BÖHLER

DO YOU REALIZE WHAT YOU'RE EXPECTING FROM YOUR TOOLS?

voestalpine BÖHLER Edelstahl GmbH & Co KG
www.voestalpine.com/bohler-edelstahl

voestalpine
ONE STEP AHEAD.

BÖHLER HIGH PERFORMANCE MOLD STEELS FOR INJECTION OF FIBER-REINFORCED PLASTICS

DO YOU REALIZE WHAT YOU'RE EXPECTING FROM YOUR TOOLS?

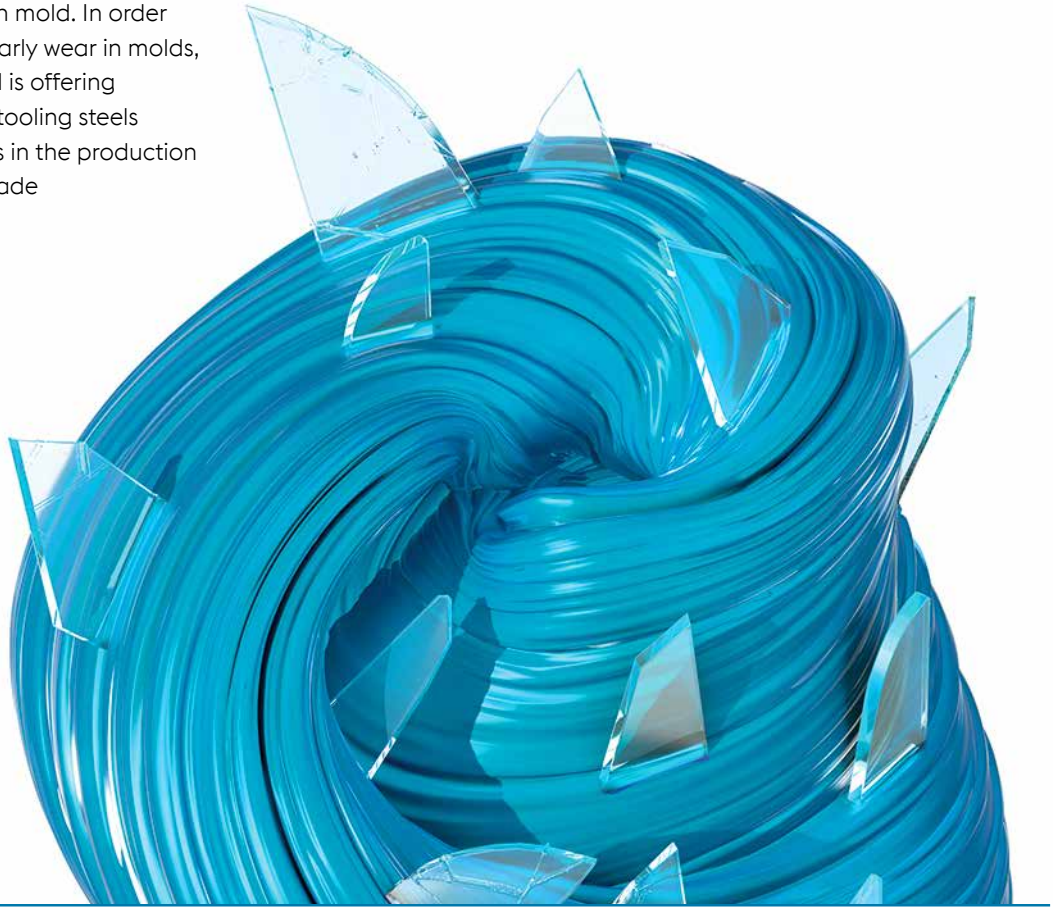
Modern industrial parts production in mainly automotive and electronic industries is characterized by the trend to substitute metals by reinforced plastics.

Being much lighter and therefore weight-saving, such plastic components help to reduce CO_2 emissions, which is a clear ecologic focus worldwide. Intricate geometries, thin wall-thicknesses and large areas of the parts are characteristics that call for a growing amount of glass or carbon fibers in the plastics to obtain sufficient stability.

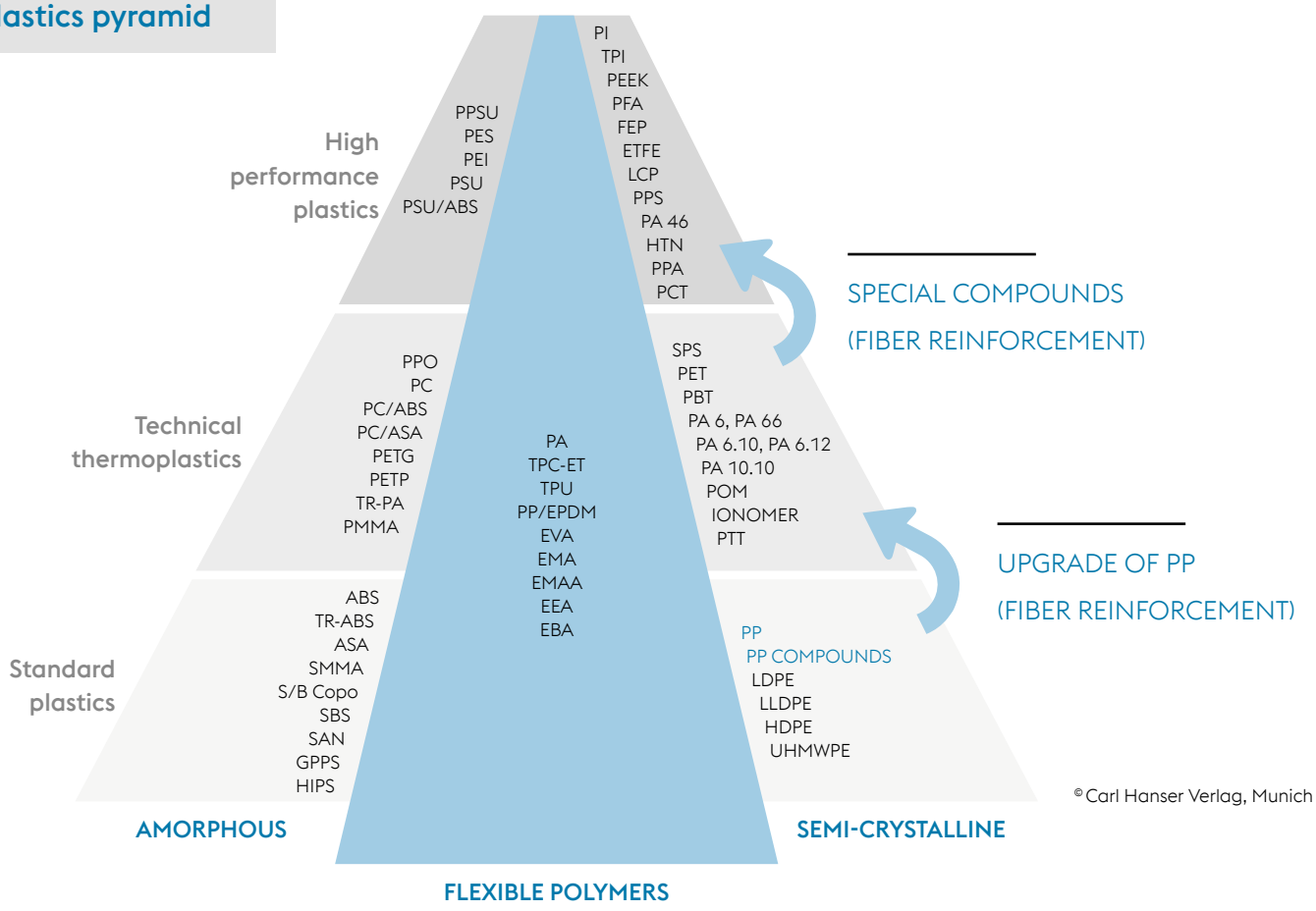
Plastics reinforced by fibers tend to be much more abrasive than conventional plastics and thus may cause premature wear of an injection mold. In order to counteract excessive and early wear in molds, voestalpine BÖHLER Edelstahl is offering a wide variety of high-quality tooling steels that are setting new standards in the production of heavy-duty components made from reinforced plastics.

Trends and requirements

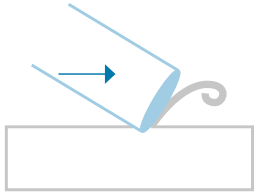
- » New types of high performance plastics (GF, CF, fibre length, filler material)
- » Increasing wear resistance requirements on mold material
- » Increasing corrosion resistance of mold material
- » Complexity of parts increased (light weight construction)
- » Increase productivity through shorter cycle times (thermal conductivity)
- » Higher closing pressures and processing temperatures



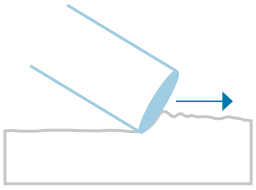
Plastics pyramid



Wear mechanism: fiber motion causes abrasive wear by



MICROCUTTING



MICROPLOWING

Beside glass fibers also glass balls, metal oxides (titanium oxide, chromium oxide), calcium carbonates, silica components (sand, quartz), ceramics .... are forcing abrasive wear.

Source: Department of Injection Moulding of Polymers, University of Leoben

Plastic molding - Example of „Polymeric Leight Weight Construction“

Prototype: Plastic steering case

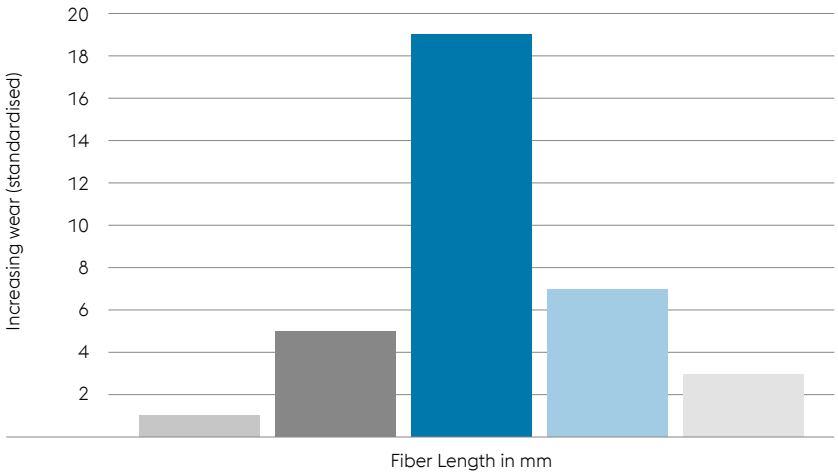
Steering casing Al- HPDC part (Symbolic picture)

- Equal cost part made of 50% glass fiber reinforced PA (Ultramid® A3R) with metal inserts
- Special FEM –Design modification
- Service temperature: max. 125 °C
- **50% weight savings**

Source: ThyssenKrupp techforum 1/2014

Influencing factors

Fiber Length

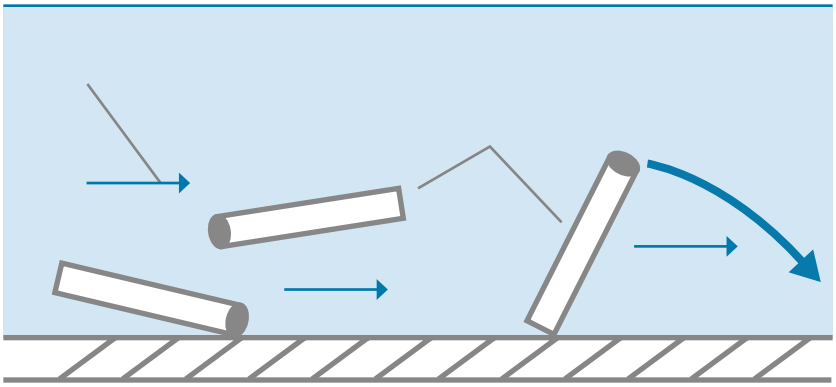


Typical fiber diameter: 10 µm

- Length up to 200 µm
- 200 µm < L < 500 µm
- 500 µm < L < 1000 µm
- 1000 µm < L < 2000 µm
- Length > 2000 µm

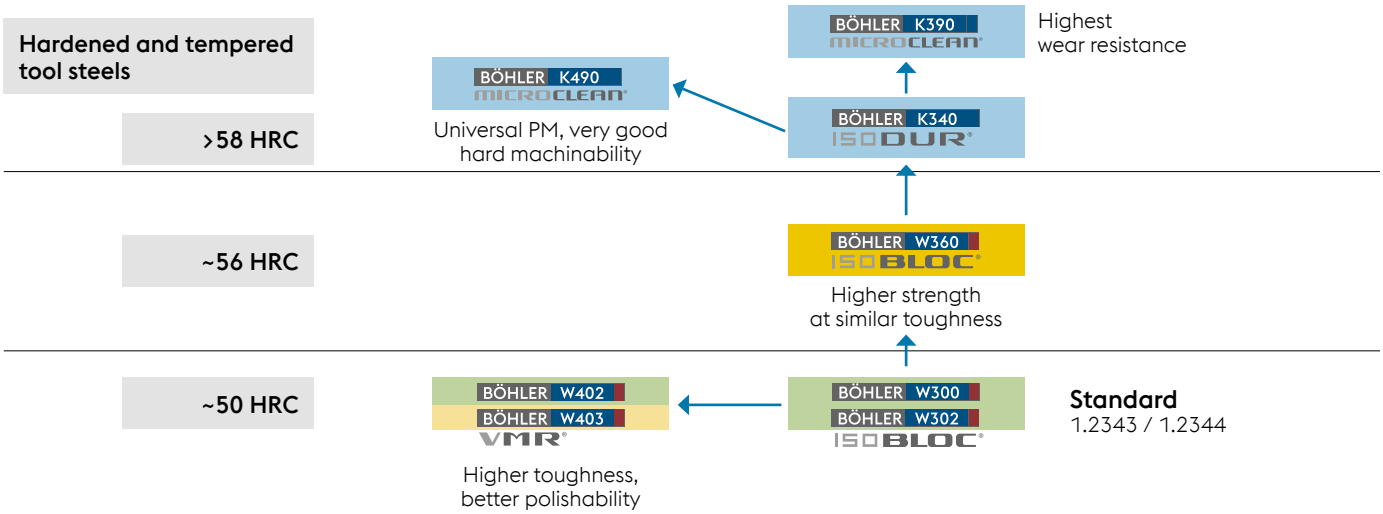
Source:
Department of Injection Moulding of Polymers, University of Leoben

Polymer melt with glass fibers



Product selection – high performance mold steels

Non corrosion resistant steels



- up to ~20% GF
- up to ~30% GF
- up to ~60% GF
- up to ~65% GF

Examples for processed plastics
PA6 - GF50
PA66 - GF40
PA66 - GF35
PA66 - GF30
PC+ABS-GF40
POM - CF35
PA6 - GF65
PA6 - CF45

MICROCLEAN®
Powder metallurgical steels

VMR®
Special materials subjected to vacuum refining or melting during at least one stage of manufacture.

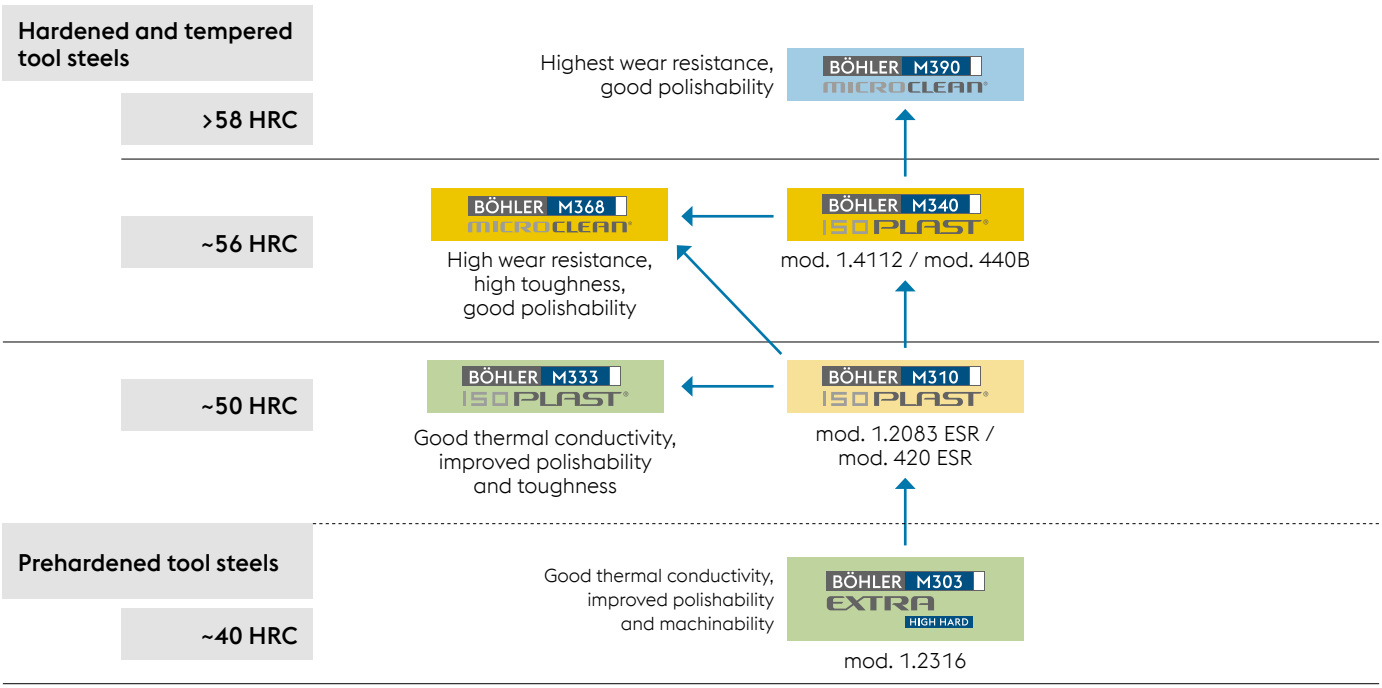
ISODUR®
Cold work tool steels in ESR quality

ISOBLOC®
Hot work tool steels in ESR quality with special heat treatment

	Chemical composition in weight %							Carbide vol-[%] hardened	Wear resistance
BÖHLER grade	C	Cr	Mo	Ni	V	Others	Standard		
BÖHLER W300 ISOBLOC	0.4	5.0	1.3	0.4	–	–	1.2343 / H11	< 1	★
BÖHLER W302 ISOBLOC	0.4	5.2	1.4	1.0	–	–	1.2344 / H13	< 1	★
BÖHLER W400 VMR	0.4	5.0	1.3	0.5	–	–	1.2340 / ~H11	< 1	★
BÖHLER W403 VMR	0.4	5.0	2.8	0.7	–	–	1.2367	< 1	★
BÖHLER W360 ISOBLOC	0.5	4.5	3.0	0.6	–	–	–	< 1	★★
BÖHLER K340 ISODUR	1.1	8.3	2.1	0.5	–	+Al, Nb	–	8.5	★★★
BÖHLER K490 MICROCLEAN	1.4	6.4	1.5	3.7	3.5	+ Nb	–	10	★★★★
BÖHLER K390 MICROCLEAN	2.5	4.2	3.8	9.0	1.0	+ 2.0 Co	–	17	★★★★★

Product selection – high performance mold steels

Corrosion resistant steels (minimum free chromium content in the matrix of 13 %)



- up to ~10% GF
- up to ~15% GF
- up to ~60% GF
- up to ~65% GF

Examples for processed plastics
PVC, CPVC, PES, PSU, PVDF, ABS

MICROCLEAN®
Powder metallurgical steels

ISOPLAST®
Plastic mould steels in ESR quality

EXTRA
Special property and/or achievement characteristics

BÖHLER grade	Chemical composition in weight %						Standard	Carbide vol-[%] hardened	Wear resistance
	C	Cr	Mo	Ni	V	Others			
BÖHLER M303 EXTRA HIGH HARD	0.27	14.50	1.00	0.85	–	+N	~1.2316	< 1	★
BÖHLER M333 ISOPLAST	0.24	13.25	+	+	+	+N	~1.2083 / ~420	< 1	★★
BÖHLER M310 ISOPLAST	0.38	14.30	–	–	0.20	–	~1.2083 / ~420	1.5	★★
BÖHLER M340 ISOPLAST	0.54	17.30	1.10	–	0.10	+N	–	ca. 8%	★★★
BÖHLER M368 MICROCLEAN	0.54	17.30	1.10	–	0.10	+N	–	ca. 8%	★★★
BÖHLER M390 MICROCLEAN	1.90	20.00	1.00	–	4.00	W=0.60	–	ca. 20%	★★★★★

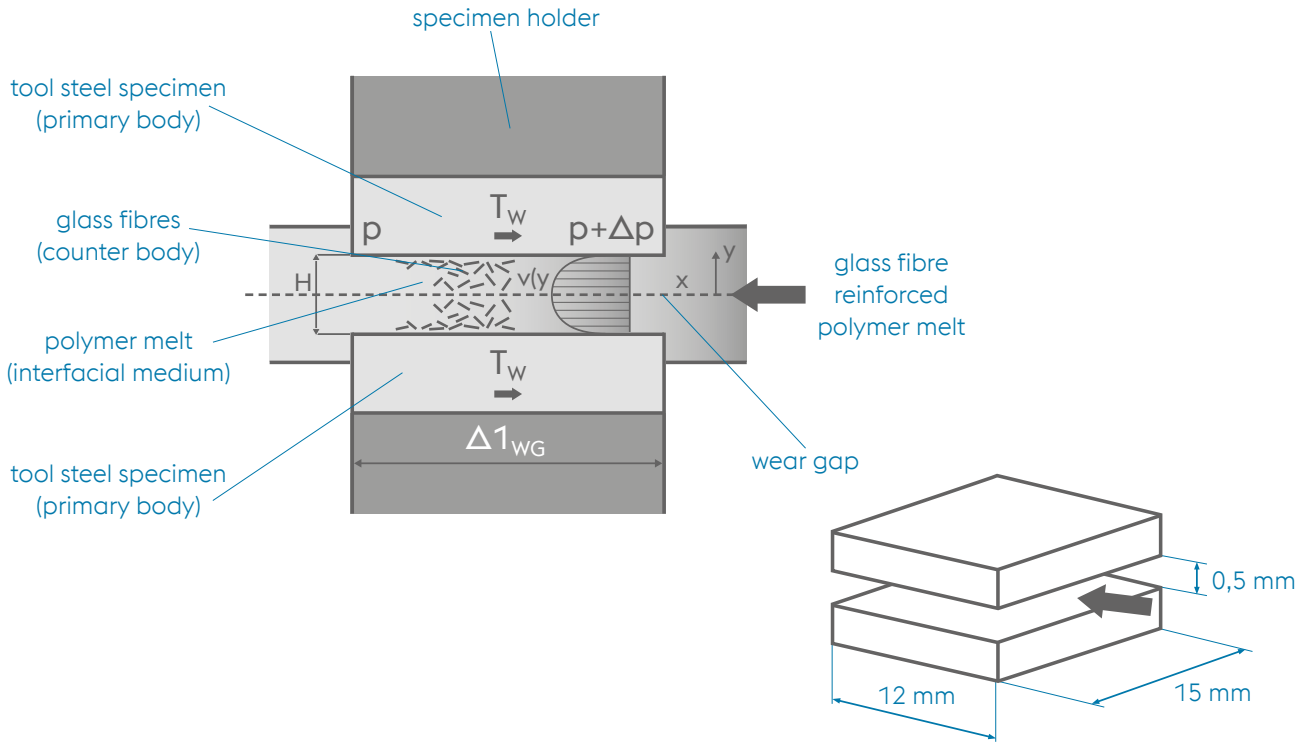
HEAT TREATABLE,
WEAR RESISTANT MOLD STEEL

The wear is determined either by mass loss or volumetrically by 3D measurement of the sample surfaces before the test and after injection of, for example, 25 kg or 50 kg of glass fiber reinforced plastic molding compound.

The wear apparatus for testing the abrasive / corrosive wear on the tribosystem polymer melt / steel is installed in the injection molding machine in the form of an injection molding tool. The wear samples, which have the same temperature as the melt, form a rectangular gap in which large local shear stresses and shear rates can be generated. The melt is injected through the wear gap and generates the material removal on the surfaces of the two wear samples (each 15 x 12 x 5 mm). The entire dosing volume of the plasticized molding compound is injected at a defined injection pressure, defined injection rate and a specified melt temperature.

The wear is determined by the material removal (mg / cm²) or the material removal height (µm) before and after injected a defined amount of plastic melt.

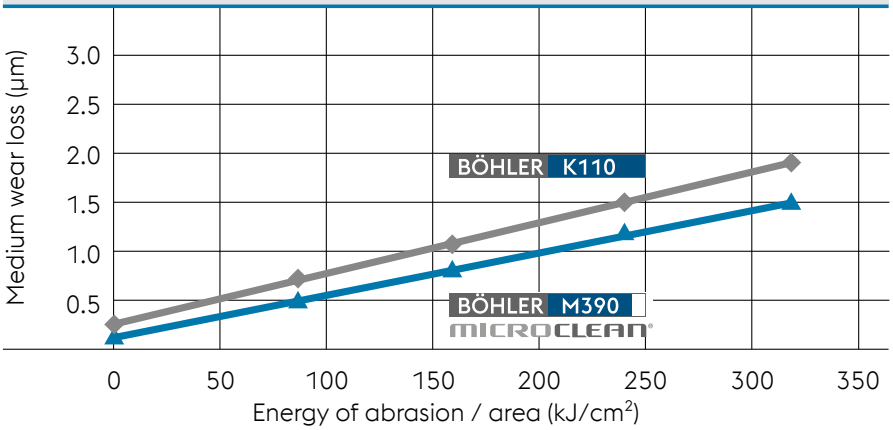
Small plates wear tests



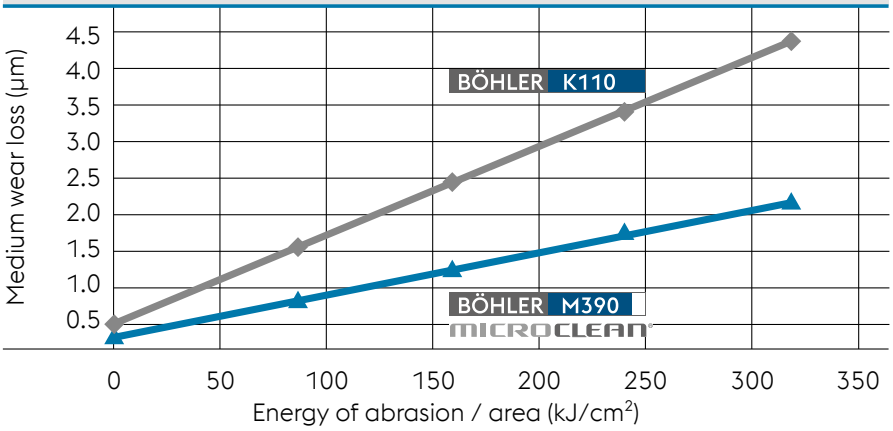
Mean depth of abrasion or weight loss of the testing plates indicates the wear resistance.

EFFECT OF CORROSION AND ABRASION – LABORATORY TEST RESULTS
K110 VS. M390 MICROCLEAN, RESULTS FROM PLATES WEAR TESTS

PA 66 + 30% GF/ 300°C



PES + 30% GF/ 400°C



Hardness

Abrasion

Free Cr

Corrosion + Abrasion

%	C	Cr	Mo	V	W
K110	1.55	11.80	0.80	0.95	
M390PM	1.90	20.00	1.00	4.00	0.60

	Hardness (HRC)
K110*)	58
M390PM	61

Beside wear and corrosion resistance further important factors to choose the right material are:

- **Tool design (complex/simple, deep/shallow cavity, ...)**
- **Tool size**
- **Surface requirements on the mold**

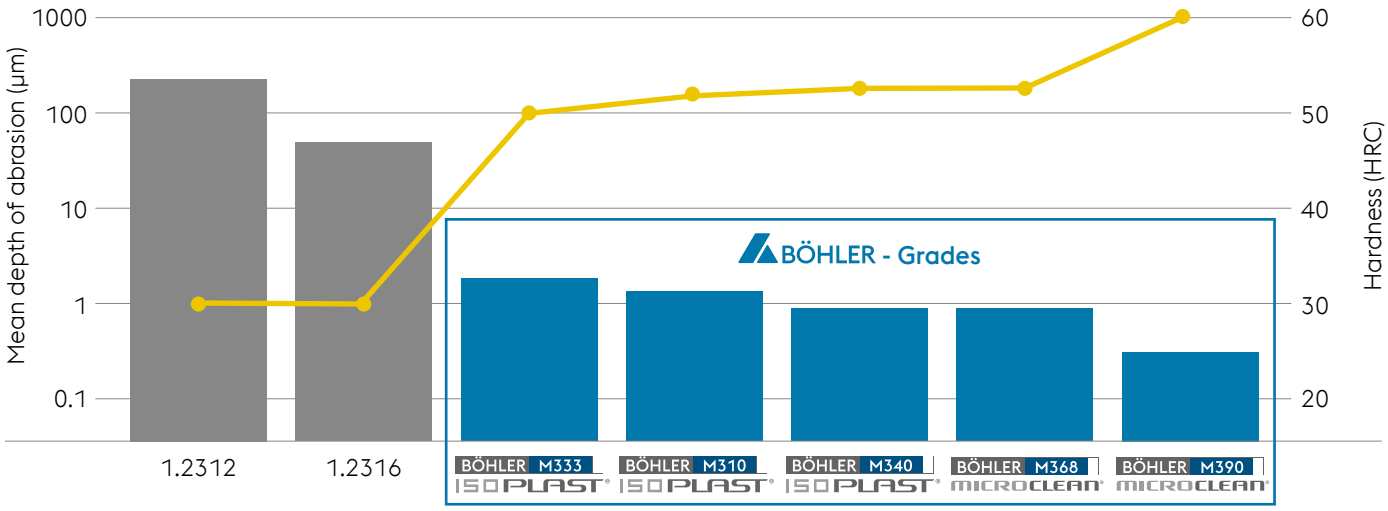
Additional aspects are for instance dimensional stability, edge stability, machinability, ability for coating....

Detailed recommendations have to be checked case by case.

Facts

- **Filling materials and additional fibers in various plastic materials have an abrasive effect**
- **Together with corrosive media (fission products,...) tribochemical wear system emerges**

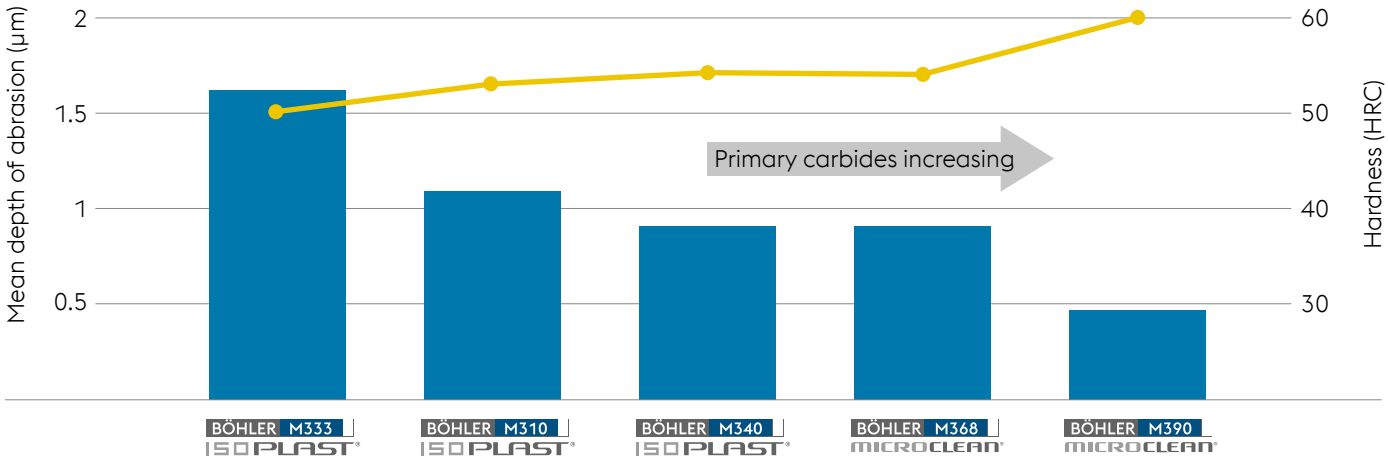
Wear resistance with plate-wear test



wear
hardness

Glass fiber reinforced polymer melt:
PA 66 + 50 % GF

Wear resistance with plate-wear test – DETAIL



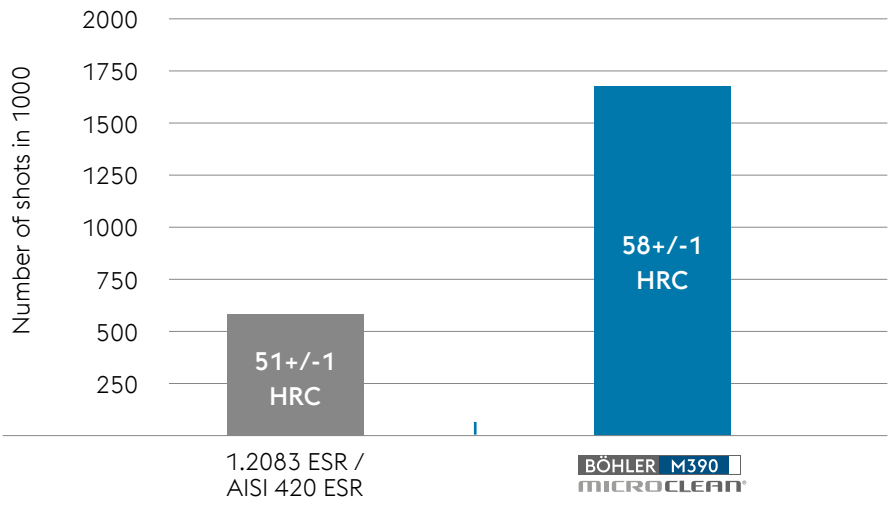
wear
hardness

Glass fiber reinforced polymer melt:
PA 66 + 50 % GF

CASE STUDIES

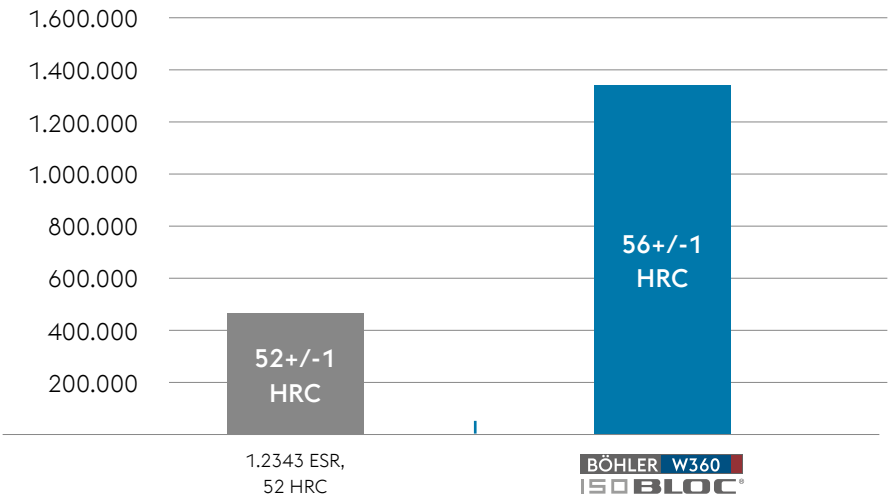
Electrical components base plates for relays

BÖHLER M390 MICROCLEAN®



Household components gears

BÖHLER W360 ISOBLOC®

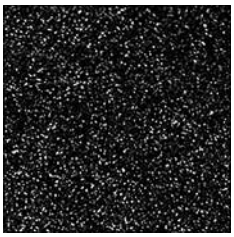


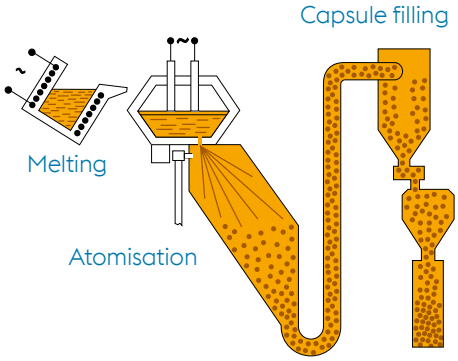
3 QUALITY LEVELS 3 TECHNOLOGIES

Powder metallurgical production

MICROCLEAN®

Microstructure
PM materials





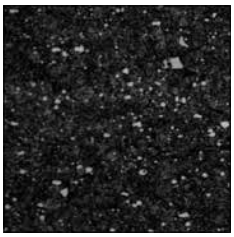
For the highest demands:

- » Segregation free high performance steel
- » The finest carbide distribution
- » The highest metallurgical purity
- » Isotropic properties
- » Maximum wear resistance with a simultaneously higher toughness
- » A high degree of hardness
- » Very good dimensional stability
- » High compressive strength

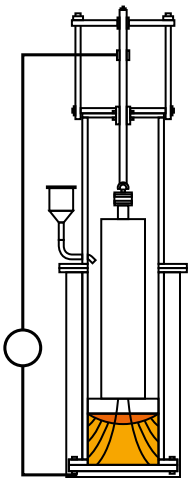
3 QUALITY LEVELS 3 TECHNOLOGIES

Electro slag remelting production

ISORAPID®



Microstructure
BÖHLER S600
in ESR quality

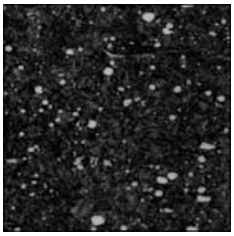


Improved service life due to:

- The least possible inclusion content
- Lower micro and macro segregation
- Good homogeneity and a higher degree of purity
- A homogenic structure throughout the entire cross-section and bar length
- Producing larger bar dimensions at a constant carbide distribution
- Uniform dimensional stability
- A broad range of application owing to a high degree of toughness

3 QUALITY LEVELS 3 TECHNOLOGIES

Conventional production



Microstructure BÖHLER S600

The standard material for reliable benefits

- » State of the Art level:
- » Structural conditions
- » Carbide distribution
- » Homogeneity
- » Individual carbides
- » Degree of purity
- » Toughness

ABOUT THE AUTHORS:

voestalpine Böhler Edelstahl is worldwide one of the leading Special Steel and Special materials supplier. We develop, produce and deliver high speed steels, tool steels and special materials worldwide, to provide our customers with exemplary solutions.

MANFRED NOCKER

PRODUCT MANAGEMENT:
PLASTIC MOULD STEEL

Manfred Nocker started his career 2001 in the technical department at voestalpine BÖHLER Edelstahl being responsible for powder metallurgical and conventional/remelted plastic mould steels. Since 2010 he is working in the marketing as product manager for plastic mould steels focusing on customer needs and coordination on development of new products.

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RONALD MÜNZER

TECHNOLOGY

Ronald Münzer started his carreer back in 1995 as a lab technician at Montanuniversität Leoben. After 2 years at Geodata (1999-2001) in mining and tunneling business he started at Boehler Schmiedetechnik (today voestalpine Bohler Aerospace) in 2001 as a Materials & Process Engineer for aerospace structural forgings. In 2012 he started at voestalpine Bohler Edelstahl in Aerospace technology being responsible for bearing steels, case hardening steels and maraging steel grades. In 2017 Ronald Münzer changed into technology for tool steels, where he is responsible for plastic mold steel grades with main focus on application engineering as well as internal forging processes and CIP.

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