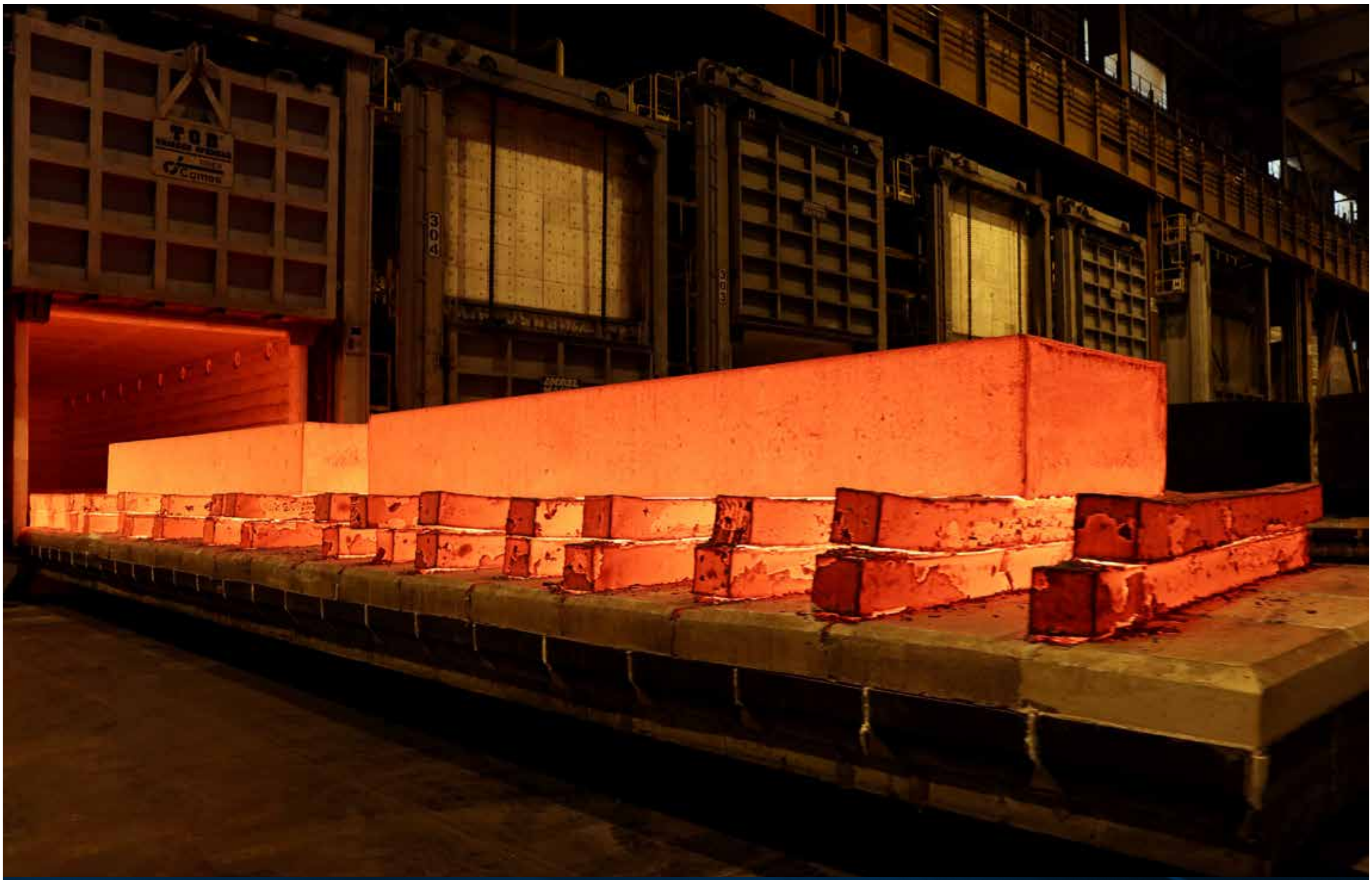

High-Quality Tool Steel
Hot-Work Steels

saarschmiede
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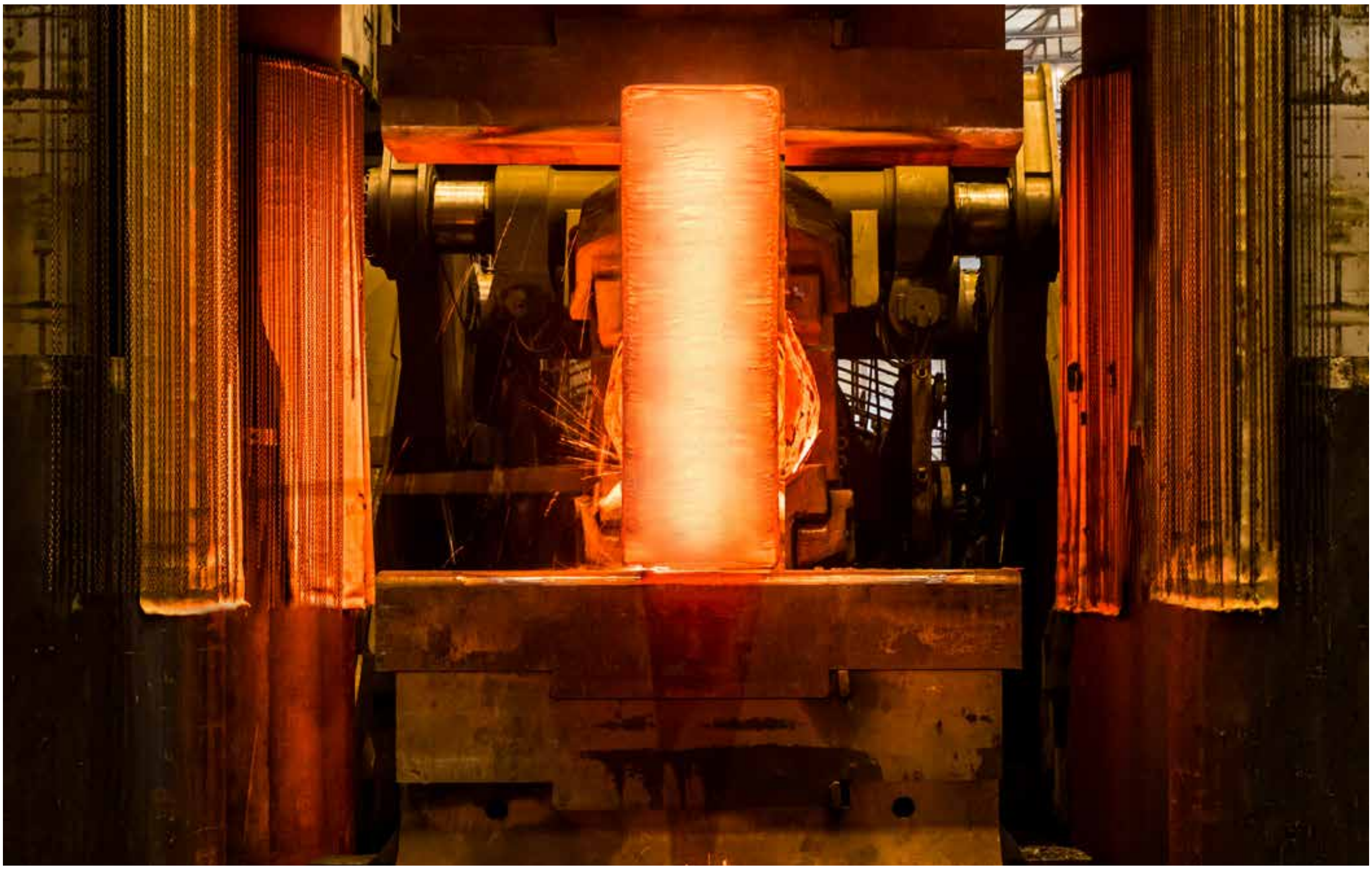


Hot-forming tools are needed for chipless forming of workpieces from iron and non-ferrous materials and their alloys as well as the production of articles of daily use from non-ferrous materials, such as glass or plastics.

Increasing capabilities of modern production machines and growing demands on quality of the products lead to continuously higher requirements for the operational properties of hot-forming tools. Moreover, as the highest possible decrease of tool costs is aimed at, the proper use of the various hot-work steels is of decisive importance for cost-efficiency.

We deliver steels and alloys of various compositions for the different hot-forming tools, which withstand wear for a long time and guarantee high cost-efficiency.

So as to simplify the selection of steel, this brochure contains some information about the applications of steels for the most important areas. Frequently, starting with the suggestions contained therein the selection of steel can be transferred to other areas of application.

ON THE SELECTION OF GRADES

The selection of grades must be carried out depending on the service requirements on the tool and must enable a cost-efficient production. Most of the time, it will be based on former experiences. As the service requirements even in similar production processes can strongly vary from company to company, the statements in the brochure can only be taken as a general information.

The following data are desirable for the selection of a new grade:

1. Tool drawing with approximate dimensions
2. Which requirements are made on the steel?
3. Information about the heat treatment facilities on site.
4. Information about the steels and alloys applied in the past and any difficulties which may have been experienced.

PROPERTIES OF THE HOT-WORK STEELS

In operation hot-work steels are subjected to mechanical and thermal stresses. They therefore must have additional properties which for many tool steels are not important or necessary only to a small measure, for example:

- High tempering resistance
- High-temperature strength
- Sufficient high-temperature toughness
- High hot-wear resistance
- Good heat conductivity
- Low tendency for thermal crack formation
- Good polishing ability
- Good resistance to corrosion and scales
- Good cooling ability

These properties are made possible by reasonable alloying in connection with appropriate heat treatment.

HOT-WORK STEELS WITH UNIVERSAL APPLICATION

Most hot-work steels have CrMo or CrW as the alloying base, whereby V, Co and Ni are alloyed in for the improvement of specific properties. The C-content is selected depending on the desired toughness and the required wear resistance, usually in the range between 0.2–0.6 %.

HOT-WORK STEELS WITH IMPROVED OPERATIONAL PROPERTIES

The operational properties of hot-work steels depend on melting, hot forming and heat treatment apart from the chemical composition.

In the case of **normal grades**, large differences in properties in the longitudinal and transverse direction cannot be avoided.

Through additional measures concerning melting, hot forming and heat treatment, the homogeneity of the materials can be decisively improved.

The application of **Electric Slag Remelted** (**ESR**) hot-work steels is appropriate in special cases such as extreme core stresses, highest demand on purity, large production series, rapid sequences, more abrupt cooling, which lead to high demands on the resistance to thermal fatigue.

SPECIAL ANNEALING TREATMENT (WORKABILITY ANNEALING BG)

For especially high demands on the structure the hot-work steels can also be supplied with an additional special annealing treatment (workability annealing). This treatment removes carbide precipitation on the grain boundaries, which often occurs after normal annealing treatment.

As hot-forming tools are preferably hardened from the lower hardening temperature range due to warping, such carbide precipitations cannot be fully dissolved under certain circumstances.

HOT-WORK STEELS AND ALLOYS FOR SPECIAL PURPOSES

In special individual cases, **maraging steels** have proven themselves, such as Maraging 250 (1.2709) for pressure casting of zinc and aluminum. Special characteristics of these steels are a simple heat treatment with hardly any warping and a focused achievement of highest strenght and toughness levels.

For stress temperatures of above 600 °C it is expedient in certain cases to use **high-temperature-strength steels and alloys**. These are especially suitable for shear blades, liners, extrusion press dies for processing of copper and copper alloys, diamond dies, drop forge dies with high thermal stresses and such like. Typical grades would be:

- Alloy A286 (1.4980)
- Alloy 718 (2.4668)
- Nimonic 90 (2.4952; 2.4969)
- René 41 (2.4973)

These materials show considerably higher high-temperature strength in comparison to the quenched and tempered hot-work steels and show advantages during operation for thermally high-stressed hot-forming tools with longer service times. The larger thermal expansion in comparison to the quenched and tempered hot-work steels and worse heat conductivity must be taken into consideration in tool production or, respectively, the use of these materials. The steels and alloys for special purposes are remelted according to special processes for the achievement of their properties, usually under vacuum.

CLOSED-DIE FORGING

Forging of steel, non-ferrous metals and their alloys in the close die is carried out on hammers and presses.

For forging with hammers, forming time, i.e. the contact between tool and forming material, is short, yet the toughness requirements for the close dies is high. Heating takes place only on the surface and is not particularly high due to the short forming time and the great heat dissipation through the die block, which is large in comparison to the forging part.

For forging on presses, forming time is considerably longer, and thus the die heating on the surface and in the core is also considerably higher. The demand on toughness of the tools is mostly smaller.

In both forging processes work is carried out with dies and with die inserts. The fundamental process differences, apart from the die construction, the sequences, the heating, cooling and lubrication conditions, have a decisive influence on the selection of the steel.

Hammer dies are therefore manufactured mainly from hot-work steels with high toughness, medium high-temperature strength, high hot-wear resistance and high resistance to thermal fatigue (NiCrMo-steels).
For working with wedged or shrunk-in inserts also higher-alloyed hot-work steels have proven themselves.
For smaller dimensions, flat engravings and low tool temperature, also unalloyed surface hardening steels can be used.

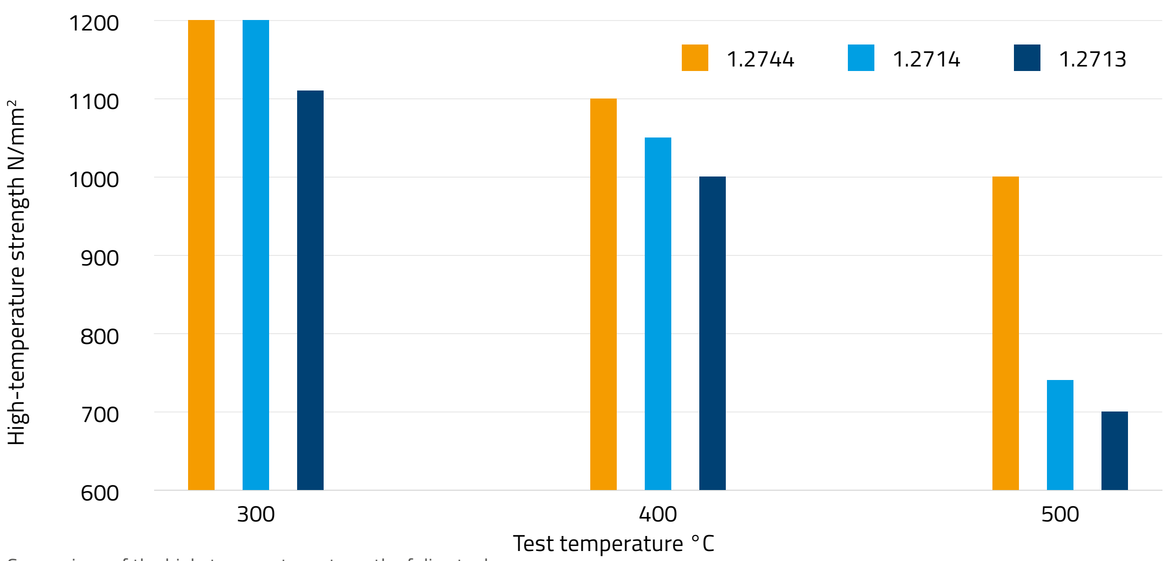
For forging under presses and on forging machines, higher-alloyed hot-work steels, partly also high-temperature alloys with high tempering resistance, high high-temperature strength and good hot-wear resistance are employed.

The variety of forging parts and thus the forms of engravings, the increasing number of forged materials, their different hot-forming behavior as well as differences in the working methods self-evidently entail also deviations from this normal case.

We supply the classic hammer die steels 1.2713 (55NiCrMoV6) or 1.2714/RGS 4 (55NiCrMoV7), in crude condition, or according to customer specification rough-machined annealed, yet normally in tempered condition with between 1,000–1,400 N/mm². This design offers advantages to the customer regarding time and costs. Furthermore no additional heat treatment is required on customer side. In this strength, die steels can still be machined in a cost-efficient way yet.

The 3 % nickel die steel 1.2743 (60NiCrMoV12-4) is normally supplied in annealed condition. It offers the possibility of low-warp air hardening and is usually applied with higher strengths than the above-mentioned die steels. The grade 1.2744 (57NiCrMoV7-7) displays a higher high-temperature strength and tempering resistance compared to 1.2714/RGS 4 due to its higher molybdenum content, and is more suitable for nitriding.

The higher-alloyed hot-work steels mainly applied in forging presses and forging machines are supplied in annealed condition as a rule and quenched and tempered after machining.
High-temperature alloys for thermally highly stressed piercers and die inserts are as a rule machined in solution-annealed condition and then precipitation hardened.



Comparison of the high-temperature strength of die steels

TREATMENT OF FORGING TOOLS IN OPERATION

Forging tools must be thoroughly warmed up already before forging so as to prevent tension and fire cracks. The warming-up temperature should be at least 200 °C in the case of NiCrMo die steels, for higher-alloyed hot-work steels at least 300 °C. For pressure-molding dies for light metals even higher warming-up temperatures are recommended.

The thorough warming up of the die can be carried out in separate warming-up furnaces with the help of gas heaters or other equipment. The frequent practice of warming-up with gas burners, or, what is even worse, through depositing hot forging pieces on the engravings, can easily lead to local over-heating and premature wear.

In the work breaks keeping the forging tools on the recommended warming-up temperature must be guaranteed. Die wear, generated through sliding of the forming material under pressure, particularly through attached scale as well as occurrences of adhesion tendency, can be prevented through surface treatment processes such as nitriding as well as the application of suitable lubricants. For the suitable selection of lubricants please pay attention to the recommendations of the manufacturers.

STEELS FOR PRESSURE DIE CASTING TOOLS

Pressure die casting is the shortest process from fluid metal to the finished piece. The process permits the manufacture of components with complicated forms and geometry with high dimension accuracy und in large series.

In the **hot-chamber process** metals with low melting point such as tin, zinc, lead, but also magnesia, are processed. The **cold-chamber process** is applied for Mg, Al, Cu and Cu-alloys (brass).

Standard steels for pressure casting are the heat-treatable CrMoV (Co) hot-work steels, which are often applied in remelted quality (ESR grade) for the achievement of a longer service life. Apart from the suitable steel selection, heat treatment and strength, the service life of the expensive pressure casting tools is decisively affected also by other factors such as the **influence of the construction** (location and design of the ingate; location, arrangement and section of the cooling holes).

INFLUENCE OF THE TOOL MANUFACTURE

Eroded surfaces tend to the increase of fire crack formation; therefore the white layer should be completely removed. An additional stress relief treatment can also be advantageous.

INFLUENCE OF SURFACE TREATMENT PROCESSES

In order to prevent occurrences of adhesion tendencies or erosion processes, pressure casting tools are often nitrided and/or coated. Layers which are too thick may also increase the fire crack formation.

MAINTENANCE AND CARE

Careful and thorough warming-up reduces the risk of fire cracks and tension cracks. Keeping warm in work breaks reduces cooling of the form and supports the service life. Intermediate stress-relieving also heightens the quality of the performance. Through focused melting, forming and heat treatment technology, it is possible to supply pressure die steels with optimized properties referring to the final use of the tools.

STEELS FOR EXTRUSION PRESS TOOLS

Bar extrusion is a chipless forming process in which a block heated to forming temperature is pressed in solid state by the forming tool whose outlet nozzle is equal to the section of the profile to be produced.

During operation, bar extrusion tools are subjected to complex mechanical and thermal stresses, which are mainly dependent on the press force, the temperature during operation and the processing speed. The pressure temperatures are between around 150 °C to around 1200 °C depending on the pressing material (from low-melting heavy-metal alloys to steel and high-melting Ni-alloys).

The steel selection for the individual block reception parts and various tools is aligned to the necessary application characteristics. Mainly medium- and high-alloyed hot-work steels are in operation, whose application characteristics are reached through quenching and tempering.

The tools which come into direct contact with the metal to be pressed, such as inner liner, pressing die, pressing disc and piercer are subjected to particularly high mechanical and thermal heating as well as high hot-wear resistance.

The block receiver is mostly designed either in 2 or 3 parts. This multipart design offers favorable tension distribution and better material utilization.

Jacket and intermediate bushing should show sufficient strength and toughness. For jacket and intermediate bushing, under normal thermal stresses steel grade 1.2311/MFR (40CrMnMo7), under higher and highest mechanical and thermal stresses 1.2343/RDC 2 (X37CrMoV5-1) is used.

The inner liner should bear the occurring thermal and mechanical tensions for as long as possible. In dependence of the pressing material, hot-work steels of the most diverse chemical composition come into consideration.
The installed strength of the inner bushing is mostly set to between 1,200 and 1,500 N/mm^2 depending on the stresses. This strength represents a reasonable compromise between mechanical load, hot-wear resistance and high resistance to heat cracking.

Due to the high forming temperatures the steel selection for processing of high-melting steels or alloys is problematic. In martensitic steels work-softening processes on the liner inner wall occur more or less fast. Through reinforcement with austenitic welding filler material the service life can be improved.

The extrusion die is subjected to high mechanical stress, partially also high thermal stresses. During normal stress conditions steel grade 1.2714/RGS 4 can be applied.
For higher and highest stresses, the application of steel 1.2343/RDC 2 is appropriate.

The pressing disc transfers the pressure of the pressing ram and, at the same time, is in close contact with the pressing material. Apart from high tempering resistance the disc must exhibit good resistance to thermal fatigue, as it is mostly exchanged and cooled after each pressing sequence.

The pressing die is among the highest stressed tools with regard to thermal and mechanical stresses. During passing through the die the pressing material not only has the highest temperature due to internal friction, but considerable friction temperature also develops on the contact surface of the die/pressing material. Particularly during pressing of heavy metal alloys, continuous work softening in the forming die occurs due to the high working temperature. Deformation, wear and loss of dimension are the result. With increasing thermal stress, steel grades 1.2343/RDC 2, 1.2344/RDC 2V (X40CrMoV5-1) and 1.2365 (32CrMoV12-28) are applied for light metal processing. In the case of heavy metal processing, 1.2344/RDC 2V, 1.2365, and beyond these, Co-containing stellites and high-temperature alloys have proven themselves.

Piercers, like dies, are subjected to high mechanical and thermal heating as they are in contact with the hot block during the complete duration of the pressing.

In heavy-metal processing, one tries to noticeably reduce the effective temperature on the tool surface through inner and outer cooling of the piercer. For piercers, only such high-alloy hot-work steels as 1.2343/RDC 2 or 1.2344/RDC 2V, 1.2365 and 1.2889 (X45CoCrMoV5-5-3) are taken into consideration.

Auxiliary tools such as dies, pressing plates and tool receivers, do not come into contact with the pressing material. They therefore do not need distinct heating characteristics like piercers and dies, yet they must bear the pressure stresses occurring.

You can obtain further information at
www.saarschmiede.com

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