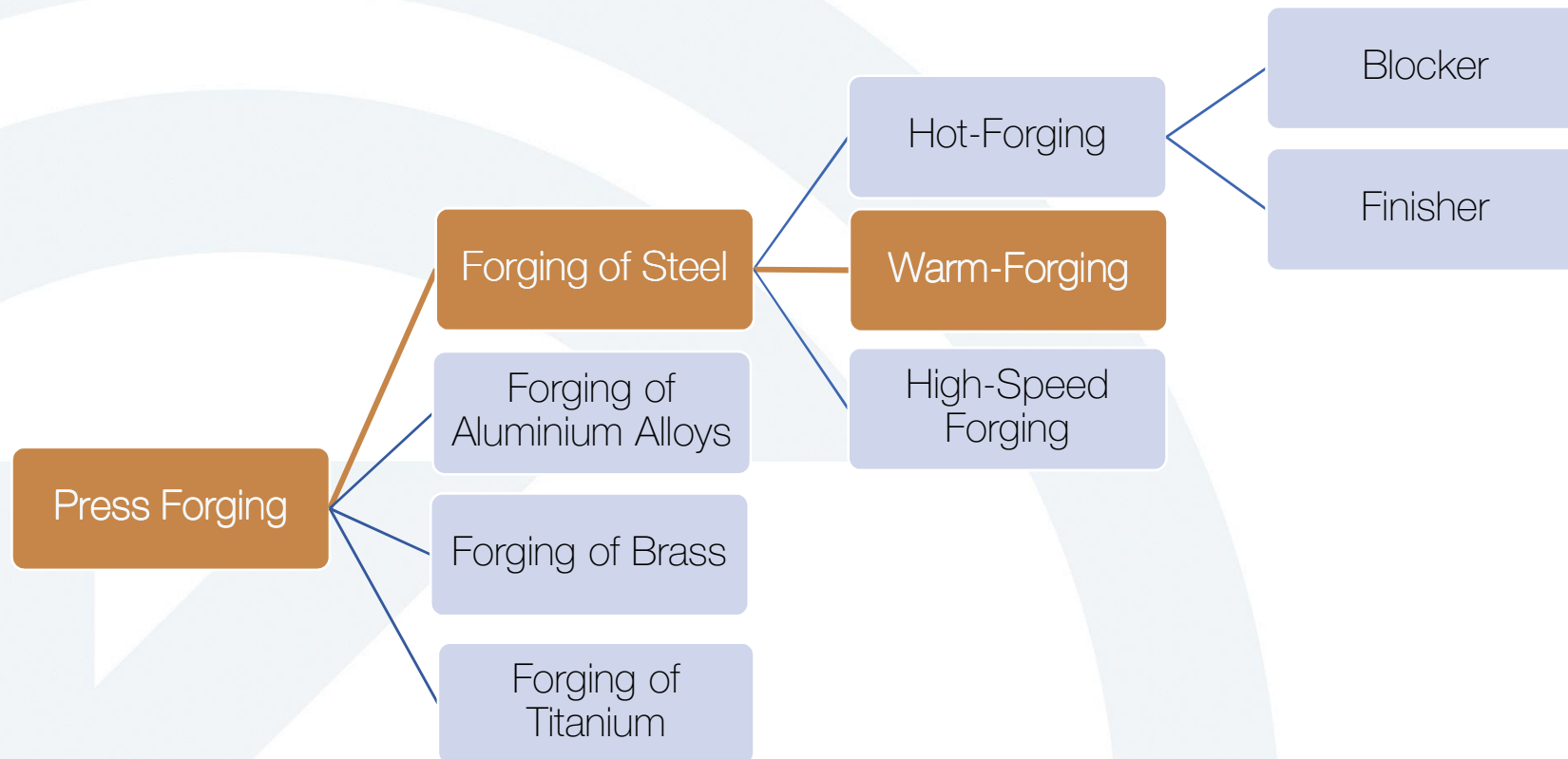
Application of CR7V-L for finisher dies has increased the performance by 65 %



Finish die for a hydraulic 3,200 tons forging press:

- Die steel: CR7V-L 48 HRC
- Improvement in performance: up to 65 % compared to standard hot-work tool steel H 13.

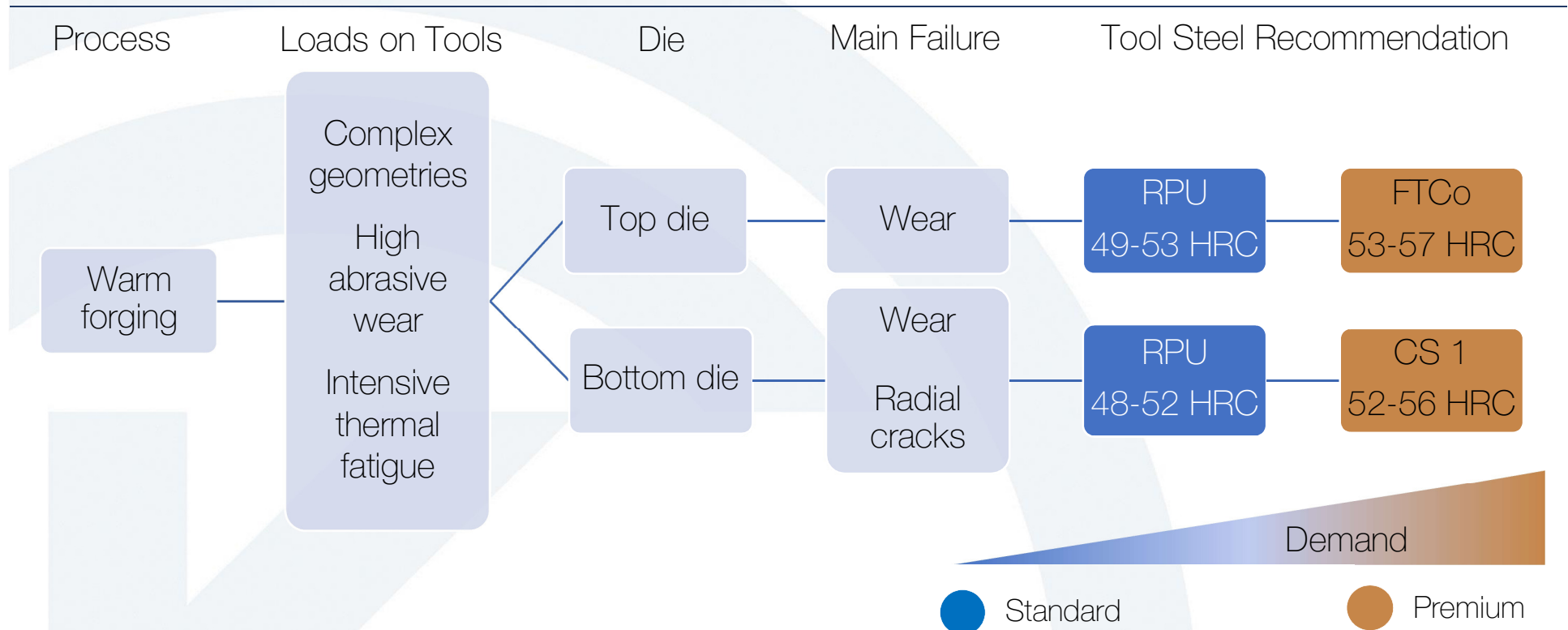
Warm-forging of steel requires specifically selected tool steels



- Warm-forging in the temperature range between 650 and 900 °C is characterized by complex geometries and high precision of the forged products.
- The dies are exposed to high abrasive wear and to thermal fatigue.

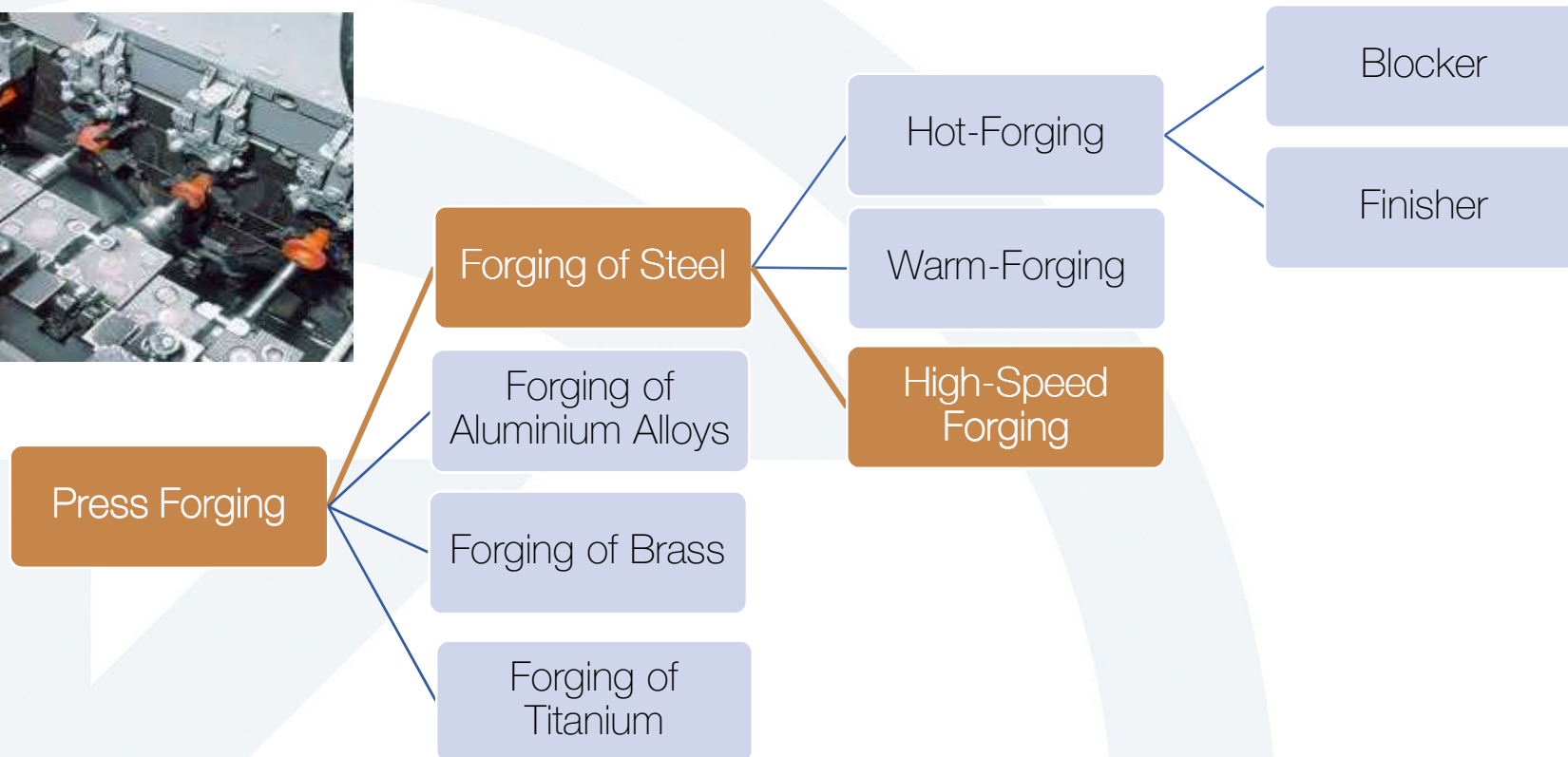
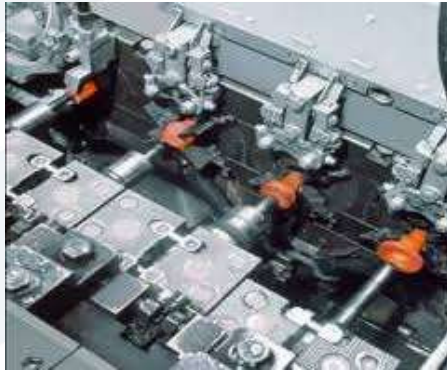


Tool steels for warm forging processes have to withstand intensive wear



- Warm forging dies are exposed to high abrasive wear and intensive thermal fatigue. Suitable tool steels need to have high carbide content and good high-temperature strength.
- Steel grade RPU can be regarded as standard die material, hardness depending on the type of die.
- FTCo provides highest wear resistance.
- Grade CS 1 offers high wear resistance in combination with improved toughness.

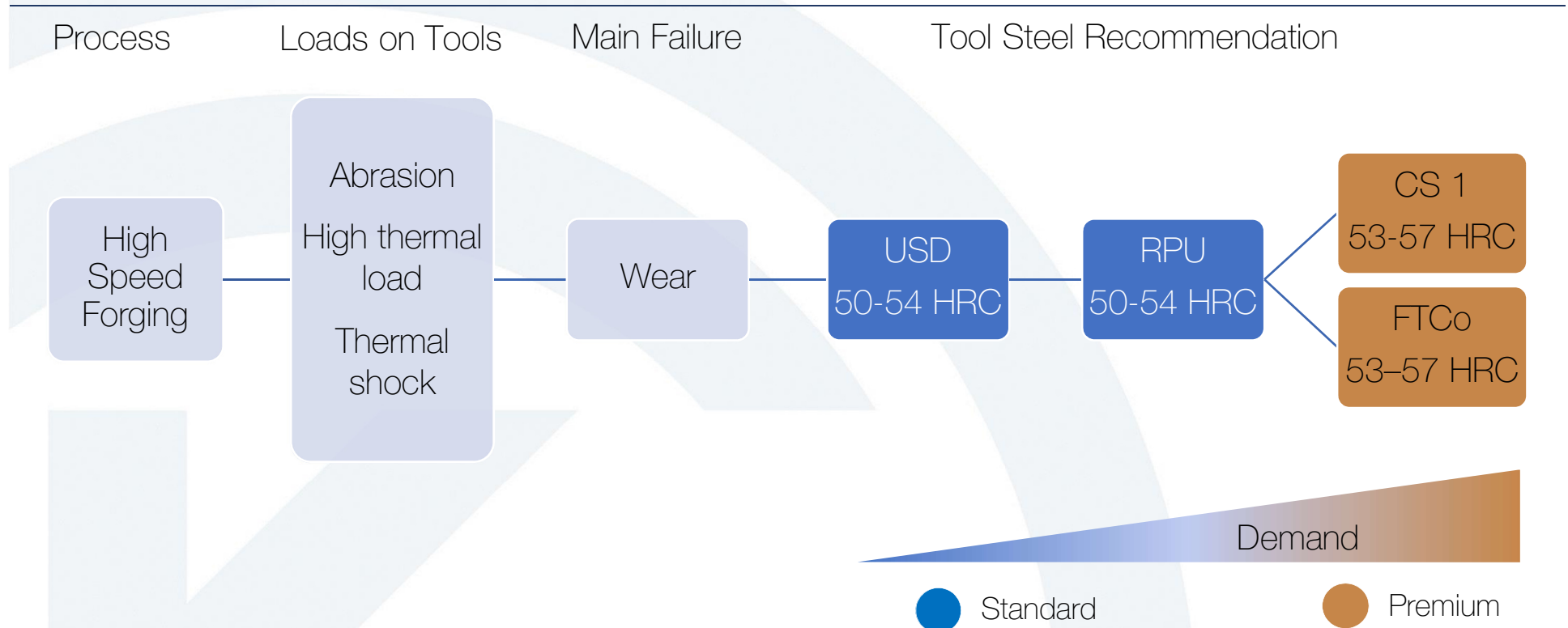
Tools for high-speed forging are exposed to a complex load situation



- High-speed forging produces rotationally symmetric parts with extremely high frequency.
- The dies are exposed to high abrasive wear and to thermal fatigue.
- The dies are exposed to high abrasive wear and to thermal fatigue



Recommended tool steels for high-speed forging withstand intensive wear



- Dies need to have a combination of toughness and wear resistance.
- USD with a hardness of 50 – 54 HRC can be regarded as a good standard tool material.
- RPU achieves a higher wear resistance and better performance.
- Highest performance can be achieved using CS 1.
- USD and RPU can be used for punches but best possible wear resistance is achieved with FTCo.

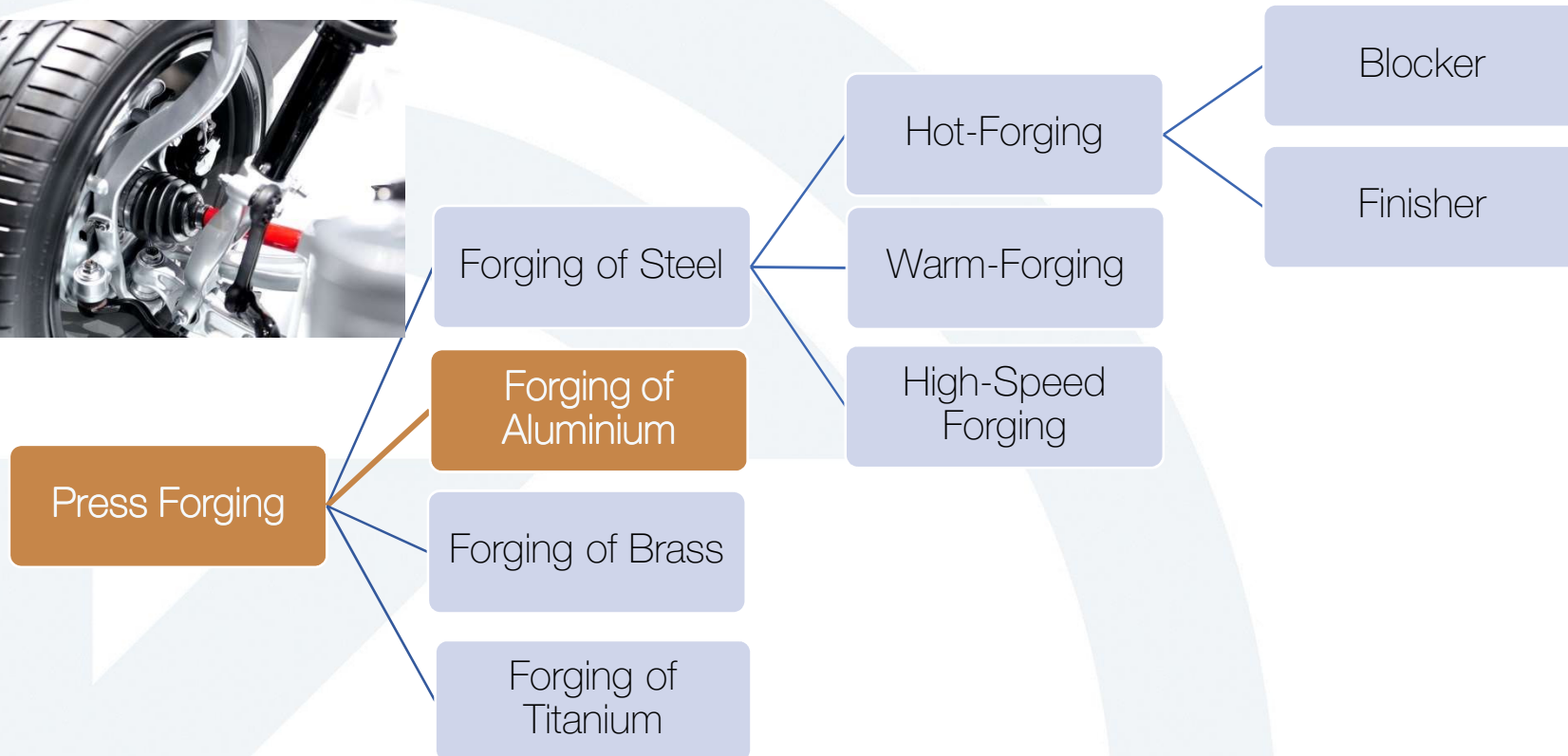


Successful application of special grade FTCo show >100% improvement



- Punches of high speed forging machine
- FTCo : 56 HRC
- Conventional hot-work tool steel: 50 HRC
- Increase of performance: 158 %
- USD and RPU can be used for punches but best possible wear resistance is achieved with FTCo.

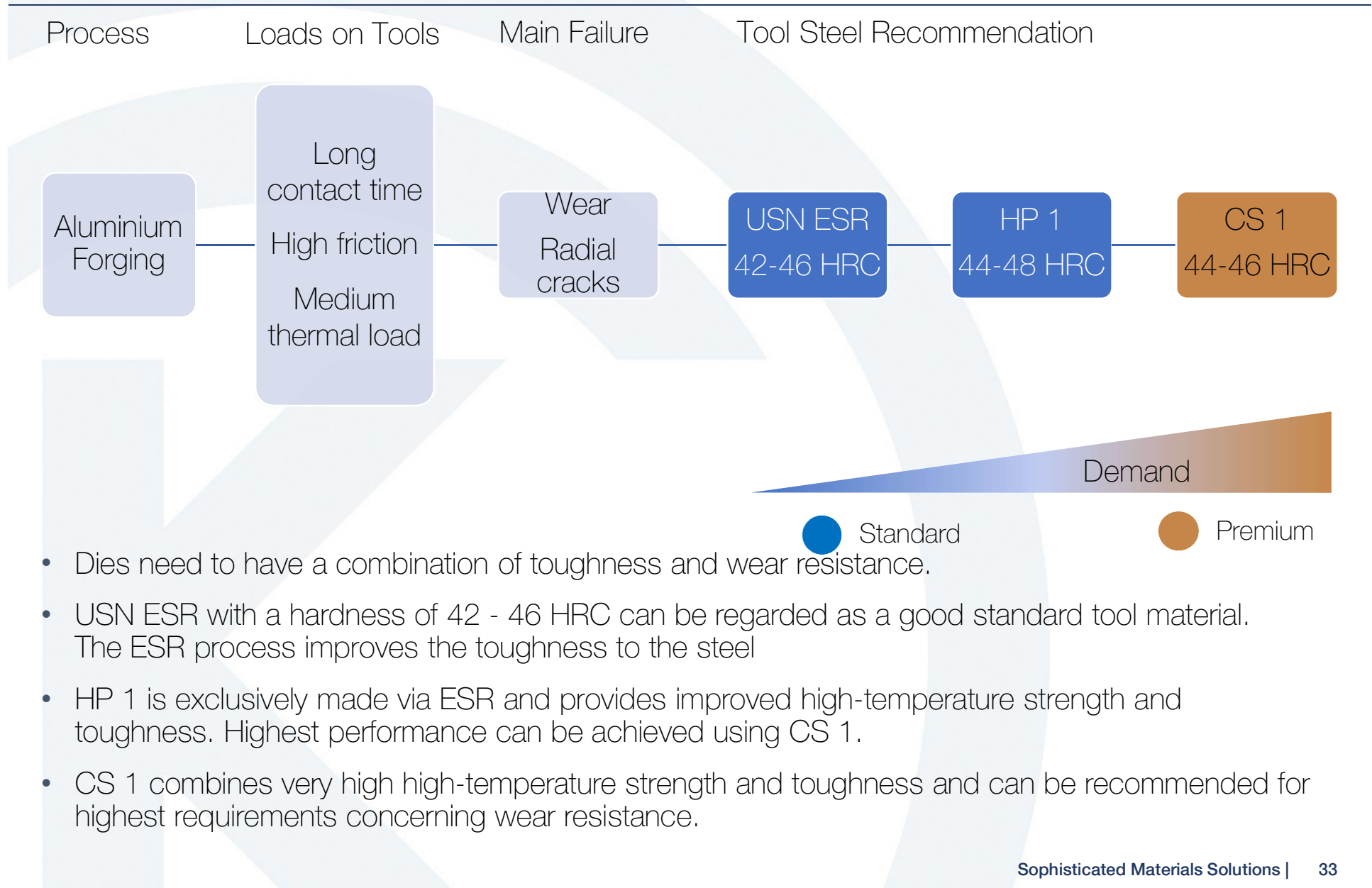
Aluminium forging contributes to light-weight construction



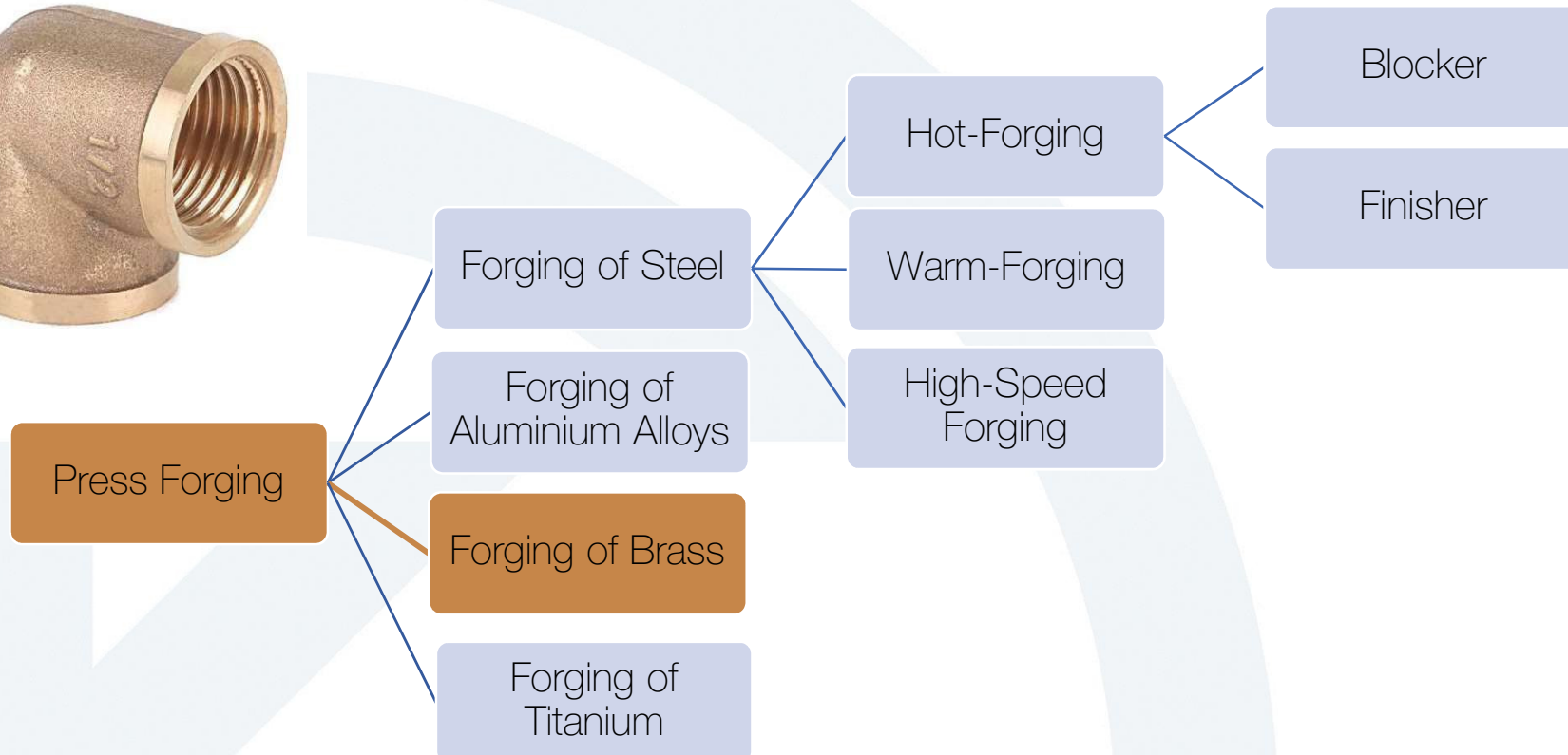
- Aluminium gains more and more importance in weight reduction of passenger cars, commercial vehicles and aeronautic applications.
- The forging temperature is in the range of 300 and 550 °C, the contact time between forging and die is longer than in steel forging.
- Aluminium forging is characterized by comparably high friction between forging and die so that the dies are exposed to considerable thermal loads and friction.



Tools steels for aluminium forging provide excellent toughness and wear resistance



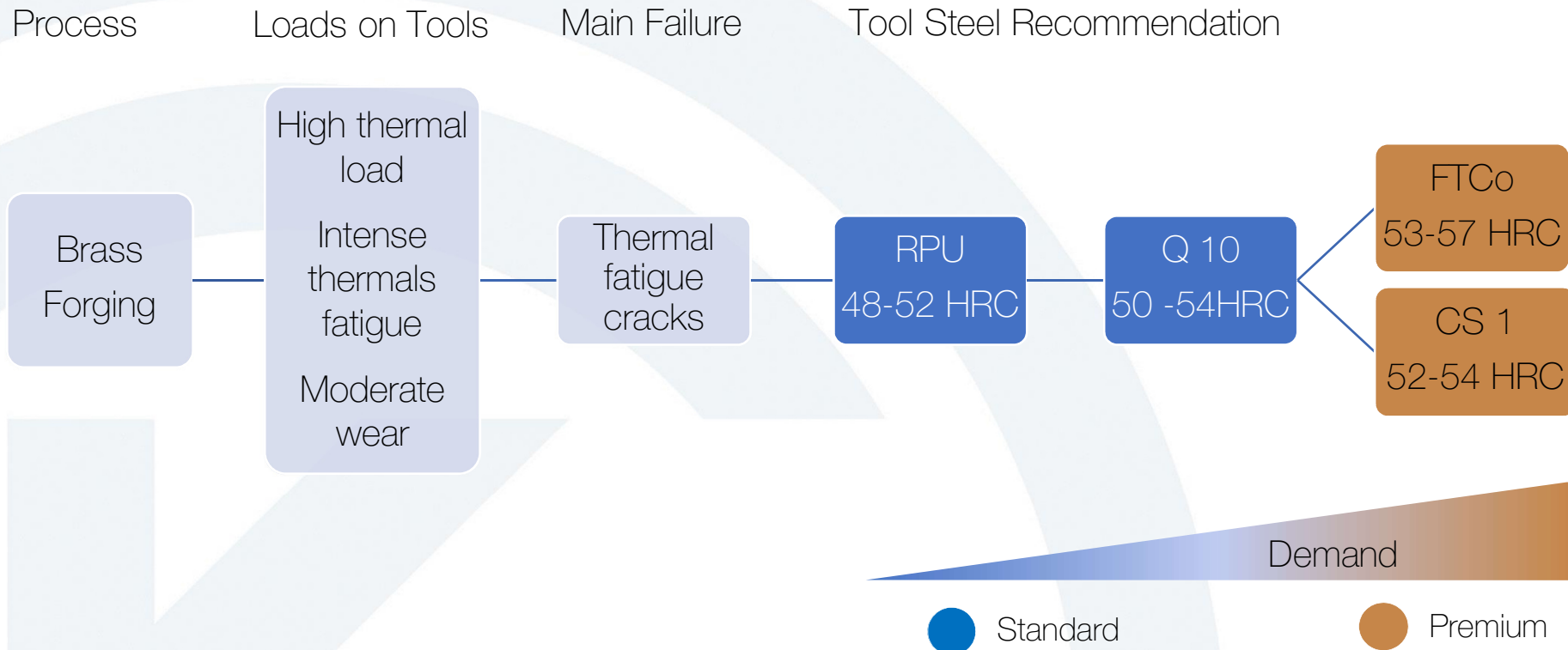
Press forging of brass – a thermal challenge



- Brass is characterized by a poor hot-deformability. For forging operations brass needs to be heated up to 700 – 900 °C.
- The comparably slow forging process exposes the dies to high thermal and abrasive influences.



For press forging of brass, FTCo and CS1 offer good tempering and wear resistance



- Simple standard applications can be fulfilled using grade RPU.
- Grade Q 10 offers an improved toughness and can therefore be considered as the recommended standard tool steel in brass forging.
- In case of highest demands of wear resistance, for example punches, special grade FTCo (53 – 57 HRC) serves as a top grade.
- Dies made of CS 1 have been used successfully in brass forging and have extended the lifetime of the dies by far.



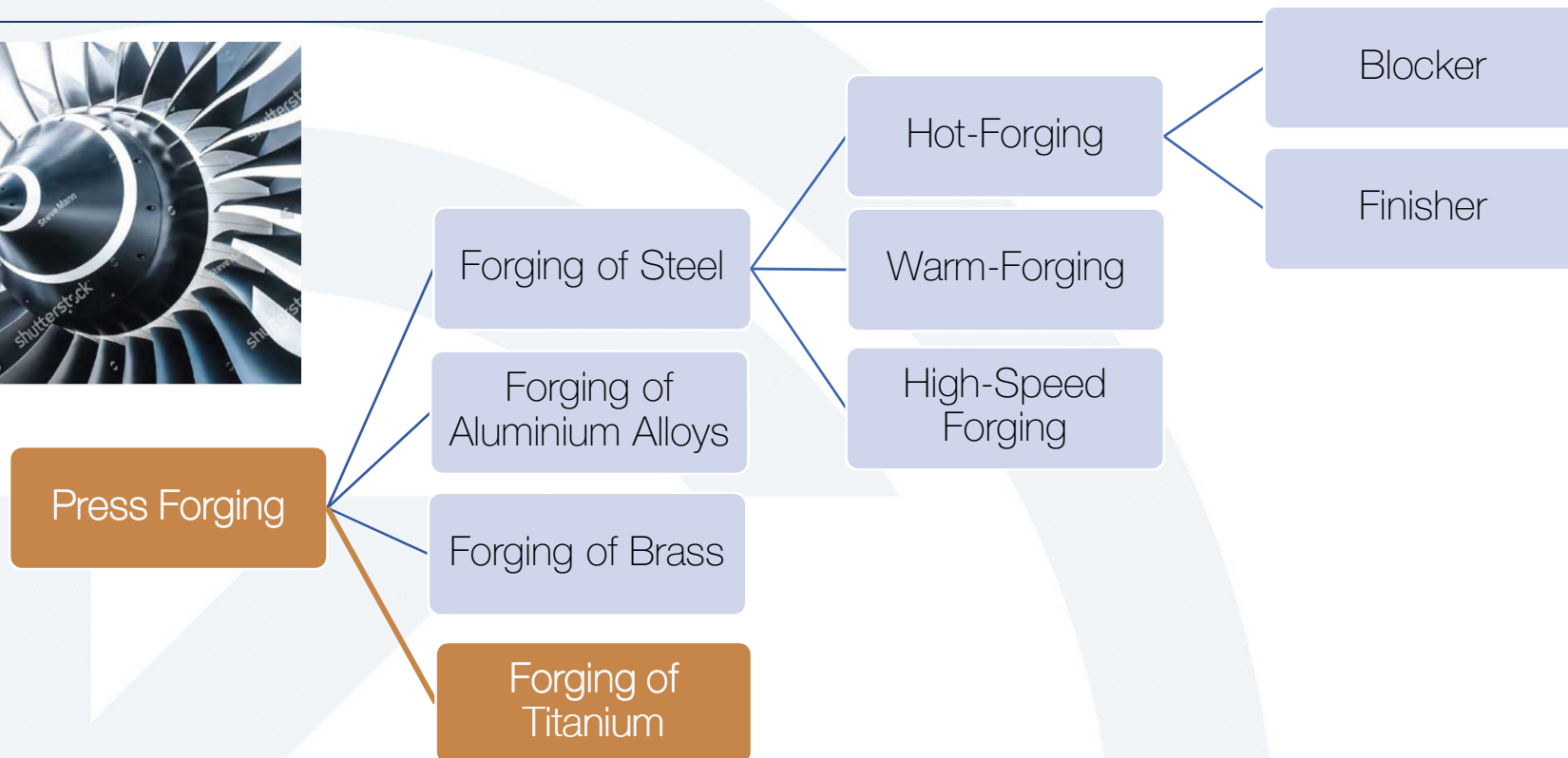
Special grade CS 1 can extend life time of forging dies in brass forging significantly



Forging die for brass:

- CS 1, 52 - 54 HRC: 30.000 forgings, still continuing
- 1.2367 mod, 55 HRC: 3.000 – 3.500 forgings

Press forging of titanium – a fast growing field of industrial production

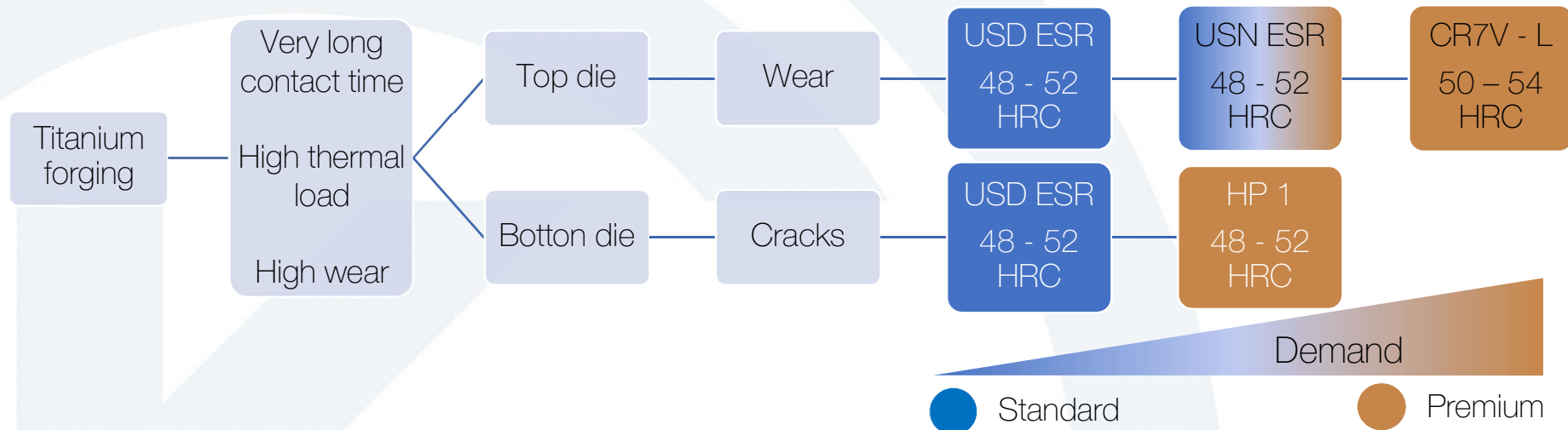


- Forging titanium is a comparably slow deformation process which results in long contact times between forging and dies.
- Dies are exposed to intensive thermal and abrasive influences.



Tool steels for titanium forging need to combine toughness and wear resistance

Process	Loads on Tools	Die	Main Failure	Tool Steel Recommendation
---------	----------------	-----	--------------	---------------------------



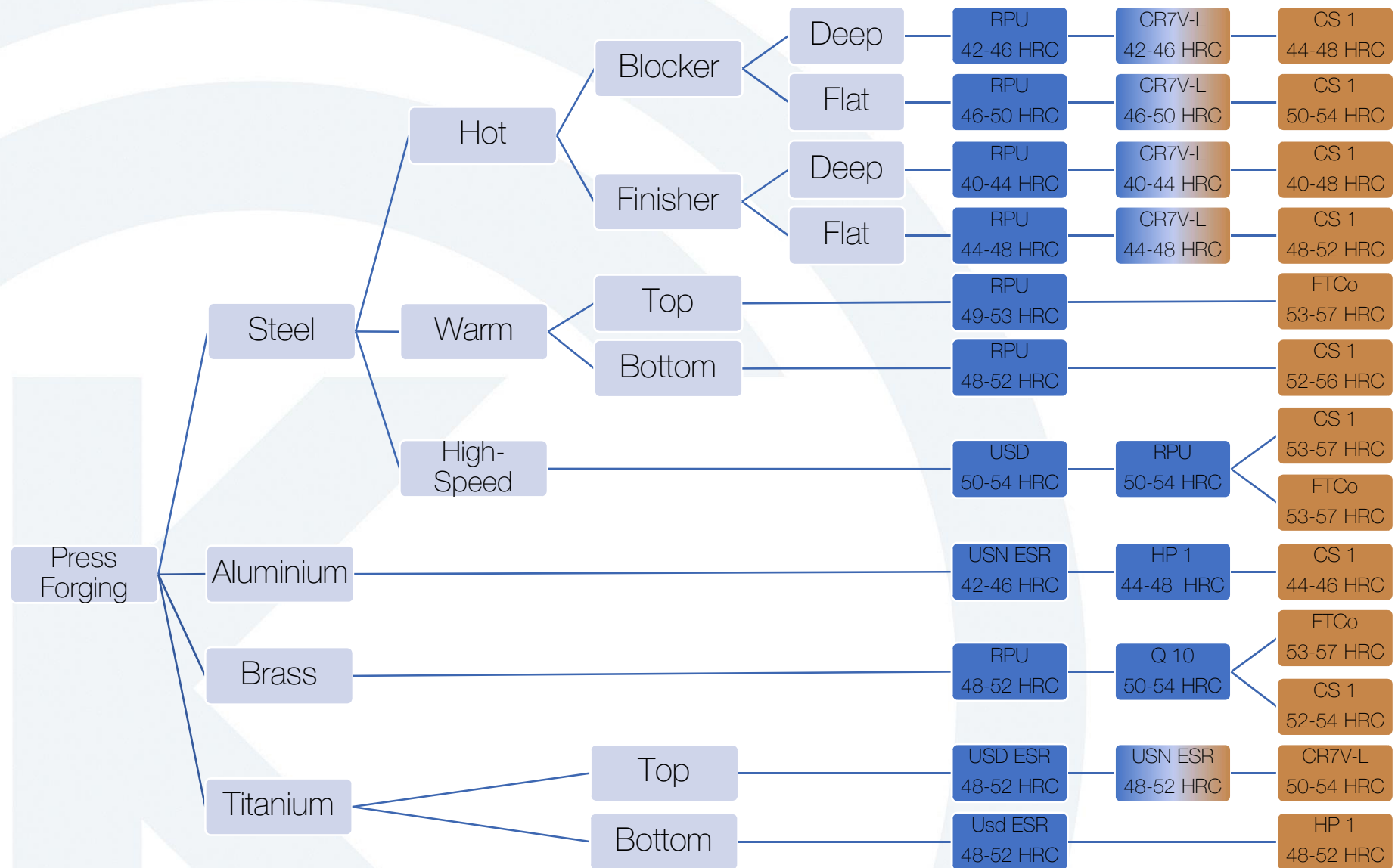
- Titanium alloys gain more and more importance in aircraft industry or medicine, e.g. as turbine blades for aircraft turbines or implants like artificial hip joints
- Forging titanium is characterized by long contact times between forging and dies and consequently in high thermal and high abrasive loads.
- The tool steel selection should be done separately for top and bottom die as they fail for different reasons.
- For better toughness all steels for titanium forging dies are made by ESR.

Carefully selected tool steels contribute
to economic forging production

Conclusion



Conclusion: Follow the „tree“ to the best suitable tool steel



- Forging of various metals like steel, aluminium, brass, or titanium plays a great role in industrial production.
- Kind & Co. provides internationally standardized and specially developed hot-work tool steels with combinations of properties tailored to meet the individual requirements.
- The correct selection of suitable tool steels as well as the proper adjustment of hardness as a main property require a determination of the specific loads on the dies.
- The examples shown in this presentation help to select suitable tool steel grades successfully.

**Thank you for
your attention!**

Kind & Co., Edelstahlwerk, GmbH & Co. KG

Bielsteiner Str. 124-130 • 51674 Wiehl, Germany

Phone: +49 (0)2262/84-0 • Fax: +49 (0)2262/84-175

Web: www.kind-co.de • Email: info@kind-co.de

