High Performance Metal Solutions

High Performance Alloys for Plastic Injection Molding

H.C.Starck

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H.C. Starck Solutions' Advancements in Alloy Development

With the innovation of new alloys, H.C. Starck Solutions has surpassed market demands for higher performance products, especially in the plastic injection molding industry. H.C. Starck Solutions' TZM alloy, composed of titanium (0.50 wt. %), zirconium (0.08 wt. %) and the balance in molybdenum, has mechanical and thermal properties that exceed pure molybdenum. The small alloying additions of titanium and zirconium form carbides that significantly increase the toughness, hardness and wear resistance of pure molybdenum while maintaining good thermal properties of high thermal conductivity and low thermal expansion. TZM alloy has high strength and elastic modulus at elevated temperatures along with good abrasion and corrosion resistance that make it useful for hot runner nozzle applications.

In some plastic injection molding applications, tungsten high density alloys are the preferred material. H.C. Starck Solutions' tungsten high density alloys consist of molybdenum (4 wt. %), nickel (4 wt. %), iron (2 wt. %) and the balance in tungsten. Tungsten alloys exhibits high strength and elastic modulus at high temperatures along with high thermal conductivity and low thermal expansion along with the benefit of being easy to machine.

H.C. Starck Solutions' extensive in-house state-of-the-art laboratory facilities with the latest in analytical tools, testing equipment, modeling and simulation software, assist engineers in developing new products and materials along with the evaluation of product performance. Our advanced material modeling and simulation capabilities support the rapid development of new products and processes at H.C. Starck Solutions.

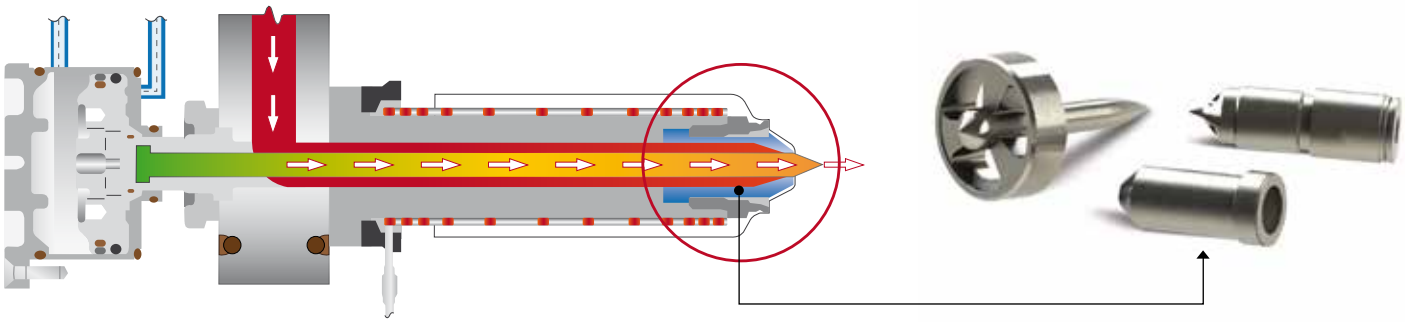
Fabricated Hot Runner Nozzle Parts from H.C. Starck Solutions Alloys

Plastic injection molding applications employ hot runner nozzles in hot runner systems for a variety of applications such as automotive, electronics, industrial, medical, packaging, sports and recreation, where plastic components are required.

Injection mold nozzle parts fabricated from H.C. Starck Solutions' alloys are utilized in hot runner nozzles. Recent advancements in hot runner systems make it easier to seamlessly inject molten plastic into a shaped mold.

H.C. Starck Solutions alloy thermal properties insure that the molten plastic is heated uniformly during the hot runner nozzle transfer process. Hot runner systems have seen a significant savings in reduced cycle time and decreased waste material.

The gate between the hot runner nozzle and injection of the molten plastic into the mold is critical for reduction in color changes and a higher quality of molten plastic.



Benefits of Molybdenum and Tungsten Alloys

- Highest quality nozzle for injecting molten plastic composite into a nozzle mold without contaminating the liquefied matrix material
- Molten plastic retains uniform temperature during the injection process using the hot runner nozzle
- Ability to operate at higher temperatures and pressures without nozzle deformation
- Longer nozzle life
- Cycle time reduction and savings with less waste material
- Reduction in color changes and higher quality of molten plastic
- Increased strength and elastic modulus at elevated temperatures
- Higher service temperatures without loss of strength and hardness compared to Cu-Be
- Low thermal expansion compared to Cu-Be or H-13 tool steel
- High thermal conductivity
- Readily machined using traditional methods

TZM Alloy with Corrosion Resistance and Increased Strength

H.C. Starck Solutions offers two processing options for optimizing materials to satisfy a customer's specific application requirements.

H.C. Starck Solutions' TZM alloy is consolidated by two primary methods:

> **Vacuum Arc Casting (VAC)**
> **Powder Metallurgy (PM)**

Vacuum Arc Cast materials, for example, have finer microstructural features that result in higher abrasion resistance, corrosion resistance, and increased strength.

A major attribute of the Vacuum Arc Cast process is the superior results obtained when alloying metal powders. Complete melting and blending of molybdenum with alloyed powders takes place in a vacuum arc furnace to assure a homogeneous material is produced.

The availability of products from both Powder Metallurgy and Vacuum Arc Cast gives users many options in selecting a material to satisfy their specific application requirements. Mill products available from either process include forging billets, bar, rod, sheet, plate and foil.

Molybdenum TZM Alloy Characteristics

Electrical Properties	
Electrical Resistivity @ 20 °C	5.3-5.5 µΩcm

Mechanical Properties	
Elongation at Break	< 20%
Modulus of Elasticity	320 GPa
Tensile Strength	560-1150 MPa

Physical Properties	
Density	10.22 g cm^{-3}
Melting Point	2500-2600 °C

Thermal Properties	
Coefficient of Thermal Expansion @ 20-100 °C	$5.3*10^{-6}$ K^{-1}
Specific Heat @ 23 °C (J K^{-1} kg^{-1})	270
Maximum use Temperature in Air	400 °C
Thermal Conductivity @ 23 °C (W m^{-1} K^{-1})	126

Molybdenum TZM Alloy Products

Powder Metallurgy

Molybdenum TZM is produced by compacting > 99.95% pure powder and alloying materials into billets that are sintered and subsequently worked into finished wrought forms. Only the highest commercially pure powders are used.

Form	Diameter/Thickness		Width/Length
	inches	mm	
Billets	1.250-30	32-762	Extruded
Forgings	*		Up to 50"/10,000 lbs.
Rod & Bar	0.1250-8.4	3.2-213	24" (610 mm) max.; 2 to 10 feet **
Plate	0.1875-2.0	4.8-50.8	24" (610 mm) max; up to 10 feet
Sheet	0.0050-0.187	0.127-4.80	24" (610 mm) max.; up to 200 feet
Foil	0.0010-0.0049	0.0254-0.12	1/8" to 12" (305 mm); nominal 200 foot coils
Extruded Tube & Shapes *			

* Submit size required for H.C. Starck quotation
** Inquire for thickness x length x width combinations

Vacuum Arc Cast

Products made by this process are available exclusively from H.C. Starck Solutions. Arc cast mill products exhibit excellent workability, weldability and good machining characteristics with lower oxygen, greater ductility and fracture toughness relative to powder metallurgy.

In the vacuum arc melting process, 99.95% minimum pure molybdenum powder with or without required additions is compacted, sintered, arc melted, and cast to produce an ingot weighing up to one ton. All these processes take place under vacuum.

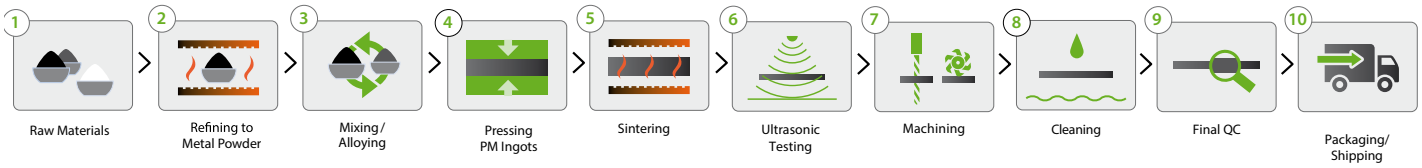
Form	Diameter/Thickness		Width/Length
	inches	mm	
Ingots	6-12	152/304	
Forgings	Submit size required for H.C. Stark Solutions quotation		
Rod & Bar	0.1250-6	3.2-152	
Plate	0.1875-2	4.8-50.8	24" (610 mm) max; up to 10 feet
Sheet	0.0050-0.187	0.127-4.80	24" (610 mm) max; up to 200 feet
Foil	0.0010-0.0049	0.0254-0.12	1/8"-1/2" (305 mm); nominal 200 foot coils

H.C. Starck Solutions' Capabilities with Tungsten High Density Alloy

From custom blending tungsten powders to near-net shaped blanks and precision machined finished components, H.C. Starck Solutions controls the whole process internally providing high quality products for critical mission applications.

H.C. Starck Solutions custom blends its tungsten powders to meet our customer's requirements. We also have the ability to tailor material properties beyond what is required by ASTM. Having the flexibility to meet a customized specification is one of H.C. Starck Solutions' many strengths.

H.C. Starck Solutions' K1705 Alloy Production Process



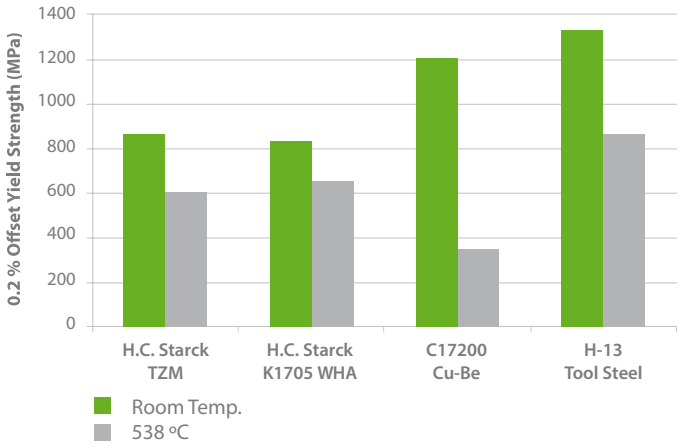
Tungsten Alloy K1705 Material and Mechanical Properties

K1705 tungsten alloy materials provide a solution in a wide range of applications requiring concentrated weight or density in a limited space. These lead-free parts meet legal requirements and recommendations to protect the environment.

Mechanical Properites		K1705
Tungsten Content	%	90.0
Density	g/cm³	17.3 ± 0.2
Hardness	HV 30	≤ 360
Tensile Strength (Typical Value)	MPa	900
Yield Strength (Typical Value)	MPa	825
Elongation (Typical Value)	%	8
Young's Modulus (Average Value)	GPa	330
Median Coefficient of Linear Thermal Expansion		
20 – 100 °C	10^{-6}/K	4.5
20 – 300 °C	10^{-6}/K	5.1
20 – 450 °C	10^{-6}/K	5.3
Thermal Conductivity	W/mK	≥ 70
Electrical Conductivity (Average Value)	% IACS MS/m	13 7.5
Specific Electrical Resistance (Average Value)	µΩm	0.13
Permeability µ		> 1.05

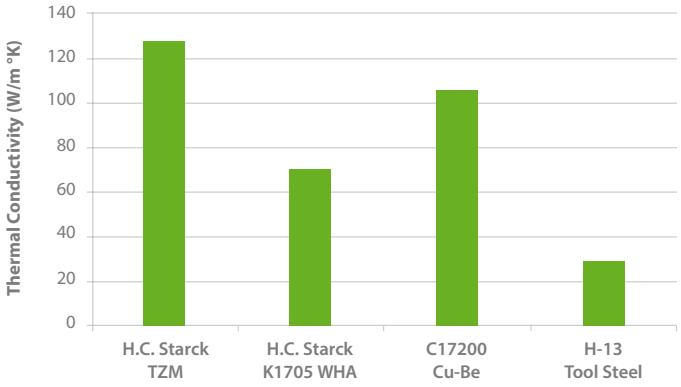
Comparison of Hot Runner Nozzle Materials

Yield Strength



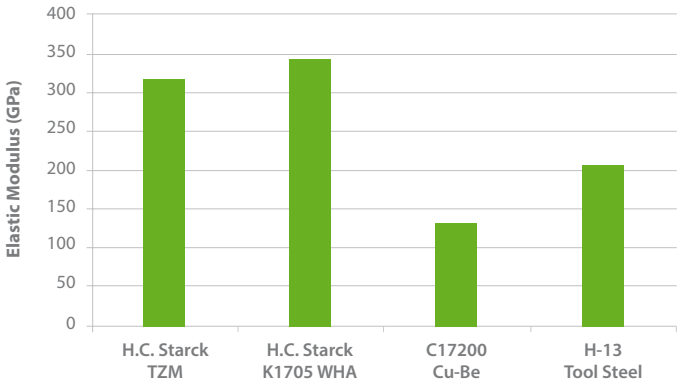
H.C. Starck Solutions materials have higher strength than Cu-Be at 538 °C.

Thermal Conductivity (Room Temp)



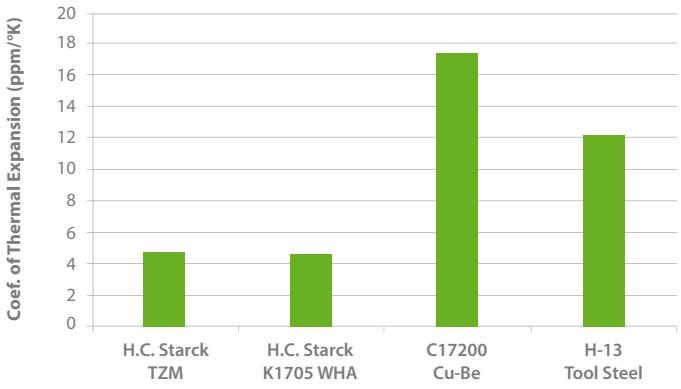
H.C. Starck Solutions materials have higher thermal conductivity compared to H-13. TZM has higher thermal conductivity compared to Cu-Be.

Elastic Modulus



H.C. Starck Solutions materials have higher stiffness than Cu-Be or H-13.

Coefficient of Thermal Expansion (20–100 °C)



H.C. Starck Solutions materials have much lower CTE than Cu-Be or H-13.

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