Hitachi Metals
NEWSLETTER

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Hitachi Metals, Ltd.

Tool steel (for molds and dies) forging a cornerstone of industry
-Hitachi Metal's advanced tool steel technology and solutions-

Tool steel represents a long-standing flagship business of Hitachi Metals, Ltd. ("Hitachi Metals"). Hitachi Metals has been engaged in the manufacturing and sales of mold and die steels for many years under the brand names of Yasugi Specialty Steel, "YSS." The business accounts for about half the entire amount of ingot mold steel (pre-production steel materials) consumed by the Yasugi Works (in Shimane Prefecture), Hitachi Metals' leading specialty steel* production base.
Molds and dies may not be things around you in everyday life. In fact, however, the products play a crucial role in many manufacturing and engineering industries, and as such, they may be referred to as a "cornerstone of industry." Since it is a cornerstone of many different industries, Hitachi Metals draws on their cutting-edge metallurgical technology to develop new products and maintain a stable supply.

In a special feature of this issue, the newsletter will introduce Hitachi Metals' tool steel business, presenting how it contributes to various industries by fulfilling its role in providing a cornerstone of industry.

*Specialty steel: A general term covering high-grade carbon steel and alloyed steel, as opposed to common steel. Carbon steel refers to steel with a carbon (C) content ranging from around 0.02 to 2.00 percent in addition to iron.

Why is specialty steel is used to make molds and dies, a cornerstone of industry?

Molds and dies are metal machine tools used to process materials into the desired shape (shape forming), an essential function for mass production in many manufacturing industries. Various types of materials, including metal, resin, and rubber, are cast, or extruded with these tools to be formed into a succession of products of an identical shape, taking advantage of the pliable or fluid property of target materials. Stamping dies are used with a press, as necessary. This is another major method handled by these tools to achieve the desired profile. This technique is capable of handling a wide range of sizes from auto body components and TV set frames to personal computer and smartphone parts.
As the quality of molds and dies has a direct effect on the quality of the resulting products, it is crucially important to ensure adequate quality of these tools to support a diverse range of manufacturing operations. Molds

and dies need to be capable of enduring extreme usage conditions due to manufacturing processes involving repeated applications of pressure, heat, abrasion, and other stress factors, and maintain adequate work performance, such as for dimensional accuracy, for a determined number of shots/presses (number of use). Therefore, these tools are made of extremely hard and durable materials.
At the same time, tool steels need to excel in cutting and processing workability (machinability). Specialty steel exhibits excellent performance for these purposes. This is the reason specialty steel is chosen as the major material for molds and dies. Hitachi Metals boasts a long history of supplying this tool steel that satisfies very challenging performance requirements.

Tell me about popular types of molds and dies!

In order to serve the need of a broad spectrum of industrial products, many different types of molds and dies are produced. Hitachi Metals is strong in manufacturing tool steel alloys, a leading material for mass-molding/diecasting, which needs to meet very high performance requirements—higher than those for any other production methods. Tool steel alloys are iron (Fe)- and carbon-based steel alloy to which chrome (Cr), molybdenum (Mo), and various other alloy elements are added in order to give additional properties to the steel. Tool steel alloy can enhance the tool's potential performance with respect to service life, workability, and other characteristics, thus significantly helping increase its user convenience and product quality.

Hitachi Metals' major tool steel (tool steel alloy) product lineup

■Hot work tool steels

Hot work dies come in contact with cast metal materials heated to high temperatures or occasionally to a molten state, resulting in dies themselves being heated to high temperatures ranging from 350 to 700 Celsius degrees. To endure these conditions, hot work die steels need to have particularly good strength at elevated temperatures and toughness (resistance to fracturing). This material is suitable for producing dies used for extrusion, diecasting*, and other mass-production lines.

Main features

1) Excellent strength at elevated temperatures and toughness
2) Excellent heat crack resistance
3) Excellent hardenability and resistance to heat-induced dimensional changes

*Diecasting:
A metal casting process that is characterized by forcing molten metal-chiefly aluminum alloy and zinc alloy-under high pressure into a mold cavity. Used in the production of parts and components for auto engines, precision equipment, electric appliances, and many other machines.

■Cold work tool steels

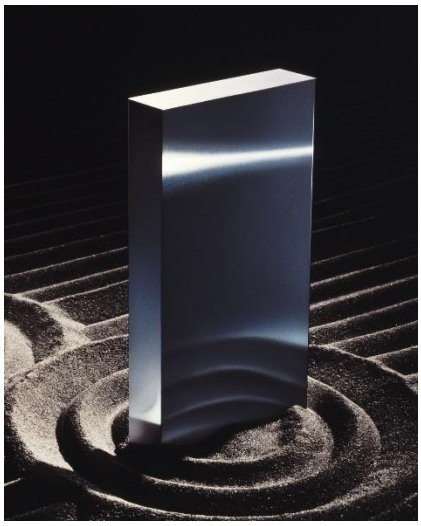
Cold work dies are used for unheated metal forming processes. In general, the working temperature ranges from room temperature up to 150 Celsius degrees.
Cold work tool steels are used primarily for metal sheet stamping dies**.

Main features

1) Excellent compressive strength to promote hardening process
2) Excellent wear resistance
3) Excellent toughness to resist process-related bending stress

**Stamping dies:
Used in the process of cutting and bending flat sheet metal—either ferrous or non-ferrous—in a stamping press where a tool and die surface forms the metal into a near net shape. Stamping includes a variety of sheet-metal forming processes, such as plastic working and punching. Progressive dies can achieve streamlined metalworking operations that encompass several different stamping processes in succession. Die stamped parts and components are produced for auto body and many industrial items.

■Steels for plastic molds



Steels for plastic molds are used for several resin (plastic) forming methods, including injection molding, compression molding, blow molding, and vacuum molding.

Main features

1) Excellent strength and toughness
2) Excellent mirror finish, a factor that can have direct effect on the product's design quality
3) Excellent machinability to be able to form complex geometric shapes

■High speed tool steels

Generally, high speed tool steels are used for cutting tools***. This material is also suitable to produce molds with excellent wear resistance and toughness.

Main features

1) High hardness at elevated temperatures to endure exposure to high temperature
2) Good wear resistance
3) Excellent strength and toughness to resist cutting-induced stress and shock-induced chipping

***Cutting tools:
Used to cut steel and other materials to achieve the desired shape by trimming (machining).
In this, cutting has a common objective with molding. It is also used to make molds and dies.

The most suitable tool steel for specific purposes is selected from among a broad range of candidates, according to the processing methods and the target shapes as well as the toughness, strength at elevated temperatures, thermal conductivity, and other properties required. In addition to these conditions, the cost-effectiveness balance is an important factor to consider for selection.

★New technology trends★

In recent years, 3D printing technology has attracted the attention of industry for offering a mold-less forming method. The major advantages of 3D printing are no front-end cost required for developing molds, and easy prototyping, which enables faster product performance verification.

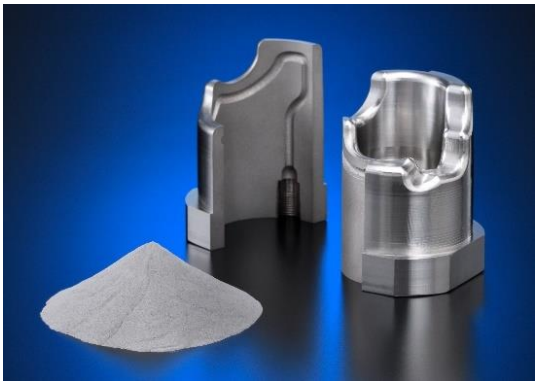
Yet, the technology has several drawbacks, including the long time needed for piece-by-piece production, compared with the time-efficient mass-molding process following the initial development step. The new technology also does not rival molds and dies with respect to cost and forming accuracy. Therefore, its current applications are chiefly to meet small-lot production and design prototyping needs. One of the most expected uses of 3D printers is to reproduce old repair parts when the related molds and dies are no longer available.

It is expected that the further progress of 3D printing technology will resolve the current issues related to cost, forming accuracy, and processing time. At present, however, 3D printers do not compare with molds and dies as a mainstream mass production technology. The following table summarizes differences between molds/dies and 3D printers.

Forming performance comparison between mold/die and 3D printer

	Mold/die	3D printer
Production cost per unit	◎	△
Mass production	◎	△
Design/prototyping	△	◎
Forming accuracy	◎	○
Processing time	◎	△
Free form fabrication	○	◎
Track record	◎	△

Hitachi Metals offers also metal powder for 3D printing, too.
(https://www.hitachi-metals.co.jp/e/products/item/am/)



Hitachi Metals' metal powder for 3D printing
and 3D printed products using the material

Who uses molds and dies as a cornerstone of industry?
Illustrate market structures up to the end user.

★Mold and die manufacturing industry supporting many users

As indicated by Hitachi Metals' extensive product lineup, molds and dies are used by many manufacturers to mass-produce a diverse range of products. Major users span many markets, such as automobiles, home appliances, industrial machinery, medical devices, and precision equipment.
Among them, the largest users are manufacturer of automobiles, a popular large-size high-tech consumer product. In the automobile industry, molds and dies play a vital role in satisfying high technical requirements with respect to large size, complex geometry, and mass production.

Also, the automobile industry embraces many supporting industries that form extensive supply chains leading up to the finished vehicle company. The pyramid diagram below illustrates the relevant market structure.

Supply chain of the automobile industry

(Products delivered in sequence upward to the top of the pyramid)

As a materials manufacturer, Hitachi Metals delivers products principally to midstream suppliers (tier companies), and occasionally, directly to the finished vehicle company. That said, mold and die steels are delivered to mold and die manufacturers in general. Thus, the primary customers of the tool steel business are tier companies.

In order to provide ever-better solutions to these tier companies, Hitachi Metals is making day-to-day efforts with a focus on the following issues:

1) **Inventive R&D to broaden the innovative steel grade lineup to cater to various needs of customers**
2) **Provision of related services (heat treatment, surface treatment) to improve user convenience**
3) **Development of business activities to improve the convenience of customers, their customers, and end-users**

Bearing these issues in mind, Hitachi Metals is proactively striving to advance into overseas markets. The following sections will present Hitachi Metals' recent activities conducted for this purpose.

1) Inventive R&D to broaden the innovative steel grade lineup to cater to various needs of customers

Hitachi Metal boasts a broad steel product lineup that contains hundreds of different types of steel (steel grade). This has been built up over many years in order to provide effective solutions to the needs of the times and customers.

For the purpose of steel making, the key to achieving the intended properties is to control the following three elements:

1. matrix, related to hardness, toughness, heat treatment effect;
2. carbide, for heightening wear resistance while lowering toughness;
and
3. non-metallic inclusions, for heightening machinability while lowering toughness.

These properties are developed by designing manufacturing processes based on chemical and physical actions, such as dissolution, heat treatment, and forging, in order to control various properties of products, including appearance configuration and internal characteristics (balance of strength and toughness).

Hitachi Metals develops proprietary techniques to control such chemical and physical properties of steel and enhance Hitachi Metals' product lineup to better respond to customer needs.
Among the latest items added to the ever-upgraded lineups are DAC-X and SLD-f. These items are exemplary representatives of the above efforts and also drivers for future market needs. Detailed reports on the two products will be provided later in this article.

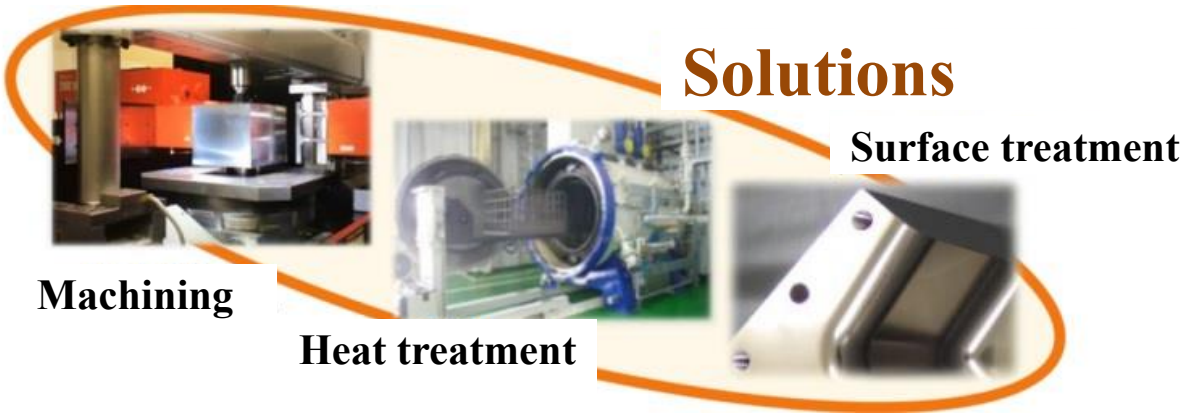

10,000-ton free forging press

In addition to steel grades established for mass production, Hitachi Metals' lineups also include several pre-markets, trial-stage products.

These are new developments resulting from day-to-day R&D activities aimed at catering to customer needs. Such activities are promoted by Hitachi Metals' research teams, who are vigorously exploring development approaches of all kinds, anticipating various possible needs and potential solutions. DAC-X, a target of long-term study as a development article, is one of such new developments. The state-of-the-art 10,000-ton free forging press, introduced in Hitachi Metals in 2018, contributed to this development.

2) Provision of related services (heat treatment, surface treatment) to improve user convenience

In a bid to boost its global competitiveness, Hitachi Metals is preparing systems to handle post-process treatment for products ordered and promoting activities to offer customer-specific solutions. Specifically for products shipped to the U.S., China, and Southeast Asia, Hitachi Metals group companies are installing equipment for machining, heat treatment, and surface treatment while updating the existing facilities. This aims to increase service capabilities to provide comprehensive support to customers to improve their convenience. In Japan, Hitachi Metals group upgraded the logistics center of Hitachi Metals Tool Steel, Ltd., a group company, for the eastern Japan market, from September 2020. The purpose of this is not only to increase the volume of orders received, but also to enhance processing functions to be able to meet customer needs more closely.



3) Development of business activities to improve the convenience of customers, their customers, and end-users

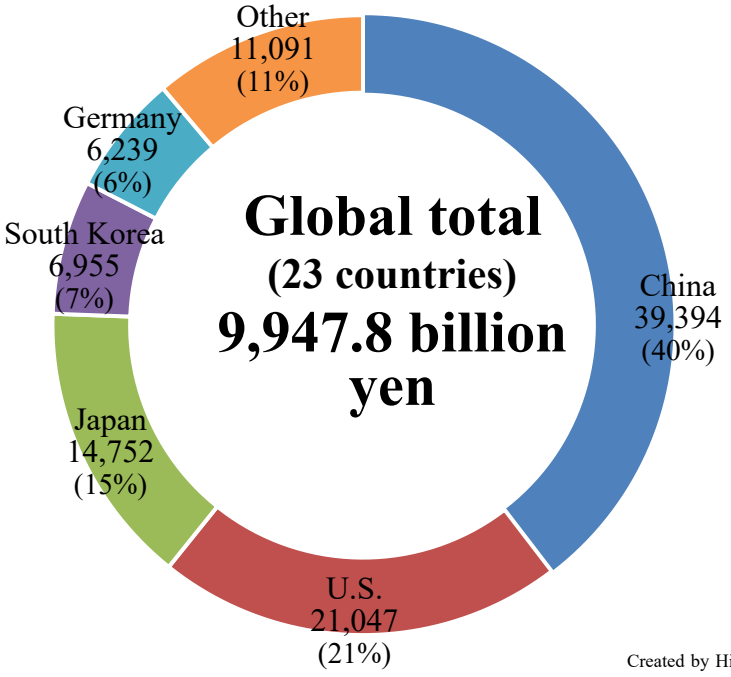
Hitachi Metals Tool Steel
Eastern Japan Logistics Machining Center
(Kazo City, Saitama Prefecture)

Hitachi Metals' industry is part of a long multi-layered supply chain. This means that Hitachi Metals' products are used by a sequence of companies at many different layers of the supply chain to contribute to the delivery of end-products. Given this, it is important to consider the needs of customers at each layer when developing manufacturing and sales activities.
To this end, Hitachi Metals cooperates with its group companies as well as dealer and distributor networks to promote appropriate business activities, paying due attention to the layers of customers.
Part of the related efforts are promoted through upgrading logistic center functions. While improving processing services, Hitachi Metals Tool Steel is enhancing and updating e-commerce capabilities. This will enable Hitachi Metals to offer a more efficient and stress-free delivery service to the customers as well as their customers.
Among other related efforts is a project related to SLD-f, which was released in August 2021. Hitachi Metals produced SLD-f60, pre-hardened tool steel that undergoes pre-heat treatment to eliminate the need for the equivalent post process and included it in the SLD-f lineup as a special sale product in cooperation with two dealers. This project aims to enhance Hitachi Metals' capabilities to respond to customer needs and increase the convenience of various layers of customers.

Which country leads the global mold and die market?

The world's largest producer of molds and dies is China. This is followed by the U.S., Japan, South Korea, and Germany. Japan is the world's third largest producer. In recent years, China and South Korea have shown significantly rapid progress. China and the U.S., the number one and number two nations, produce 2.6 times and 1.4 times, respectively, as much as Japan.

World output of molds and dies (per 100 million yen)



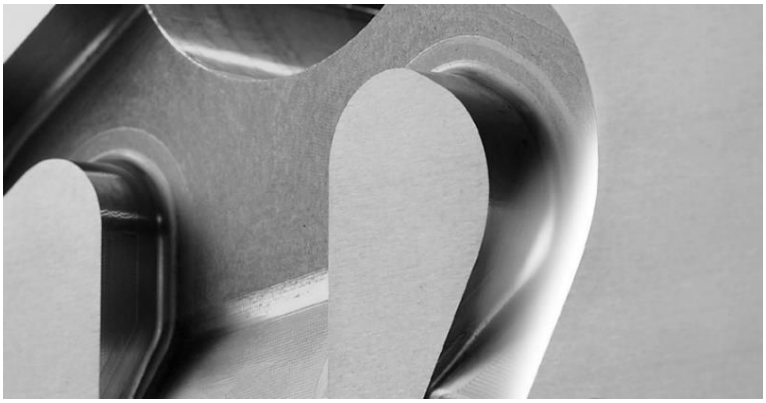
Created by Hitachi Metals, based on "Overview of Japan's Die and Mold Industry"

★Initiatives for carbon neutrality★

Against the background of international calls for carbon neutrality policies as well as the need for increased production efficiency, demand for molds and dies is expected to grow stably in the future.
Being a major mass-production method, molding/diecasting can contribute to achieving carbon neutrality. In addition, industrial efforts are being promoted to develop new materials and improve technologies aimed at providing drastic solutions to this challenge.
The Hitachi Metals Group is carrying out specific activities to reduce CO_2 emissions, having set the medium-term goal of achieving a 38% reduction by fiscal 2030 (compared to the fiscal 2015 level) and the long-term goal of achieving net zero emissions (going carbon neutral)[*1] by fiscal 2050.
Specifically, the Advanced Metals Division, together with the Global Research & Innovative Technology Center (GRIT), Hitachi Metal's R&D function, is planning and implementing R&D projects to diminish the life cycle CO_2 emissions of products, including those for extending the serviceable life of equipment to be used under extreme conditions.
The Specialty Steels Business has established a production system using an electric furnace steel-making technique that uses an iron source with lower CO_2 emissions (iron scraps). Also, the business has begun to focus on the production of high-function materials designed to help customers' energy conserving efforts. One such exemplary product is SLD-f, which is designed to decrease man-hours for molding processing and lead time for die making, looking to contribute to energy conservation. A detailed report on the product will be provided later in this article.
Moreover, in order to reduce CO_2 emissions attributable to the manufacturing processes, Hitachi Metals is introducing appropriate heat management systems to facilitate energy conservation[*2] as well as increasing the usage ratio of renewable energy-based power.
Going forward, Hitachi Metals will prepare manufacturing systems that use low-carbon fuels and introduce electric material handling equipment in plants of Hitachi Metals.

The following section presents two products ― hot work tool steel, DAC-X, and cold work tool steel, SLD-f, ― Hitachi Metals' latest products released with an eye on future needs for molds and dies. Please enjoy the description of the developmental background of each product.

>Latest product completed in September 2021
Die steel for diecasting DAC-X with outstanding strength at elevated temperatures



In response to the recent market needs for increased fuel efficiency and lower prices for vehicles, the automobile industry is expanding usage of aluminum diecast products, due to their suitability for weight saving and higher productivity. Many automakers are broadening the range of application and pursuing higher design quality of these products.
In line with this trend, the shape of dies ordered is becoming more complex, and this poses production challenges, including difficulty with heat treatment resulting in lower toughness, which raises the risk of causing gross cracks. Also, in pursuit of increased productivity, the requirement for shorter diecasting cycle time tends to raise the risk of heat cracks. This is a result of heavier metal load imposed by temperature difference related to heating and cooling processes for diecasting.

To address these challenges, Hitachi Metals developed DAC-X new die steel for diecasting, utilizing the 10,000-ton free forging press installed in the Yasugi Works in 2018. DAC-X features high strength at elevated temperatures and toughness together. This has been achieved by effectively combining alloy designs to heighten strength at elevated temperatures and a composition control process specific to the steel grade. In particular, the product exhibits good heat crack resistance for use under high heat load conditions. This can bring several benefits, such as extended die life, reduced man-hours for repair, and faster diecasting cycle, which will help further improve the productivity and quality of dies (See "DAC-X heat crack resistance improvement examples" [*3]).
Therefore, using DAC-X will enable lower total cost for diecasting processes.

DAC-X

DAC-i

Prior to DAC-X, Hitachi Metals developed DAC-i in October 2018. This is a general-purpose steel grade developed to have excellent strength at elevated temperatures and toughness for larger dies and diecast products. DAC-i, together with newer DAC-X, will lead the related lineup aiming to offer next-generation standard die steels for diecasting.

■ Comments of development engineer

(Yosuke Nakano, Metallurgical Research Laboratory, Advanced Metals Division)

>>What does the name mean?

The letter "X" is associated with our manufacturing output to customers and has its origin in three terms. The first term is "variable x," which was chosen to represent our wish to offer "an unknown number of possibilities" to customers. The second is "cross," by which we suggest our pledge to "cross the bounds to open up possibilities."
The third is "Transformation: X," which refers to the initiative of the automobile industry to achieve a once-in-century evolutionary transformation.
The engineers hope to contribute to the industry's grand initiative.
"DAC" is the name of Hitachi Metals' established series of die steels for diecasting, one of Hitachi Metal's hallmark product. "DAC" stands for "Die A Cast."
"i" in "DAC-i" has its origin in two words: "isotropy" and "innovation." The former refers to the established technique for development of DAC and the latter refers to innovation added to the series. Hitachi Metals has adopted the isotropy theory to develop a specialty steel making approach to reduce impurities and increase property control performance, in order to enhance toughness and other characteristics.

>>What was particularly challenging about the development project?

One of the most challenging issues I faced was when some property control-related requirements went beyond the capacity of the press (4,000 ton) available in our plant in the early days of development. However, the issue was overcome by utilizing the new 10,000-ton press introduced in 2018.

>>What are particularly appealing features of the product?

The product's strongest feature lies in its distinctive heat crack resistance supported by the high strength at elevated temperatures. We worked out alloy designs to heighten strength at elevated temperatures while pursuing better toughness by developing a composition control technique capable of mass production. As a result, we successfully achieved the two characteristics, which normally pose a trade-off challenge.
In addition, we adopted techniques based on the isotropy theory to reduce impurities.
Customers can benefit from using this product, especially by reducing the risk of early occurrence of heat cracks, resulting in longer die life. This will contribute to lower depreciation cost of dies.
Customers can also cut down on the per-unit cost of diecast products, although depending on the type of products to process. I believe this will give them an advantage in deploying effective business strategies. I wish many customers will choose this product.

>>What are Hitachi Metals' global marketing plans for competing with China and the U.S., the world's largest two producers?

Marketing plans are in preparation to explore the possibility of global development. We have set China, the world's largest market, as the primary target with an eye on expansion to the rest of the world at the same time.
Hitachi Metals will promote the lineup led by DAC-X along with DAC-i general-purpose steel, aiming to further increase convenience for the customers around the world.

>Cold work tool steel SLD-f with excellent machinability and toughness: Achieved by ultra-high tensile strength steel processing technique

The automobile industry is requiring higher tensile strength for materials of vehicle body parts (pressed components) in order to increase collision safety and facilitate weight saving. Increasing the strength and hardness of high tensile strength steel is posing a significant risk of damaging dies in the process.
Also, amid growing calls for the overall supply chain to shorten lead times, all suppliers are facing stronger demands for shorter development and production lead times.
In response to this situation, Hitachi Metals developed new cold work tool steel SLD-f.
SLD-f can support about 3.5 times higher efficiency cutting conditions[*4] than the standard conditions represented by SKD11 general-use cold work tool steel. This was made possible by achieving an appropriate composition to form belag[*5] and micronizing carbides. SLD-f will help customers improve machining and diecasting speeds. Due to its high toughness, this steel product is superior in durability and chipping resistance. It also demonstrates stable hardness for high-temperature tempering, which is effective for reducing dimensional changes due to PVD treatment[*6] and maintaining the firmness.
The lineup includes SLD-f60, the special sale product introduced earlier in this article. SLD-f60 is pre-hardened die steel[*7] based on 60HRC grade steel that undergoes pre-heat treatment and allows die sinking. Based on SLD-f new cold work tool steel with good machinability, this product is processed into a pre-hardened steel plate and offered by the Hitachi Group's dealers. By adopting this product, customers can eliminate needs for handling complicated heat treatment work and correcting distortion, thereby further reducing man-hours.

■ **Comments of development engineer** (Tatsuya Shoji, Yasugi Works, Advanced Metals Division)

>>What does the name mean?

"SLD" is the name of Hitachi Metals' established series of cold work tool steels, one of Hitachi Metal's hallmark products. "SLD" stands for "Stainless Like Die" steel, referring to its rust resistance superior to comparable products available in those days.
The letter "f" comes from the initial letter of "fabulous cutting," and this suffix is added to the name of products having particularly good machinability among the cold work tool steel series.

>>What were the highlights of the development project?

The most important highlight is the success in providing high machinability to 60HRC grade steel. In order to ensure that the steel maintains good machinability performance, we developed a compositional design that enables belag, oxide inclusions, to be formed and maintained on the tool surface during machining operation. Other highlights were related to raising toughness in order to increase the chipping resistance of dies during operation, as well as maintaining stable tempering hardness exceedingly the 60HRC level even when the material is subject to high temperature tempering before PVD treatment. Also, the product has better resistance to heat treatment-induced dimensional changes.
The most difficult challenge we faced was to establish composition designs to achieve the above-described four characteristics at the same time and related production techniques to support mass production. Belag formation is a long-established technique for protecting the tool in cutting steel

material. At Hitachi Metals, however, this technique has never been adopted as a major composition control method for steel grade development. Thus, we were the first in the company to adopt the process as a primary method.

>>What has inspired you to adopt the belag formation method despite a lack of precedent in the company?

Hitachi Metals' R&D teams understand the importance of striving to achieve a breakthrough by leveraging long-standing techniques to invent new techniques in order to cater to customer needs. Our recent success represents an outcome of work practice based on this understanding.
The engineers are promoting constant and vigorous efforts in pursuit of new processes and techniques, including for property control for development grades. I believe this is a source of strength of Hitachi Metals.

>>What has been the market response since SLD-f was launched last summer?

Many customers, especially in the automobile and machine tools sectors, appreciate the benefits of shorter die-making lead time. SLD-f can support about 3.5 times (more than 4 times under certain conditions in some examples) higher machining efficiency than the existing SKD11 equivalent tool steel, and the benefits of shorter lead time are greater for more costly steels.
Effect of shortening lead time varies depending on the process purposes and conditions. We also offer services to improve process efficiency, looking to provide a driver for the company's solutions business and offer greater benefits to the customers.

>>What is the customer feedback about SLD-f60, the recent special sale product? What is Hitachi Metals' plan for future special sale products?

Like SLD-f, SLD-f60 is favorably received by customers, who appreciate the product for its ability to save time for heat treatment, and accordingly correct distortion induced by the process. We received reports from some customers who achieved a significantly shorter overall die-making lead time.
The special sale product is offered by Hitachi Metal's dealers which undertake the processing of tool steel into the pre-hardened (58-60HRC) 6-face plate product. Going forward, Hitachi Metals will explore more opportunities to form a partnership with dealers and distributors and offer additional solutions to better satisfy customer needs.

The cornerstone of industry can't be formed overnight. Hitachi Metals is taking up various new challenges, including for achieving carbon neutrality, which will require Hitachi Metals to do something more than an extension of the existing businesses. To this end, Hitachi Metals strives to upgrade the product capabilities, in order to present suitable approaches to address many different needs of society at large as well as a range of customers leading up to end users and innovate product development and creation processes to create new product value that can open the way to the future.

Hitachi Metals will continue working to enhance product quality and technical prowess to be able to contribute to social development as a leading global manufacturer.

Inquiry contacts for the press: Corporate Communications Department, Hitachi Metals, Ltd. hmcc.sa@hitachi-metals.com

References:

*1. CO_2 emissions goals: Absolute total value of Scope 1 (direct CO_2 emissions by the Company) and Scope 2 (indirect emissions from the use of electricity, heat, and steam supplied by other companies)

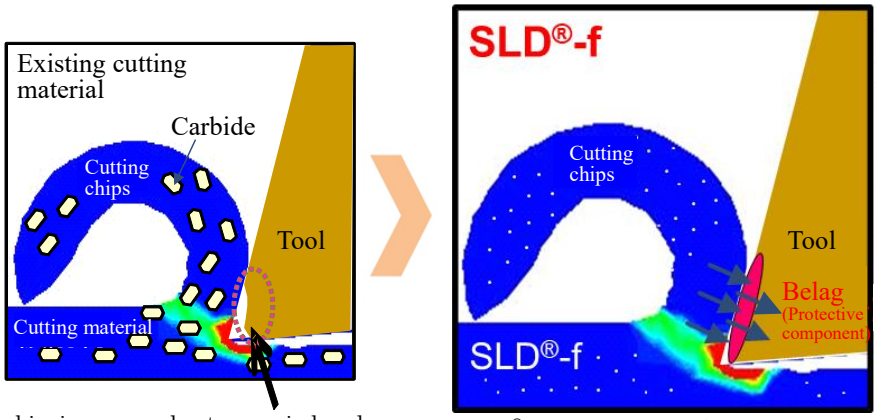
*2. Heat management: A method of saving energy chiefly by improving and optimizing the operation of heat treatment systems as well as increasing heat insulation performance

*3. DAC-X heat crack resistance improvement examples:

	Item	Die size	Casting machine size	Die hardness	Existing material	Effect
Company A	Auto parts	110×130×170	2,250 t	46HRC	Steel focusing on strength at elevated temperature	1.5 times longer die life
Company B	Auto parts	15×65×110	500 t	48HRC	High toughness steel	2.5 times longer die life
Company C	Hard disk	75×205×245	350 t	48HRC	Steel focusing on strength at elevated temperature	A 30% reduction in the number of die repair

*4. High efficiency machinability achieved

Comparison of machinability with existing cutting material (SKD11 equivalent)



Tool chipping occurs due to wear induced by weld deposit of cutting materials and

SLD®-f components work as "belag," a protection of the tool.

■Machinability of SLD®-f

About 3.5 times higher efficiency cutting conditions than the SKD11 standard cutting conditions

[cutting conditions (representative example (tool: 10mm in diameter, four blades))]

		SKD11	SLD®-f
Cutting conditions	Cutting speed (rotating speed)	150m/min (4,100/min)	450m/min (14,330/min)
	Feeding speed	1,800mm/min	6,305mm/min
	Depth of cut (ap x ae) *	15×1.0 mm	
	Cutting oil	Dry (air blow)	
Cutting chips		27cm^3/min	95cm^3/min

*ap: axial depth of cut; ae: radial depth of cut

*5. Belag: Oxidized weld deposit occurring on the rake face of a tool during machining operation. Formed belag acts as lubricant, effective in increasing the tool's wear resistance.

*6. PVD treatment: Physical vapor deposition treatment. A surface modification technique used to produce ceramic thin films on the surface of the metal. Ceramic films provide the metal material with a battery of characteristics, such as wear resistance, scuffing resistance, improved sliding performance, weld deposit resistance, heat resistance, and corrosion resistance.

*7. Pre-hardened die steel: Undergoes pre-heat treatment to obtain the specified hardness. This tool steel can eliminate the need for quenching, tempering and other heat treatment in the die-making process. Expected benefits include shortened delivery time and reduced risk of causing problems such as heat distortion.

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Stories are aimed at enabling many readers to gain in-depth understanding.
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