ASSAB TOOL STEEL FOR

PLASTIC MOULDING

ASSAB

Selecting a tool steel supplier is a key decision for all parties, including the tool maker, the tool user and the end user. Our products are always state-of-the-art. Consequently, we have built a reputation as the most innovative tool steel producer in the world.

ASSAB produce and deliver high quality Swedish tool steel to more than 100,000 customers in over 100 countries.

Wherever you are in the manufacturing chain, trust ASSAB to be your number one partner and tool steel provider for optimal tooling and production economy.

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STEEL AFFECTS US IN MILLIONS OF WAYS

Plastic moulding is a part of our everyday lives. Car parts, mobile phones, spectacles and computer chassis are all manufactured in moulds. However, the materials needed to make these moulds often require unique and demanding characteristics. This is why it is crucial to select the correct steel grade for your specific mould.

Many of the most well-known brands use ASSAB Tool Steel in their manufacturing processes, since plastic moulding is a demanding industry.

Harsh environment put steel under considerable stress. The problems are well-known, choosing the right tool steel is the solution.

A moulder knows that the cost of excessive mould maintenance, e.g. major repolishing, cleaning, replanting and replacing of worn or broken parts has to be taken into account. The costs of production and down time, overtime payment, late-delivery penalties and loss of customer goodwill also need to be considered.

The moulders also know that they have to solve the problem of maximising the life and performance of the production tool, e.g. the mould, to achieve the lowest possible total tooling cost per part produced. The cost of the tool steel in a mould usually represents only 5 – 10% of the tool costs. The effect on the total cost will be even less.

The drive to find new solutions, ongoing development and research are the hallmark of ASSAB as a business partner.

Continuous improvements and new product development are possible because we understand and listen to our customers needs.

Wherever production calls for precision and optimum performance, ASSAB's world leading tool steel is used.

In this brochure we present all our high quality material used for production of plastic parts. We also focus on important factors that contribute to an economical production.

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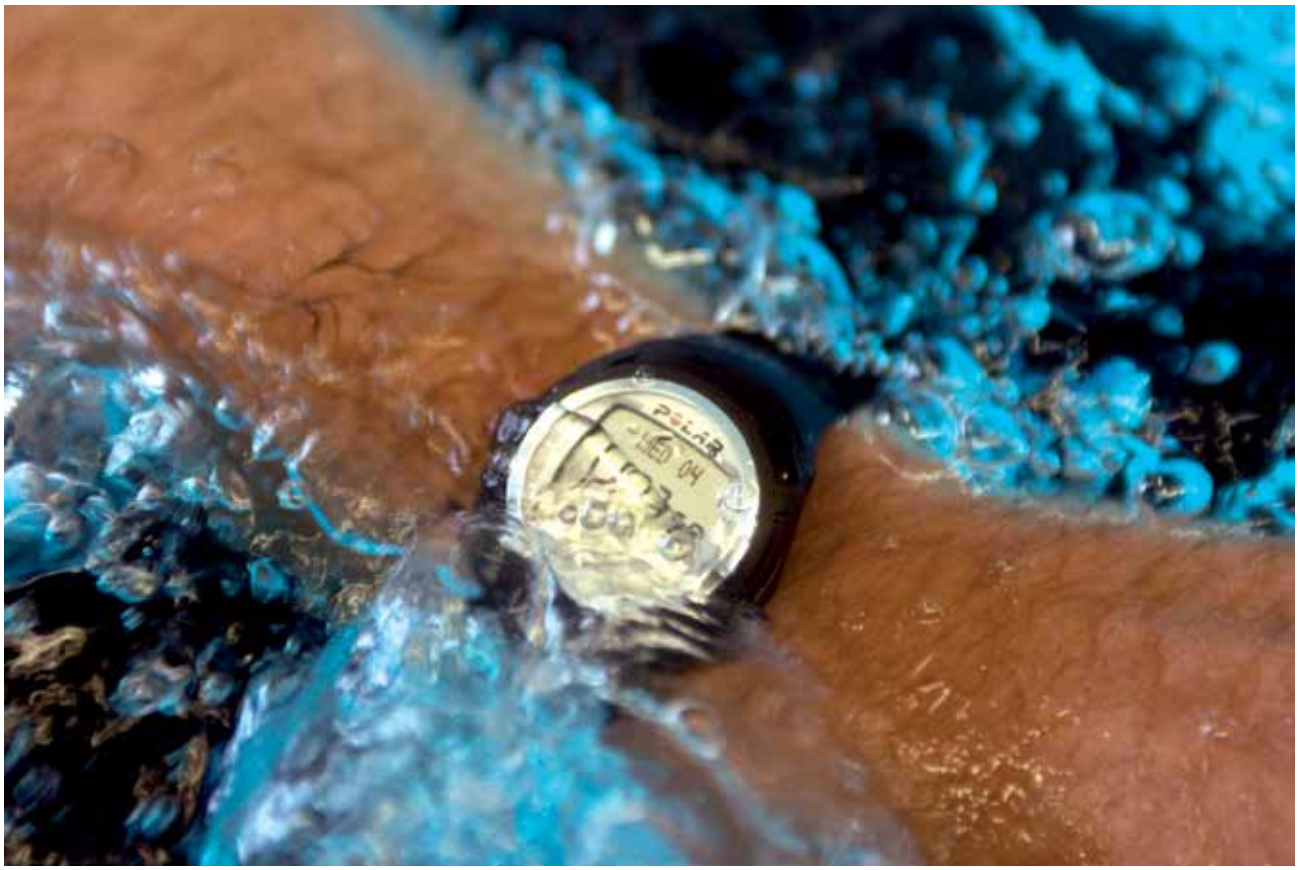


PRODUCT DESIGN

We at ASSAB can help the product designer to ensure that the final moulding matches his original concept. We are able to provide high quality mould steel to meet every plastics moulding and extrusion requirement.

Our Technical Support will give competent technical advice and information on the selection of the appropriate steel, heat treatment and application techniques.

THE IMPORTANT ROLE OF THE PRODUCT DESIGNER

When setting out to create a new moulded part a product designer faces many criteria that have to be satisfied.

Apart from its purely functional performance, the moulding is often required to match high standards of finish and tolerance over a long production run.

Whether these requirements are successfully met or not depends to a large extent on good component design, good mould design, good mould-making and the selection of the best mould steel for the job.

CHOOSING THE BEST MOULD STEEL FOR THE JOB

The product designer is thus involved in a lot of important decisions. Decisions that sooner or later will relate to the mould steel selected. He has to ask himself questions such as:

How important is the surface finish?

Does it need to be a mirror or optical finish?

(On page 8 you can see where we can be of assistance in helping him to answer these questions.)

Will the mould for the part be patterned by photo-etching? Are there several patterned parts to be matched, e.g. mouldings in a car interior?

(On page 10 you can see what ASSAB has to offer in this field.)

Will the moulding material be corrosive, abrasive or both?

(For further information on how we tackle these problems see page 19.)

How critical is it that the tolerances are held within close limits? What quantities have to be produced?

(The answer is important since the production quantity will affect the degree of wear resistance and other properties required in the mould material.)

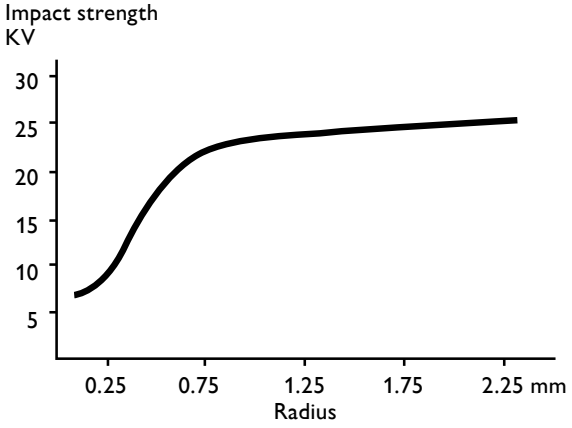
AVOID SHARP CORNERS AND STAY OUT OF TROUBLE!

Avoiding sharp corners and edges wherever possible is one example of how an experienced product designer can improve mould life and moulding productivity.

Sharp corners in mouldings, and therefore in the mould, are always potential stress-raising points. Points likely to cause cracking and failure of both moulding and mould.

By increasing the radius of the corners of moulded parts a product designer significantly improves the impact strength of the mould.

The result is a stronger mould, much better able to resist high locking and injection pressures.



Effect of increasing radius on impact strength.

(Steel type: AISI H13 at 46 - 47 HRC. Sample taken from surface in the longitudinal direction.)

MOULD DESIGN

The mould designer can significantly contribute to optimum tooling economy by thinking standard, i.e., using standard steel grades, standard steel sizes and standard machined plates.

THE IMPORTANT ROLE OF THE MOULD DESIGNER

In seeking to produce the best possible mould, a mould designer faces several criteria that have to be satisfied.

Together with the mould maker he shares the heavy responsibility of producing a mould that gives reliable and economical production of the part conceived by the product designer.

He also endeavours to ensure that the mould can be constructed as easily and economically as possible by the mould maker.

Whether these requirements are successfully met or not depends to a large extent on specifying the best mould steel and hardness for the mould concerned.

A clever mould designer can also add a valuable service to all concerned by thinking standard.

TAKE A SHORT CUT TO PRODUCTIVITY BY THINKING STANDARD!

Most mould designers are used to specifying a whole range of standard parts such as guide pins and bushings, ejector pins etc. Since these parts are available quickly at competitive prices they help the mould maker save valuable time.

But there is even more time and money to be saved. Time and cost savings can be further improved by extending this standard thinking to standard steel sizes, machined plates and steel grades.

In fact, by specifying readily available steel grades in standard sizes the mould maker can ensure prompt deliveries while keeping initial machining costs and material losses to a minimum.

CHOOSING THE OPTIMUM MOULD STEEL FOR BEST TOOLING AND PRODUCTION ECONOMY

The choice of steel grade and supplier is often made at the design stage in order to simplify and speed up the delivery of the mould. This means that the material and parts can be ordered in good time and that the work can be better planned.

This is not always a simple task. In many cases the choice of steel grade is a compromise between the wishes of the mould maker and the moulder.

The mould maker is primarily interested in the machinability of the steel, its polishability, heat treatment and surface treatment properties.

The moulder is looking for a mould with good wear and corrosion resistance, high compressive strength etc.

MOST COMMONLY USED MOULD STEEL

The steel types most commonly used are:

- Pre-hardened mould and holder steel
- Through-hardening mould steel
- Corrosion resistant mould steel

(For further information on these steel types and their properties see pages 21–22.)

WHEN TO USE PRE-HARDENED MOULD AND HOLDER STEEL

These steel are mostly used for:

- Large moulds
- Moulds with low demands on wear resistance
- Extrusion dies
- High strength holder plates

These steels are delivered in the hardened and tempered condition, usually within the 270 – 400 HB range. No heat treatment is necessary before the mould is put into use.

The surface hardness can be increased in many cases (see "Why Heat Treatment" on page 11).

Pre-hardened mould steels are generally used for large moulds and for moulds with moderate production runs.

ASSAB PRE-HARDENED MOULD AND HOLDER STEEL

ASSAB 718 HH (AISIP20 modified) which is refined by the vacuum degassing technique, offers good machinability and homogeneity, very good polishability and consistent photo-etching properties due to a low sulphur content.

Nimax ESR is a low carbon, ESR remelted steel with excellent toughness, weldability and polishability. This material is also available without ESR as Nimax.

Mirrax 40, ESR remelted, offers corrosion resistance, good homogeneity, cleanliness and excellent polishablility.

ASSAB 718 HH is delivered at 340 - 380 HB. Nimax ESR, Nimax and Mirrax 40 are delivered at 360 - 400 HB.

Ramax HH (AISI 420 F modified) and RoyAlloy are

pre-hardened stainless holder steels sulphurised for improved machinability. The delivery hardness of Ramax HH is approx. 340 HB and RoyAlloy is approx. 310 HB. They are ideal partners for Stavax ESR, Mirrax ESR, Mirrax 40, Polmax, Corrax and Elmax SuperClean when a completely stainless mould package is desired.

WHEN TO USE THROUGH-HARDENED STEEL?

These steels are mostly used:

- For long production runs
- To resist abrasion from certain moulding materials
- To counter high closing or injection pressures
- For high pressure processes like compression moulding

The steels are delivered in the soft annealed condition. They are usually rough-machined, stress-relieved, semi-finish machined, hardened and tempered to the required hardness and then finish-machined ground and often polished or photo-etched.

Through-hardened steel, used for cavity and core inserts, are usually placed in holder blocks of pre-hardened steels such as RoyAlloy or Ramax HH.

By using through-hardened mould or cavity inserts, e.g. in the range 48 – 60 Rockwell C, you will obtain better wear resistance, resistance to deformation and indentation and better polishability.

Better wear resistance is especially important when filled or reinforced plastic materials are used. Resistance to deformation and indentation in the cavity, gate areas and parting lines helps to maintain part quality.

Better polishability is important when high surface finish is required on the moulded part.

ASSAB THROUGH HARDENING STEEL

Stavax ESR (AISI 420 modified), Mirrax ESR, Polmax (AISI 420 modified), ASSAB 8407 Supreme (AISI H13 improved), Vidar 1 ESR (AISI H11) and Unimax are all typical through-hardening steels.

Our powder-metallurgy tool steels, Vanadis 4 Extra SuperClean, Vanadis 8 SuperClean, ASSAB PM 23 SuperClean and Elmax SuperClean, are our most wear resistant steels.

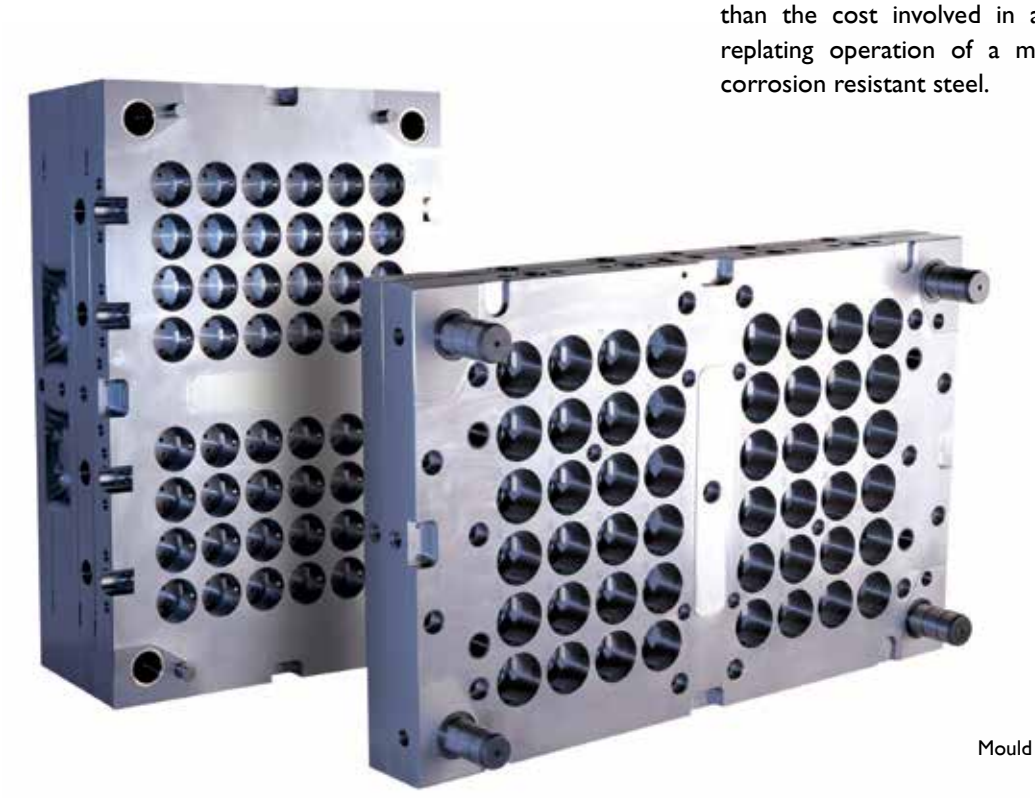
Vancron SuperClean's low friction properties can reduce problems with sticking of plastic to mould surface.

For applications where an excellent corrosion resistance in combination with excellent wear resistance is required Vanax SuperClean can be used.

WHEN TO USE CORROSION RESISTANT MOULD STEEL

If a mould is likely to be exposed to corrosion, a stainless steel is strongly recommended.

The increased initial cost of this steel is often less than the cost involved in a single repolishing or replating operation of a mould made of a non-corrosion resistant steel.



Mould base in RoyAlloy

Plastic moulds and dies can be affected by corrosion in several ways:

- Plastic materials can produce corrosive by-products, e.g. PVC
- Corrosion leads to reduced cooling efficiency when water channels become corroded or completely blocked
- Condensation caused by prolonged production stoppages, humid operating or storage conditions, often leads to corrosion

ASSAB CORROSION RESISTANT MOULD STEEL

Stavax ESR and Mirrax ESR, are corrosion resistant mould steels offering excellent polishability combined with good wear and indentation resistance. Mirrax ESR is developed to meet the increased requirements on good toughness and through hardenability in larger sections.

Polmax is also a corrosion resistant mould steel specially developed to meet the high demands on polishability. Mirrax 40 is a corrosion resistance pre-hardened mould steel with good polishablility.

Elmax SuperClean is a powder-metallurgy mould steel with high wear and corrosion resistance.

Corrax is a precipitation hardening mould steel with unmatched corrosion resistance, easy heat treatment and good weldability.

Tupperware plastic boxes produced in a mould made of Mirrax ESR

OTHER MATERIAL

The copper alloy Coolmould is used in moulds when high thermal conductivity is needed. Either by itself or in combination with other insert material.

FINDING THE CORRECT WORKING HARDNESS FOR THE MOULD

The chosen working hardness for the mould, and the heat treatment method used to achieve it, affect a lot of properties. Properties such as toughness, compression strength, wear and corrosion resistance.

Generally it can be said that increased hardness results in better resistance against wear, pressure and indentation and that decreased hardness leads to better toughness.

A normal working hardness for a through-hardening steel is 46 – 60 Rockwell C. The optimum working hardness used depends on the chosen steel, the mould size, layout and shape of the cavities, the moulding process, plastic material etc.

For recommended steel grades and working hardness related to various plastic materials and processes, see page 20 –22.

MOULD MAKING

A substantial part of the total tooling cost is incurred during the manufacturing of the mould. It is therefore of great importance that the mould making process should be as straight-forward as possible.

THE IMPORTANT ROLE OF THE MOULD MAKER

A well equipped machine shop with competent and experienced personnel is an essential part of the mould making process.

The significant investment that this process represents is ultimately focused on the mould material. An experienced mould maker, therefore, places high demands on his steel supplier and his product when it comes to steel quality and properties as well as steel finish and availability.

CHOOSING THE OPTIMUM MOULD STEEL

The mould maker is looking for a mould steel free from defects, easy to machine and polish, stable in heat treatment and suitable in many cases for EDM and/or photo-etching.

WITHOUT DEFECTS

All material supplied by ASSAB have been subjected to various external and internal inspection procedures, including ultrasonic testing. This ensures that high and even quality standards are met.

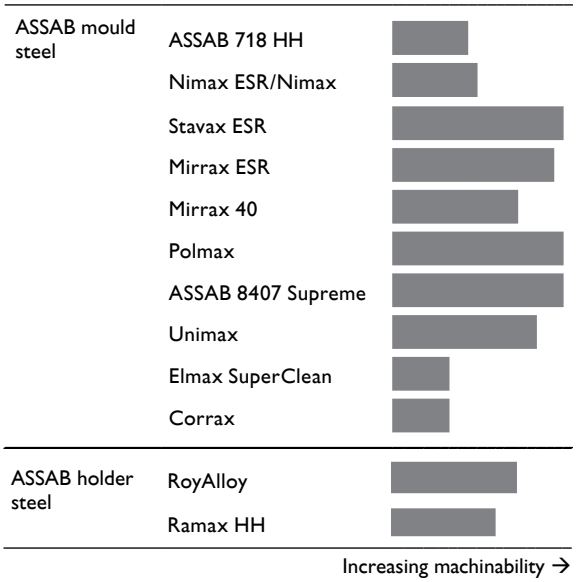
GOOD MACHINABILITY— GOOD ECONOMY

The cost of machining, accounts for roughly 1/3 of the total cost of mould manufacture. So a good and uniform machinability is of outmost importance.

Most of ASSAB's mould steels are supplied in the fully annealed condition enabling the best possible metal removal rates for the type of steel concerned.

The exceptions are the ASSAB pre-hardened steels, ASSAB 618 T, ASSAB 618 HH, ASSAB 718 HH, ASSAB 8407 Supreme (AISI P20 modified), Nimax ESR, Nimax, RoyAlloy, Ramax HH, Corrax and Mirrax 40.

A machinability comparison guide for a number of grades of ASSAB steel is shown below. The guide is based on tool wear tests:



The ASSAB steel grades, ASSAB 718 HH, Nimax ESR, Nimax, Ramax HH, RoyAlloy and Mirrax 40 were tested in the pre-hardened condition.

Pre-hardened steel like ASSAB 718 Supreme or Nimax is a good choice for production of buckets.

HOW IMPORTANT IS GOOD POLISHING?

Polishing sometimes accounts for up to 30% of the total mould cost. Not surprisingly, since it is a very time consuming and expensive process.

The result obtained depends to a large extent on the polishing techniques and a few other factors.

The cleanliness of the steel, i.e. the type, distribution, quantity and size of non-metallic inclusions, the homogeneity of the steel, the hardness of the steel and, for hardened steel, how the heat treatment has been carried out.

Non-metallic inclusions are reduced to a minimum if the steel is vacuum-degassed and/or Electro-Slag Refined (ESR process) during production. This ESR treatment results in improved homogeneity and minimal amount of inclusions compared to conventional steel production processes..

WHY HEAT TREATMENT?

The purpose of heat treating a finished tool is to obtain suitable mechanical properties such as hardness, toughness and strength. But there are some problems associated with heat treatment. Problems like distortion and dimensional changes have to be solved.

Electrolux vacuum cleaner.

SOLVING THE DISTORTION PROBLEM

The tool should be stress-relieved after rough-machining in order to minimise distortion problems. In this way the stresses induced by the machining-operations are relieved and any distortion is then rectified in the semi-finish machining before heat treatment.

When using through-hardening steel at maximum hardness levels, however, the requirement for minimum distortion may have to be sacrificed. The reason is that higher hardening temperatures and rapid quenching rates are necessary. This is especially the case when heavy sections are involved. The safest way of avoiding distortion is to use a pre-hardened steel such as ASSAB 718 HH, Nimax ESR, Nimax or Mirrax 40 — for which no additional heat treatment is required.

Different types of surface treatment can locally increase surface hardness.

HOW TO DEAL WITH DIMENSIONAL CHANGES

It is true that some dimensional changes are inevitable during hardening. But it is also possible to limit and control these changes to a certain extent. For instance by slow uniform heating to the austenitising temperature, by using a temperature that is not too high, by using a suitable quenching medium or a step quenching procedure.

Stavax ESR, Mirrax ESR, Unimax, ASSAB 8407 Supreme, Vidar 1 ESR, Polmax and Elmax SuperClean can all be air hardened when dimensional stability is important.

Corrax needs only an aging process at 500 – 600°C and no quenching. This means that no distortion will occur, only a linear and homogenous shrinkage in the order of 0.1%. Since it is totally predictable it is easy to compensate for this shrinkage by adding stock before the heat treatment.

TAKE THE SHORT CUT TO PRODUCTIVITY

Purchasing steel in a pre-finished form is a smart way of releasing toolmaking capacity for the more skilled machining operations. Many grades of steel are obtainable in a number of forms and finishes. And many of them have been pre-machined to a greater or lesser degree. ASSAB tool steel are available as machined bars. It is always possible to find a suitable stock size for the work in hand and thus reduce the amount of unnecessary and expensive machining.

In all cases a plus machining allowance is made on all sizes to allow for final finishing to a standard dimension.

MACHINED BAR

By using machined bar as starting material a tool maker gets considerable benefits which have an effect on the total cost of the steel.

- Less material by weight can be purchased, which means that waste is considerably reduced.
- No machining costs for removal of the decarburised surface layers are involved.
- The manufacturing time is shortened, which makes planning simpler and calculations more accurate.

ELECTRICAL DISCHARGE MACHINING (EDM)

When spark eroding cavities, one or two important points should be noted in order to obtain satisfactory results. During the operation the surface layer of the steel is rehardened and consequently in a brittle state. This may result in cracking and shortened tool life. To avoid this problem the following precautions should be taken.

- Finish the EDM operation by fine sparking, i.e. using low current and high frequency.
- The affected surface layer should be removed by polishing or stoning.
- If the spark eroded surface texture is to be used in the finished mould it should be retempered at a temperature ~25°C below that used previously.
- If the spark eroded surface is to be textured by photo-etching it is important that all of the affected surface layer is carefully removed by stoning etc.

WIRE EDM

This process makes it easy to cut complicated shapes from hardened steel blocks for example during manufacturing of extrusion dies. However, hardened steel always contain stresses and when large volumes of steel are removed in a single operation, distortion may be caused or even cracking. These difficulties can be reduced by conventionally machining the work piece before heat treatment to a shape near the final form. This allows the work piece to adjust to the final shape and stress pattern during heat treatment.

WHY THE PHOTO-ETCHING PROCESS HAS BECOME SO POPULAR

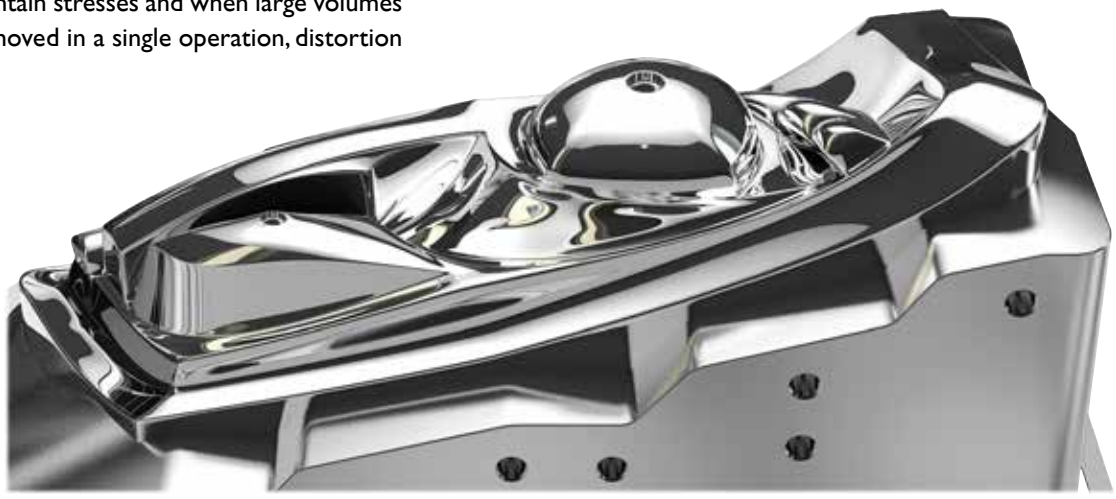
Plastic mouldings with a textured surface have become increasingly popular. And texturing by photo-etching is frequently used as a finish on moulding tools instead of polishing.

The photo-etching process gives the product an attractive, easily held surface, relatively insensitive to minor scratches and damage.

POINTS TO BE OBSERVED WHEN PHOTO-ETCHING

The results obtained by photo-etching do not entirely depend on the process technique and the selected mould material. The way in which the tool has been treated during manufacture is also of great importance. Therefore, the following points should be observed.

- If a number of moulding inserts are included in a tool and these are to be etched with the same pattern, the mould material and the rolling direction should be the same for these parts (preferably from the same bar or block).



A highly polished mould for production of car headlights.

- Complete the machining operation by stress-relieving, followed by finish-machining.
- There is generally no advantage in using finer abrasives than 220 grain on a surface that is to be photo-etched.
- Spark eroded surfaces should always be ground or polished otherwise rehardened surface layers from the spark erosion will cause a poor etching result.
- Flame hardening should be avoided prior to photo-etching.
- In some cases a welded tool can be photoetched provided that the same material is used in the weld as in the tool itself. In such cases the welded area should be indicated to the photo-etcher.
- If a tool is to be nitrided this must be done after photo-etching.
- The surface area of a mould cavity is greatly increased by texturing, which may cause ejection problems. Early consultation with the photo-etching specialist is recommended to determine the optimum draft angle for the shape and pattern concerned.

ASSAB MOULD STEEL SUITABLE FOR PHOTO-ETCHING

ASSAB 718 HH, Nimax ESR and Nimax pre-hardened mould steels, Unimax, ASSAB 8407 Supreme (AISI H13 improved) and Vidar 1 ESR (AISI H11) through-hardened steels yield particularly good and consistent results due to their very low sulphur contents.

Stavax ESR, Mirrax ESR, Elmax SuperClean, Corrax, Polmax and Mirrax 40 can be photo-etched to the required pattern but will require a slightly different etching technique, because of their corrosion resistance.

MOULDING

By specifying ASSAB material, the moulder can take an important step towards getting a reliable and productive tool.

THE DEMANDS OF THE MANUFACTURER OF PLASTIC MOULDINGS

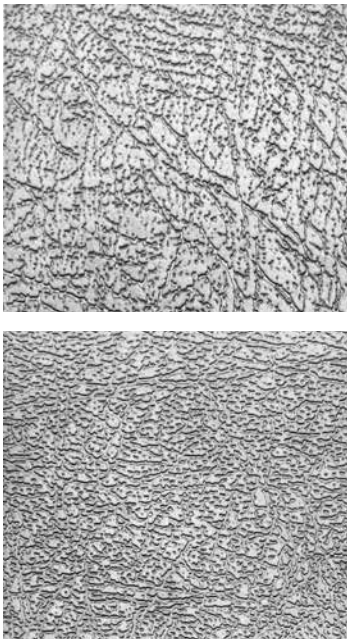
The manufacturer expects his mould to be delivered on time. And he expects it to produce a certain quantity of components at a specified quality level and at lowest possible cost. The manufacturer's essential demands are:

- A reliable mould delivery date, implying the ready availability of suitable mould materials
- A reliable mould performance in terms of a uniform, high rate of production, uniform quality of mouldings, long mould life and low mould maintenance costs
- Availability of replacement materials and components

All these demands can be summarised as tool reliability.

There are several textured parts in a car interior

Photo-etched surfaces



TOOL RELIABILITY

Tool reliability depends on such factors as the ready availability of suitable mould material and components, the performance of the mould steel and the interchangeability of mould components.

AVAILABILITY OF MOULD STEEL

The ready availability is determined by local stocks, reliable delivery service and comprehensive product and size range.

LOCAL STOCKS

The location of stock is important if good delivery service is to be maintained.

With our worldwide network, we place great emphasis on matching our stock size programme and our stock levels to the local needs of each individual market.

RELIABLE DELIVERY SERVICE

Our widespread network of ASSAB warehouses and our complete range of products form the basis for our delivery service.

Each of our stock locations has a well established distribution system.

COMPREHENSIVE PRODUCT RANGE

To sum it up, we are able to offer a wide range of mould and holder steels. To use competent technical advice and printed material on the selection, heat treatment and application of mould materials, EDM, polishing and surface texturing of tool steel are very important aspects of our service.

MOULD STEEL PERFORMANCE AND TOOL RELIABILITY

The performance of the mould steel has a decisive influence on the reliability of the tool.

Mould cavity and insert materials are therefore selected according to the types of plastics to be moulded, length of production run, moulding process used and the nature of the product.

The performance of the mould steel depends on wear resistance, compressive strength, corrosion resistance, thermal conductivity and toughness.

We have concentrated our mould steel programme on a few steel grades, each suited to specific applications. This assures not only ready availability but also gives the mould maker and the moulder an opportunity to become more readily familiar with the characteristics of each steel (e.g. machinability, heat treatment response etc.) and performance.

WEAR RESISTANCE

The level of wear resistance required will depend on the type of resin to be used, mould process, amount of additives, length of production, tolerances etc.

Mould steel cover a wide range of wear resistance and compressive strength. In principle, they fall into two categories: pre-hardened mould steels for moderate demands, e.g. ASSAB 718 HH, Nimax ESR, Nimax, Mirrax 40 and RoyAlloy and through-hardening mould steels for severe demands, e.g. Stavax ESR, Mirrax ESR, Polmax, Corrax, ASSAB 8407 Supreme, Vidar 1 ESR, Unimax and Elmax SuperClean.

Pre-hardened mould steel can be surface treated to obtain greater wear resistance, for instance, by nitriding. However, through-hardened steel give the best combination of wear resistance and compressive strength.

The wear resistance of fully hardened steel can be further improved by surface treatment or surface coating, such as nitriding, hard chrome plating, PVD etc.

Such surface treatments are preferably applied only after the mould has been fully approved, since further machining can be difficult.

It should be noted that the corrosion resistance of ASSAB mould steels Stavax ESR, Mirrax ESR, Mirrax 40, Polmax, Corrax and Elmax SuperClean is reduced by nitriding.

The powder metallurgy grades, Elmax SuperClean, Vanadis 4 Extra SuperClean and Vanadis 8 SuperClean are extremely wear resistant. They are recommended for small moulds, inserts and cores subjected to abrasive wear. Vancron SuperClean's low friction properties can reduce problems with sticking of plastic to mould surface.

COMPRESSIVE STRENGTH

The compressive strength required is determined by the plastic moulding process, the injection and closing pressures and the tolerances of the finished moulding. During moulding compressive forces are concentrated on the parting faces of the tool.

Local hardening, e.g. flame hardening, can give the required increase in compressive strength when a pre-hardened steel is used.

CORROSION RESISTANCE

The moulding surfaces should not deteriorate during production if you want to produce plastic mouldings at a high and constant rate of production and at a uniform level. Corrosion with a consequent threat to production efficiency can be experienced in several ways.

- Certain types of plastics can emit corrosive by-products during production. An example is the hydrochloric acid produced from PVC. This effect can be minimised by not exceeding the recommended moulding temperature for this material, usually about 160°C.
- The cooling medium can be corrosive. This can result in a loss of cooling efficiency or even in the total blockage of the cooling channels.
- Productions in a humid or corrosive atmosphere or prolonged storage may cause surface damage by water, condensation and eventually rust in the cavities with loss of surface finish on the products.

All the problems mentioned above create a demand for insert and holder materials with some degree of resistance to corrosion.

Corrax, which has the best corrosion resistance, is used wherever corrosion is the main problem, i.e. processing corrosive plastics. Stavax ESR, Mirrax ESR and Mirrax 40 pre-hardened are corrosion resistant mould steels with high cleanliness. Polmax can meet the highest demands on polishability combined with corrosion resistance. Elmax SuperClean is combining moderate corrosion resistance with extremely high wear resistance and RoyAlloy or Ramax HH are corrosion resistant steels with very good machinability. By using Ramax HH or RoyAlloy for the holders the stainless properties are extended to the full mould. Vanax SuperClean combines excellent corrosion resistance with excellent wear resistance.

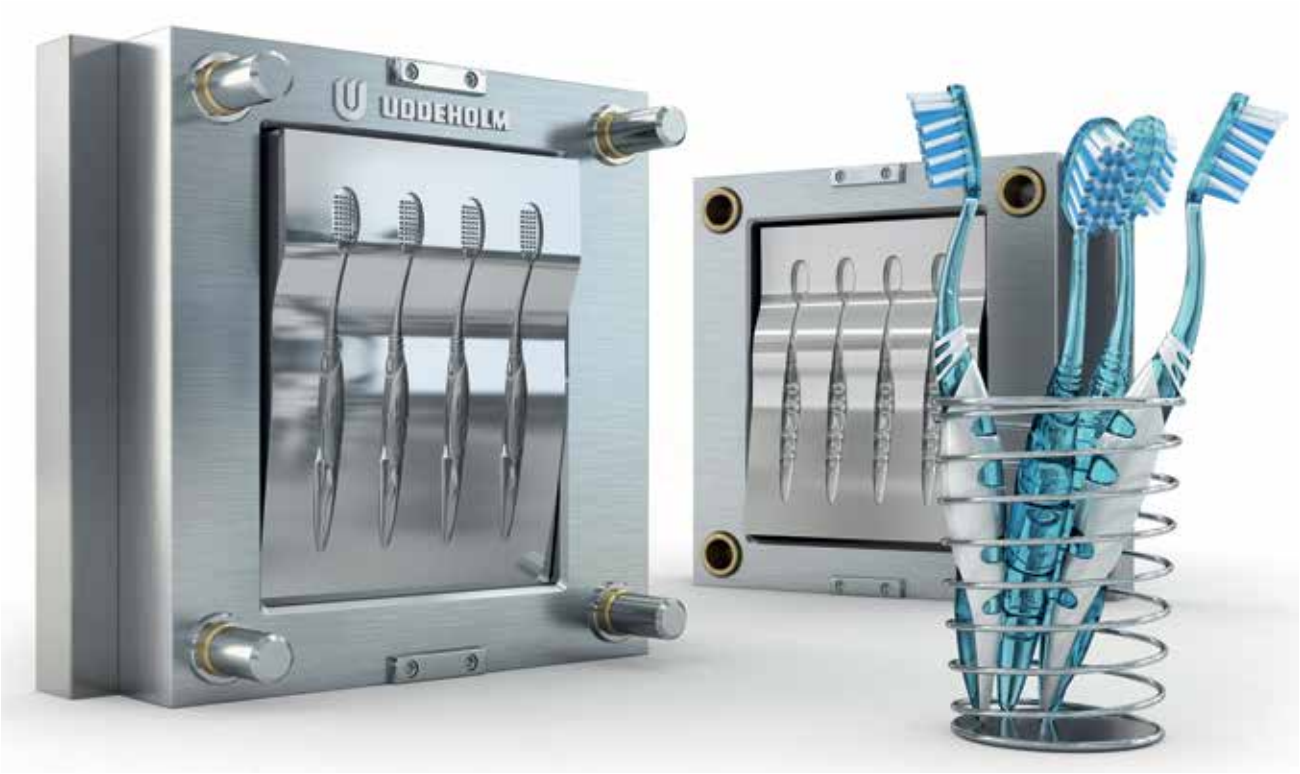
THERMAL CONDUCTIVITY

The rate of production of a moulding tool depends mostly on the ability of the mould to transfer the heat from the moulded plastic to the cooling medium.

In highly alloyed steel the coefficient of thermal conductivity is reduced to some degree compared to a low alloyed steel. However, investigations clearly indicate that it is the plastic in the moulded part that dominates the heat flux in a mould due to its very low thermal conductivity compared to steel.

However, good corrosion resistance is also of great importance when aiming for a high and uniform production rate. Corrosion resistance has a beneficial effect on the resultant heat transfer properties in the cooling channels. The use of stainless mould steel such as Stavax ESR, Mirrax ESR or Mirrax 40 is often the answer.

When mould materials with good corrosion resistance, combined with very high thermal conductivity are required, we can supply Coolmould a high strength copper alloy grade with high thermal conductivity, good corrosion and wear resistance and good polishability.



TOUGHNESS

Development of cracks is the worst thing that can happen to a mould.

Complicated cavities with small radii, sharp corners, thin walls and severe changes of section are commonplace today. Toughness is therefore one of the most important properties a mould steel should possess.

The fracture toughness of a material is a measure of its capacity to withstand crack propagation from stress raisers when subjected to tensile stresses. In practice these stress raisers occur as surface defects from machining operations, incipient fatigue cracks, inclusions or as faulty structure due to improper heat treatment.

We are fully aware of the importance of toughness. We utilise state of the art metallurgical technology to give the mould steel optimum toughness. By utilising such techniques as vacuum degassing, special refining processes and electro-slag remelting, the toughness properties of all our steels are the highest currently available. This improved toughness is evident not only at the surface but also in the centre of the steel.

FRICTION

In injection moulding applications where a high surface quality is required, as for optical parts, sticking may appear between the plastic component and the steel mould surface.

Strong adhesive forces can lead to difficulties at component ejection, but also to a deteriorated surface finish of the plastic part. By using Vancron SuperClean, a nitrided PM material, a considerable reduction of the ejection force may be had as a result of the low friction properties emanating from the dense nitride particle distribution present in the steel.

Reduced problems of sticking is noted for injection moulding of e.g. PC and COC (Cyclic Olefin Copolymers).

The low content of non-metallic inclusions and the structure of small nitride precipitates give good conditions to perform high gloss polishing of Vancron SuperClean.

INJECTION MOULDING

Injection moulding is a moulding procedure whereby heated and plasticised thermoplastic or thermoset material is injected under high pressure into a relatively cool mould cavity for solidification. Injection moulding is a high production method. However the moulds can be extremely complicated and expensive.

PERFORMANCE OF MOULDS

The performance of the mould can be effected by the selection of mould material. The performance can mean different to different people:

- Mould life
- Quality of the plastic part
- Productivity

MOULD LIFE

The mould life may be determined by different mechanisms such as:

- Wear
- Surface defects
- Deformation
- Corrosion

Wear may occur because of reinforced plastic or very long runs, surface defects may appear already during mould manufacturing as a result of polishing or EDM defects. Deformation can sometimes be a result of too high a clamping force. Corrosion may of course be a problem when moulding corrosive resins like PVC, but may also be the result of aggressive cooling water or humid atmosphere.

QUALITY OF THE PLASTIC PART

The quality of the plastic part is a matter of the look of the part, but of course also the function of the part.

Steel selection is important for high polished moulds. The steel must be clean and have a very low amount of inclusions. Tolerances may be effected because of uneven mould temperatures which of course is very much dependent on the cooling channels size and position but also on the selection of mould material.

Material like aluminium or copper alloys, with high thermal conductivity, may in some cases be used as mould material.

PRODUCTIVITY

Even productivity can sometimes be effected by the selection of mould materials. The most obvious situation is the selection of high thermal conductivity materials.

MOULD MATERIAL REQUIREMENTS

Depending on number of shots, plastic material used, size of the mould and needed surface finish also a lot of different materials can be used. Following basic mould material properties must be considered:

- Strength and hardness
- Toughness
- Wear resistance
- Cleanliness
- Corrosion resistance
- Thermal conductivity

COMPRESSION MOULDING

Compression moulding is a technique mainly for thermoset moulding in which the moulding compound is placed in the open mould cavity, the mould is closed and heat and pressure are applied until the material is cured.

Compression moulding is often used for moulding of glass fibre reinforced plastic.

There are several advantages with compression moulding for example:

- No waste of plastic material (no gate or runner system)
- Minimum of internal stresses in the part
- Process can be used for very heavy parts
- Less expensive equipment.

Limitations are:

- Difficult to mould complex articles with undercuts or small holes
- Fair tolerances
- Flash can be a problem

MOULD MATERIAL REQUIREMENTS

Important properties are:

- Wear resistance
- Strength and hardness

High hardness steel is normally used. When the moulds are big it is common to use pre-hardened material with high hardness inserts where the need for wear resistance is highest.

BLOW MOULDING

Blow moulding is a process for shaping thermoplastic into a hollow product. A hot thermoplastic tube is stretched with air pressure and cooled against a mould surface.

A variety of blow moulding techniques exist for different applications:

- Extrusion blow moulding
- Injection blow moulding

In extrusion blow moulding a hollow tube (parison) is extruded. The tube is then positioned in a mould and compressed air cause the tube to press against the cool walls and solidifies to the mould surface shape. Extrusion moulding exists as continuous extrusion and intermittent extrusion.

Injection blow moulding involves first forming of a perform, by extrusion or injection moulding, which is later blown to the desired shape.

MOULD MATERIAL REQUIREMENTS

Mould material requirements are of course totally different if talking about the injection moulding or extrusion of performs or if talking about the blow moulding itself. For requirements on material for extrusion and/or injection moulding we refer to the information for each process.

Blow moulding is a low pressure method where strength and wear demands are very moderate.

Some parts of the mould, like shot off areas and/or neck ring, may require higher strength material. PVC is a common material for bottles and may cause corrosion problems. Blow moulding is a very high productivity method why cycle times are of great importance.

MOULD MATERIAL PROPERTIES

Important properties are:

- Moderate strength demands
- Corrosion resistance
- Heat conductivity

MOULD MATERIAL RECOMMENDATIONS

The most common material to use in blow moulds is aluminium alloys, with inserts of higher hardness materials.

Steel is also used and in some cases even in the soft annealed condition.

EXTRUSION

A continuous operation in which hot plasticised material is forced through a die opening that produces a profile of the desired shape.
The plastic material is placed into a feed hopper, which feeds the cylinder. A rotating screw carries the material through the cylinder and forcing it through a die of the proper shape. The extruded profile is going through a cooling media and when cooled sufficiently it is cut to length. Cooling can be done by exposure to air in room temperature, passing through a bath held at controlled temperature or by compressed air. Normally a special calibrator unit is used to give the profile its finished size. The cooling is a sensitive process in order to keep tolerances and avoid warpage.

DIE MATERIAL REQUIREMENTS

In the extrusion process many engineering parts are involved. The calibrator units are often produced in aluminium in order to get quick cooling. The die is however normally produced in steel. The strength requirements are moderate. However, corrosion resistance is needed for extrusion of PVC profiles and wear resistance for reinforced profiles.

Normally pre-hardened grades have enough strength for normal extrusion. The dies are sometimes nitrided for increased wear resistance.

WELDING CONSUMABLES

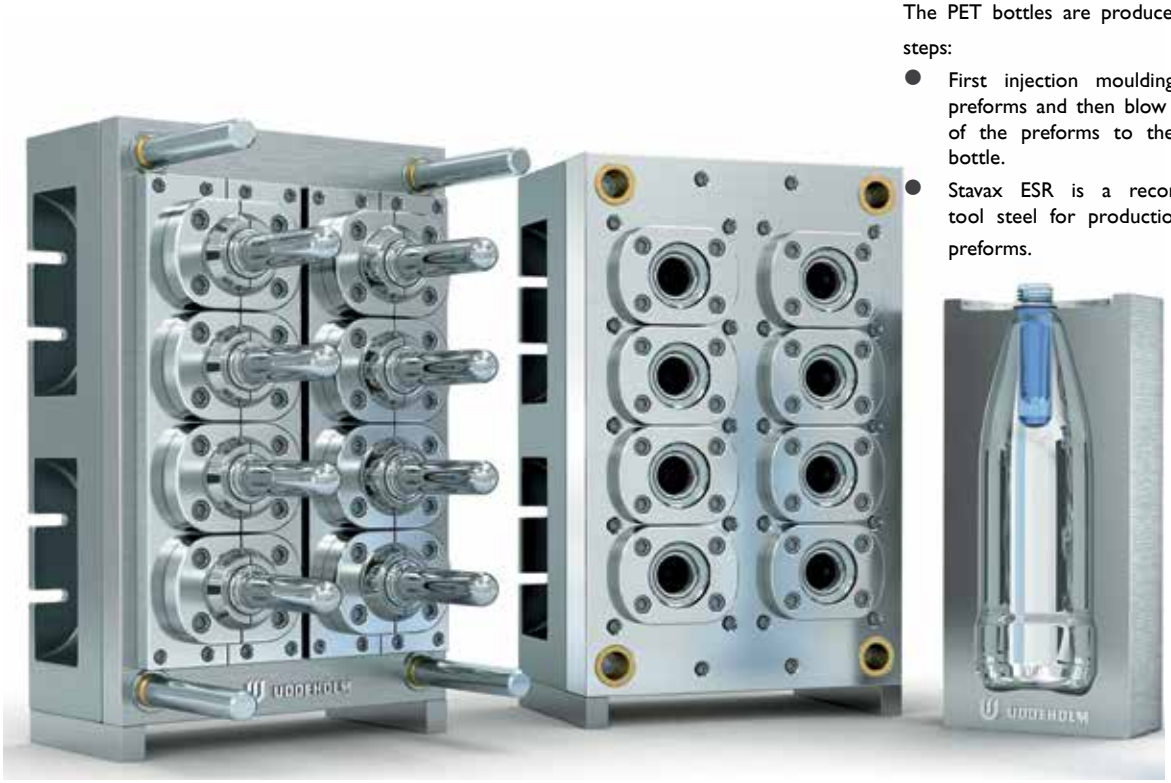
To ensure successful repair welding it is of outmost importance to exactly match the consumables to the mould steel. Especially if the welded surface is to be photo-etched or polished.

We offer welding consumables for the ASSAB tool steels ASSAB 718 HH, Nimax ESR, Nimax, Unimax, Mirrax, Corrax, Stavax ESR, Coolmould and RoyAlloy. They are available as TIG-wire.

ASSAB 718 HH is also available as coated electrode for MMA welding.

Cold work tool steel including precision ground flat stock, drill rod and hollow bar, plastic mould steel, die casting die steel and hot work steel.

We also offer laser welding wire for Nimax ESR, Nimax, Stavax ESR and Dievar.



The PET bottles are produced in two steps:

- First injection moulding of the preforms and then blow moulding of the preforms to the finished bottle.
- Stavax ESR is a recommended tool steel for production of the preforms.

PRODUCT PROGRAMME FOR PLASTIC MOULDING

ASSAB GRADE	CHARACTERISTIC / APPLICATION
ASSAB 618 T (WNr. 1.2738 modified)	ASSAB 618 T is a pre-hardened steel with a delivery hardness of 310 - 355 HB. Its high level of through-hardenability even for big dimensions over 1000 mm, coupled with its high impact toughness, makes ASSAB 618 T especially suitable for moulds with very large dimensions. ASSAB 618 T is ideally suited for large moulds for producing car bumpers, dashboards etc.
ASSAB 618 HH (WNr. 1.2738)	ASSAB 618 HH is a pre-hardened mould steel with good polishing and etching properties. It is suitable for a wide range of injection moulds, blow moulds and extrusion dies. ASSAB 618 HH is supplied at 340 - 380 HB.
ASSAB 718 HH (WNr. 1.2738)	ASSAB 718 HH is manufactured to consistently high-quality standards with very low sulphur content giving a steel with very good polishing and etching properties. ASSAB 718 HH is supplied at 340 - 380 HB. It is suitable for a wide spectrum of tooling application including injection moulds, blow moulds, extrusion dies and forming tools (possibly flame hardened).
Nimax ESR	A low carbon steel, delivery hardness ~380 HB. Excellent toughness, machinability and weldability. The ESR process also gives excellent polishability and etching properties.
Nimax	A low carbon steel, delivery hardness ~380 HB. Excellent toughness, machinability and weldability. Good polishing and etching properties.
Mirrax 40	A pre-hardened corrosion resistant mould steel supplied at ~380 HB with good machinability, very good toughness and excellent polishing properties.
Stavax ESR / Mirrax ESR (AISI 420, modified)	Through-hardening corrosion resistant mould steel with very excellent polishability.
Polmax (AISI 420, modified)	A through-hardening corrosion resistance mould steel with extremely good polishability.
Corrax	A precipitation hardening steel with exceptionally good corrosion resistance, easy heat treatment and good weldability.
AM Corrax	A precipitation hardening steel with extremely good corrosion resistance. Delivered as powder for additive manufacturing (AM) to be used in the same applications as conventional Corrax.
ASSAB 8407 Supreme (AISI H13, improved)	A versatile through-hardening 5% Cr mould and die steel with good wear resistance and polishability.
Vidar 1 ESR (AISI H11)	A 5% Cr mould and die steel with good through-hardening properties. Suitable for general hot work and plastic mould applications, specially large plastic moulds with requirements on high toughness in combination with very good polishability and texturing properties.
Unimax	A steel with very good hardenability, suitable for surface coating. The unique combination of toughness and wear resistance makes it suitable for long run moulding and moulding of reinforced plastics.
ASSAB XW-10 (AISI A2)	A through-hardening steel, recommended for very long production runs of smaller, complicated mouldings.

ASSAB GRADE	CHARACTERISTIC / APPLICATION
Elmax SuperClean Vanadis 4 Extra SuperClean Vandis 8 SuperClean	Powder metallurgically produced mould steels characterised by very good dimension stability, good polishability and wear resistance. Elmax SuperClean is corrosion resistant, Vanadis 4 Extra SuperClean has the highest toughness and Vanadis 8 SuperClean the best wear resistance. Recommended for long production runs of smaller and complicated shapes and/or abrasive plastics.
Vancron SuperClean	Vancron SuperClean is a nitrided powder metallurgical tool steel offering an excellent combination of galling resistance and adhesive wear resistance. The low friction properties can reduced problems with sticking of plastic to mould surface.
Ramax HH (AISI 420 F modified) RoyAlloy	Pre-hardened stainless holder steel with good machinability, high tensile strength and good corrosion resistance.
Coolmould (Copper Alloy)	A high strength copper mould alloy with high thermal conductivity. For applications like pinch off and neck rings for blow moulds, cores and inserts in injection moulds and injection nozzles and manifolds for hot runner systems.

CHEMICAL COMPOSITION

ASSAB grade	Typical Analysis %								Approx. supplied hardness, Brinell
	C	Si	Mn	Cr	Ni	Mo	V		
Mould Steels									
ASSAB 618 T	0.26	0.1	1.45	1.25	1.0	0.6	0.12		310 - 355
ASSAB 618 HH	0.37	0.3	1.4	2.0	1.0	0.2	-		340 - 380
ASSAB 718 HH	0.37	0.3	1.4	2.0	1.0	0.2	-		340 - 380
Nimax ESR / Nimax	0.1	0.3	2.5	3.0	1.0	0.3	-		380
Mirrax 40	0.21	0.9	0.45	13.5	0.6	0.2	0.25	+N	380
Corrax	0.03	0.3	0.3	12.0	9.2	1.4	-	Al 1.6	330
AM Corrax**	0.03	0.3	0.3	12.0	9.2	1.4	-	Al 1.6	-
Vidar 1 ESR	0.38	1.0	0.4	5.0	-	1.3	0.4		180
ASSAB 8407 Supreme	0.39	1.0	0.4	5.2	-	1.4	0.9		180
Stavax ESR	0.38	0.9	0.5	13.6	-	-	0.3		190
Mirrax ESR	0.25	0.3	0.5	13.3	1.3	0.3	0.3	+N	250
Polmax	0.38	0.9	0.5	13.6	-	-	0.3		190
Unimax	0.5	0.2	0.5	5.0	-	2.3	0.5		185
ASSAB XW-10	1.0	0.3	0.6	5.3	-	1.1	0.2		215
Elmax*	1.7	0.8	0.3	18.0	-	1.0	3.0		280
Vanadis 4 Extra*	1.4	0.4	0.4	4.7	-	3.5	3.7		230
ASSAB PM 23									
Vanadis 8*	2.3	0.4	0.4	4.8	-	3.6	8.0		≤ 270
Holder Steels									
Ramax HH	0.12	0.2	1.3	13.4	1.6	0.5	0.2	+N	340
RoyAlloy	0.05	0.4	1.2	12.6	-	-	-	+N + Cu	310

* ASSAB SuperClean PM tool steel ** Solutions treatment 850°C 30 minutes

PROPERTIES

ASSAB grade	ASSAB 618 T	ASSAB 618 HH	ASSAB 718 HH	Nimax	Mirrax 40	Corrax	Vidar 1 ESR	ASSAB 8407 Supreme	Stavax ESR	Mirrax ESR	Polmax	Unimax	ASSAB XW-10	Elmax	Vanadis 4 Extra +	ASSAB PM 23 +	Ramax HH	RoyAlloy
Approx. Hardness (HB) HRC+	(335)	(360)	(360)	(380)	(380)	46	48	52	52	52	52	58	59	58	62	62	(~340)	(~310)
Wear resistance	4	4	4	4	4	5	6	7	7	7	7	8	8	9	10	10	4	3
Toughness	9	8	8	10	6	7	8	6	5	6	5	6	3	4	5	4	3	4
Compressive strength	5	5	5	5	5	6	6	7	7	7	7	8	9	9	9	10	4	4
Corrosion resistance	2	2	2	2	7	10	3	3	8	9	8	3	2	6	2	2	7	7
Machinability**	5	4	4	5	6	4	9	9	8	7	8	7	5	3	4	3	7	7
Polishability	7	6	7	7	8	7	8	8	9	9	10	8	5	8	8	8	4	4
Weldability	6	6	6	7	5	6	4	4	4	4	4	4	2	2	2	2	6	6
Nitridability	6	6	6	5	-	-	10	10	-	-	-	8	6	-	8	8	-	-
Photo-etchability	8	7	8	8	8*	8*	9	9	8*	8*	8*	9	5	8*	8	8	3	3

+ ASSAB SuperClean PM tool steel * Special process required ** Tested in delivery condition

The properties of the main mould and holder steel grades have been rated from 1 to 10, where 10 is the highest rating. Such comparisons must be considered as approximate, but can be a useful guide to steel selection.

Note: It is not possible to make valid "total comparisons" between steel grades by adding their respective "points" — it is only intended that individual properties be compared.

MOULD STEEL SELECTION

GENERAL RECOMMENDATIONS

PROCESS / MATERIAL		ASSAB STEEL GRADES	HARDNESS HRC (HB)
INJECTION MOULDING	Thermoplastics	ASSAB 618 T	36 (~335)
	● Pre-hardened mould steel	ASSAB 618 HH	39 (~360)
		ASSAB 718 HH	39 (~360)
		Ramax HH	37 (~340)
		Mirrax 40	40 (~380)
		Nimax ESR	40 (~380)
		Nimax	40 (~380)
	● Through-hardened mould steel	Corrax	36 - 50
		Mirrax ESR	45 - 50
		ASSAB 8407 Supreme	45 - 52
		Stavax ESR	45 - 52
		Polmax	45 - 52
		Vidar 1 ESR	45 - 52
		Unimax	50 - 58
		Elmax *	56 - 60
		Vanadis 4 Extra *	58 - 64
		ASSAB PM 23 *	60 - 65
	Thermosetting plastics	Unimax	52 - 58
		Elmax *	56 - 60
		ASSAB XW-10	56 - 60
		Vanadis 4 Extra *	58 - 64
		ASSAB PM 23 *	60 - 65
COMPRESSIONS/ TRANSFER MOULDING	Thermosetting plastics	Mirrax ESR	45 - 50
		Stavax ESR	45 - 52
		ASSAB 8407 Supreme	45 - 52
		Unimax	52 - 58
		Elmax *	56 - 60
		Vanadis 4 Extra *	58 - 62
		ASSAB PM 23 *	60 - 65
BLOW MOULDING	General	ASSAB 618 T	36 (~335)
		ASSAB 618 HH	39 (~360)
		ASSAB 718 HH	39 (~360)
		Nimax	40 (~380)
	PVC	Corrax	36 - 50
		Ramax HH	37 (~340)
		Mirrax 40	40 (~380)
		Stavax ESR	45 - 52
		Mirrax ESR	45 - 50
EXTRUSION	General	ASSAB 618 T	36 (~335)
		ASSAB 618 HH	39 (~360)
		ASSAB 718 HH	39 (~360)
		Nimax ESR	40 (~380)
		Nimax	40 (~380)
	PVC	Corrax	36 - 50
		Ramax HH	37 (~340)
		Mirrax 40	40 (~380)
		Mirrax ESR	45 - 50
		Stavax ESR	45 - 52
		RoyAlloy	34 (~310)
HOLDER MATERIAL	High strength, pre-hardened, free-machining, plus corrosion resistance for low-maintenance production runs. Also for "hygienic" operating conditions. No plating required.	RoyAlloy	34 (~310)
		Ramax HH	37 (~340)

* ASSAB SuperClean PM tool steel

SPECIAL RECOMMENDATIONS

SPECIAL REQUIREMENT / DEMAND		ASSAB STEEL GRADES	HARDNESS HRC (HB)
LARGE MOULD SIZE	For automotive components, including panels, bumpers, fascias, etc.	ASSAB 618 T	36 (~335)
		Corrax	36 - 46
		Mirrax ESR	36 - 50
		ASSAB 8407 Supreme	36 - 50
		Vidar 1 ESR	36 - 50
		Mirrax 40	40 (~380)
		Nimax ESR	40 (~380)
		Nimax	40 (~380)
	As above, with low demands on surface finish	RoyAlloy	34 (~310)
		Ramax HH	37 (~340)
HIGH SURFACE FINISH	For moulding optical/medical parts, clear covers/panels	Nimax ESR	40 (~380)
		Mirrax 40	40 (~380)
		Mirrax ESR	45 - 50
		Stavax ESR	45 -52
		Polmax	45 - 52
		ASSAB 8407 Supreme	45 - 52
		Vidar 1 ESR	45 -52
		Unimax	54 - 58
		Elmax *	56 - 60
		Vanadis 4 Extra *	58 - 62
COMPLEX SHAPES	1. For large automobile / household components	ASSAB 618 T	36 (~335)
		ASSAB 618 HH	39 (~360)
		ASSAB 718 HH	39 (~360)
		Mirrax ESR	36 - 50
		Corrax	34 - 46
		Mirrax 40	40 (~380)
		Nimax ESR	40 (~380)
		Nimax	40 (~380)
		Vidar 1 ESR	36 - 50
	2. For small parts with low wear demands	ASSAB 618 HH	33 (~360)
		ASSAB 718 HH	39 (~360)
		Corrax	34 - 46
		Mirrax 40	40 (~380)
		Nimax ESR	40 (~380)
		Nimax	40 (~380)
	3. For small parts with high wear demands, e.g. electrical / electonic mouldings	Mirrax ESR	48 - 50
		ASSAB 8407 Supreme	50 - 52
		Stavax ESR	50 - 52
		Unimax	54 - 58
		Elmax *	56 - 60
		Vanadis 4 Extra *	58 - 64
		ASSAB XW-10	60 - 62
		ASSAB PM 23 *	60 - 65
		Vanadis 8 *	60 - 64
ABRASIVE MOULDING MATERIALS	Reinforced / filled moulding materials; engineering resins	Vidar 1 ESR	50 - 52
		Mirrax ESR	48 - 50
		ASSAB 8407 Supreme	50 - 52
		Stavax ESR	50 - 52
		Unimax	54 - 58
		Elmax *	56 - 60
		ASSAB XW-10	58 - 62
		Vanadis 4 Extra *	58 - 64
		Vanadis 8 *	60 - 64

* ASSAB SuperClean PM tool steel

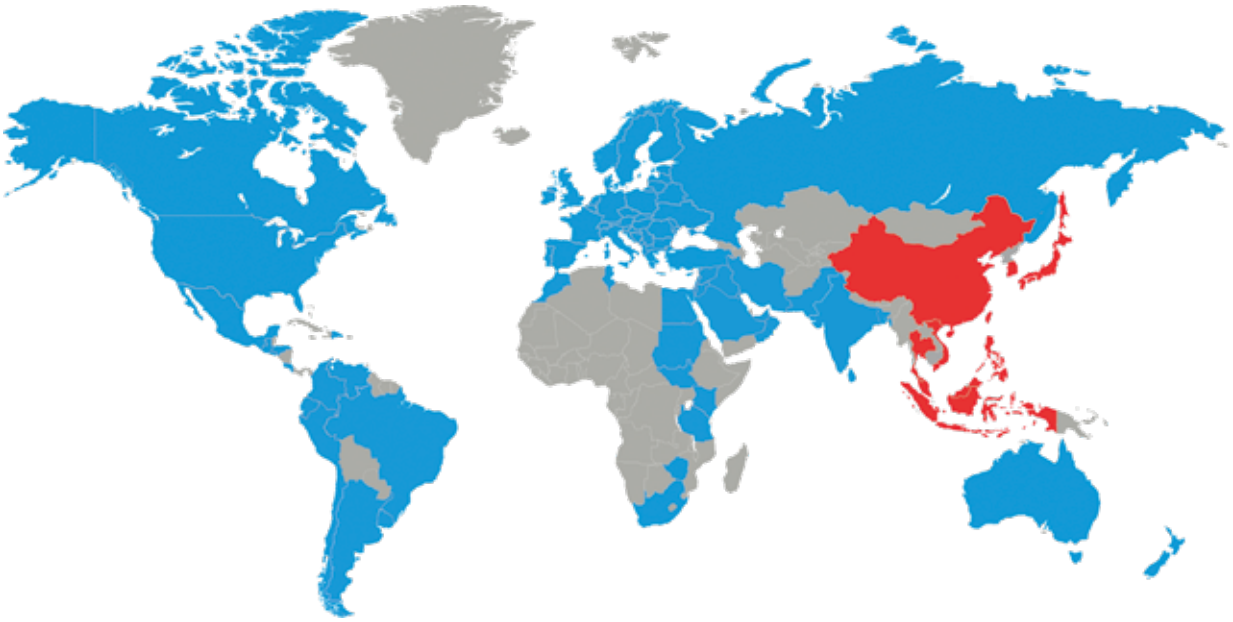
SPECIAL RECOMMENDATIONS

SPECIAL REQUIREMENT / DEMAND		ASSAB STEEL GRADES	HARDNESS HRC (HB)
LONG PRODUCTION RUNS	For thermoplastic parts, including disposable cutlery, containers and packaging	Mirrax ESR	45 - 50
		Stavax ESR	45 - 52
		ASSAB 8407 Supreme	45 - 52
		Vidar 1 ESR	45 - 52
		Unimax	54 - 58
		Elmax *	56 - 60
		Vanadis 4 Extra *	58 - 64
CORROSION RESISTANCE	1. For corrosive moulding materials, including PVC 2. For humid moulding / mould storage conditions 3. General resistance to surface staining / rusting 4. Resistance to corrosion of cooling channels	Corrax	34 - 50
		RoyAlloy	34 (~310)
		Ramax HH	37 (~340)
		Mirrax 40	40 (~380)
		Mirrax ESR	45 - 50
		Stavax ESR	45 - 52
		Elmax *	56 - 60
PHOTO-ETCHING	1. Pre-hardened mould steels	ASSAB 618 T	36 (~335)
		ASSAB 718 HH	39 (~360)
		Mirrax 40	40 (~380)
		Nimax ESR	40 (~380)
		Nimax	40 (~380)
	2. Through-hardened steel	Mirrax ESR	45 - 50
		ASSAB 8407 Supreme	45 - 52
		Vidar 1 ESR	45 - 52
		Stavax ESR	45 - 52
		Unimax	54 - 58
		Elmax *	56 - 60
		Vanadis 4 Extra *	58 - 64
		ASSAB PM 23 *	60 - 65
HIGH THERMAL CONDUCTIVITY	For injection and blow moulds, cores and inserts; parts for hot runner systems	Coolmould	~40

* ASSAB SuperClean PM tool steel

ASSAB
SUPERIOR TOOLING SOLUTIONS
A ONE-STOP SHOP

ASSAB is unmatched as a one-stop product and service provider that offers superior tooling solutions. In addition to the supply of tool steel and other special steel, our range of comprehensive value-added services, such as machining, heat treatment and coating services, span the entire supply chain to ensure convenience, accountability and optimal usage of steel for customers. We are committed to achieving solutions for our customers, with a constant eye on time-to-market and total tooling economy.



Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. ASSAB not only supplies steel products with superior quality, we offer state-of-the-art machining, heat treatment and surface treatment services to enhance steel properties to meet your requirement in the shortest lead time. Using a holistic approach as a one-stop solution provider, we are more than just another tool steel supplier.

ASSAB and Uddeholm are present on every continent. This ensures you that high quality tool steel and local support are available wherever you are. Together we secure our position as the world's leading supplier of tooling materials.

For more information, please visit www.assab.com

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