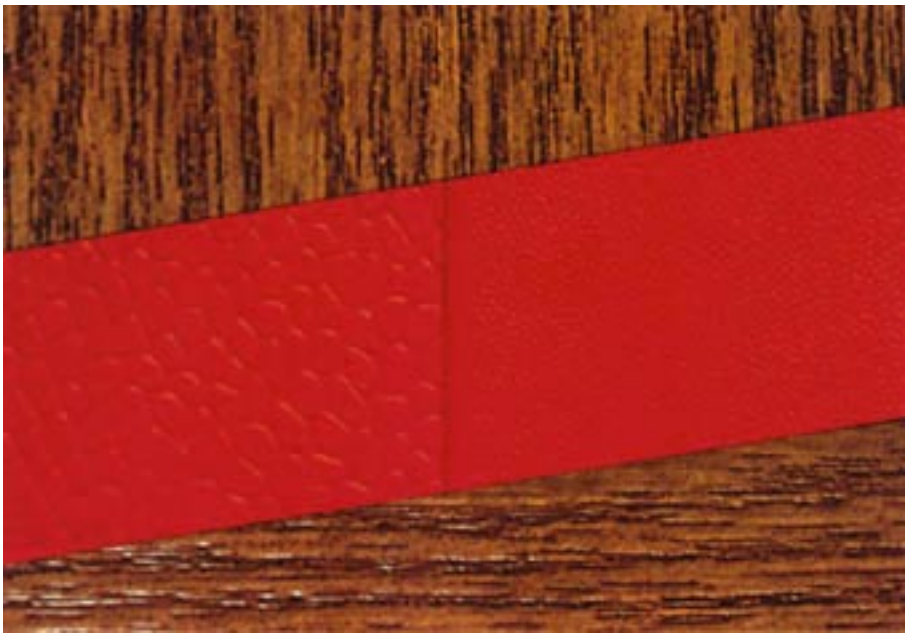


PHOTO-ETCHING OF TOOL STEEL

UDDEHOLM

Wherever tools are made
Wherever tools are used

Introduction

A wide variety of moulded parts are produced with a patterned or textured surface. Normally, the pattern is reproduced on the moulding surfaces of the tool by the photo-etching process.

The photo-etching process

Published information about the techniques employed by the specialist photo-etching companies is very limited. Essentially, however, the required pattern is transferred to the moulding surface by a photographic process. The pattern is then etched to the required depth by the application of an appropriate acid, under closely controlled condition.

Photo-etching can be performed both on complete tools or on specified areas of the tool only.

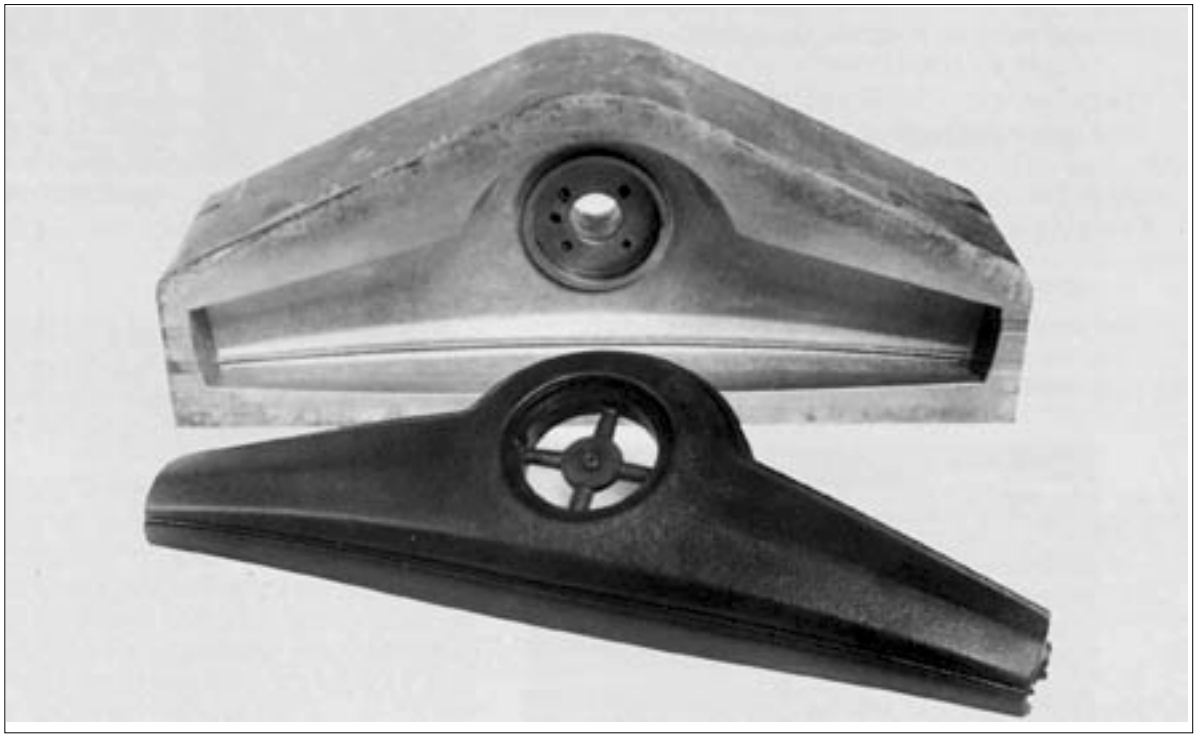
Photo-etching enables a wide variety of different patterns to be produced in virtually any tool. The patterns may resemble leather or wood graining, for example, or be a straight forward line pattern with varying directions and depths. Typical applications are for car interior fittings, etc., and plastic casings for different kinds of machines and instruments. In recent years, photo-etching has become an increasingly popular and practical method for imparting attractive and appealing surfaces to different products.

Advantages of textured surfaces

A textured surface hides minor surface flaws which may occur in manufacture or during further treatment and fitting. Because of this, the rejection rate for the finished products is lower. Moreover, photo-etching replaces the lengthy and expensive finish polishing process.

The product is given an aesthetically attractive surface finish. The surface is easier to grip than a bright surface, which facilitates holding and handling. Irritating reflections are largely avoided. A further advantage is that finger prints and similar marks do not show up as much as on a bright surface.

This brochure deals with photo-etching as a finishing process, with the possibilities offered by it and with the factors which must be taken into account to ensure a satisfactory result. These factors were determined by a test programme carried out with the cooperation of a leading photo-etching company.



Textured mould and moulded part for automobile steering wheel.

Test programme

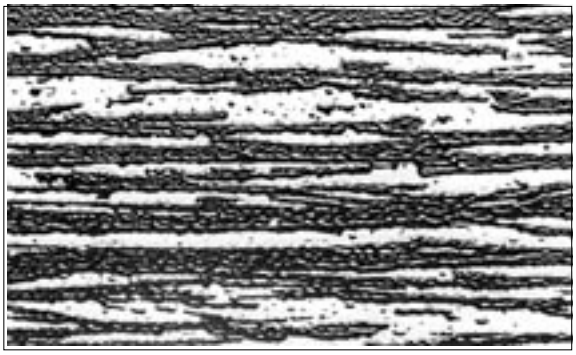
To ensure that the toolmaker and the tool-user gets the optimum results from Uddeholm tool steels that are photo-etched, Uddeholm Tooling has carried out a series of tests. The test programme examined a number of influencing factors, including:

- Photo-etching of different tool steel grades, annealed and hardened.
- Flame-hardening, welding and EDM.
- Grain flow direction of the tool steel.
- Variations in steel analysis and cleanliness.
- Material size.

Several different tool steels were studied, by etching plates measuring 50 x 60 mm (2" x 2 1/4"). All surfaces were ground with a 280-grain grinding wheel. In one set of tests, all the specimens were etched under identical conditions in order to grade the "etchability" in terms of the amount of stock removed from the different material. After this, etching conditions were varied with the aim of producing optimum etching results.

The steels listed below have been examined in the first instance as longitudinal specimens (in the rolling direction of the material) in the soft-annealed state and also according to the parameters shown in the chart.

Uddeholm grade	AISI	Other parameters studied
RIGOR	A2	Hardness: 60 HRC High retained austenite content.
CALMAX		Hardness: 57 HRC
ORVAR SUPREME	H13	Hardness: 52 HRC Rough- and fine-spark-machined.
IMPAX SUPREME	P20	Analysis variation. Flame-hardened to 54 HRC. Surface and centre of large dimension. Welded with IMPAX electrode.
STAVAX ESR	420	Hardness: 300 HB 55 HRC Welded with STAVAX electrode.
ELMAX		Hardness: 58 HRC



Photograph of a patterned surface.

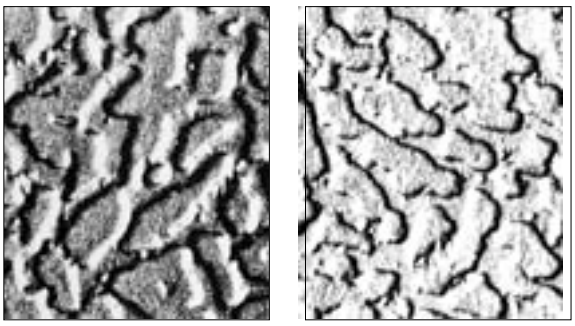
PHOTO-ETCHING OF DIFFERENT STEEL GRADES

Results

The etching results were assessed taking into account the etching depth, pattern similarity, side-etching effect and surface appearance. The surfaces have not only been visually appraised but also examined at a high magnification in order to detect and study any microscopic differences.

Annealed material

Depending on the type of etching method used, a special etching media may be needed when etching steels with good corrosion resistance. This is valid for *STAVAX ESR* and *ELMAX*. However, owing to its alloy content also *ORVAR SUPREME* and *CALMAX* gives weaker etching than other grades when the standard media is used and in view of this the special media is recommended.



Soft-annealed *Hardened to 55 HRC*

STAVAX ESR textured with special media.

The other steels examined show good results upon visual examination after having been etched by the standard process. When the surfaces are examined under the microscope (9 x magnification), some minor differences can be observed.

The observed differences normally have no practical significance. They nevertheless show that if a tool with inserts which are to be etched with the same pattern is being made it is advisable for material from the same bar or block to be used in all parts in order to get a pattern of identical and uniform appearance on the moulding. (See "Grain flow direction of the tool steel", page 6.)

Hardened material

All grades were examined in the fully hardened condition. Here, too, the four grades *ORVAR SUPREME, CALMAX, STAVAX ESR* and *ELMAX* differ from the others in respect of etchability.

When the surfaces are studied under the microscope, some tendency to streakiness is discernible in some of the hardened specimens. The streaks are parallel to the direction of rolling, and the phenomenon is an expression of the normal rolling direction which appears in alloyed tool steels. The streakiness, however, is of such modest proportion that it lacks significance when using tool steels with normal degrees of segregation, but at the same time it demonstrates the importance of selecting a steel that is as homogeneous and uniformly worked as possible.

The presence of a high content of retained austenite in a hardened tool is normally a disadvantage. Etchability, however, is not affected even by a relatively high content of retained austenite according to a test performed on *RIGOR*.

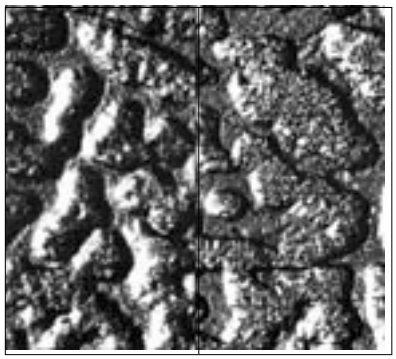
Nitrided material

When a tool or insert is to be nitrided, this must be done after photo-etching.

Flame-hardened material

The influence of flame-hardening on the etching of *IMPAX SUPREME* was also studied and here there is a decided difference between the locally hardened zone and the hardened and tempered basic material. In the flame-hardened zone, a faint streakiness similar to that in hardened specimens is discernible. In addition, there is a difference in etching depth between flame-hardened and hardened and tempered material.

Flame-hardening, therefore, should be carried out after photo-etching, wherever possible.



Basic material. *Flame-hardened zone.*

Welding

In certain circumstances it may be necessary to weld a tool, for instance for repair purposes. Welding always severely affects the uniform structure of the parent material.

The weld metal and the base steel must be similar in composition if a welded surface of a plastic mould is to be textured via photo-etching. If not, the response to etching will vary between the weld and the base metal and this will result in a witness mark on the plastic component. Welds in *IMPAX SUPREME, STAVAX ESR* and *CALMAX* with IMPAX WELD, STAVAX WELD or CALMAX WELD (or TIG-WELD) will normally not be discernible after photo-etching.

More information on welding is given in the brochure "Welding of Tool Steel".

Areas which have been welded should always be clearly indicated to the photo-etching company.

Electrical discharge machining (EDM)

If EDM is not carried out in the right way, some defects may remain in the surface of the material. The influence of spark-erosion on photo-etchability has therefore been studied. Specimens with both a rough-sparked and a fine-sparked surface were tempered at 250°C (480°F). Photo-etching on a rough-sparked surface gives a very poor result. Even after a careful fine-sparking operation, it may be difficult to get an acceptable result.

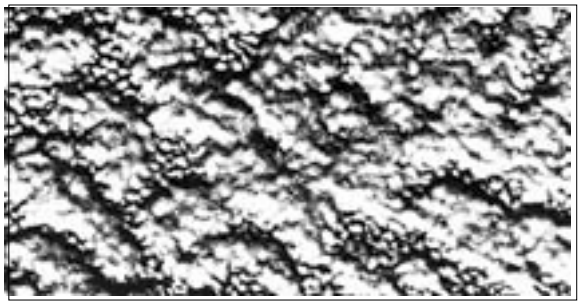


Photo-etching on a rough-sparked surface.

Tempering does not give an appreciable improvement. If doubts are entertained as to how the spark-machining has been carried out the material should always be ground or polished to remove any residual traces of the sparking. Special test kits are available for checking removal of residual effects after spark-erosion.

Areas which have been spark-eroded should be clearly indicated to the photo-etching company.

Grain flow direction of the tool steel

CALMAX has been examined on both the lengthwise and crosswise direction in the soft-annealed state. No appreciable difference between the specimens was observed. For fine patterns, however, experience shows that some difference can occur. Where it is important that photo-etched patterns on different mould parts match exactly, e.g. when using inserts, the following procedure is strongly recommended:

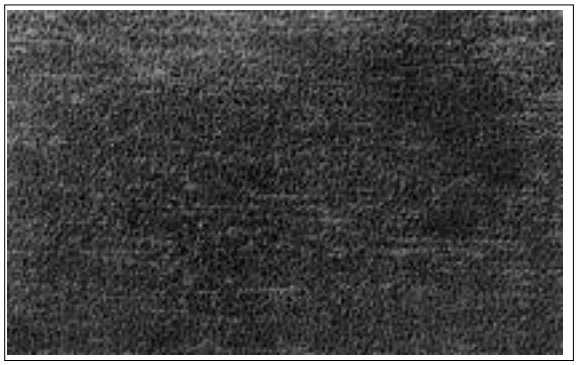
1. Make **all** parts to be textured from the same bar or block of steel.
2. Make sure that all surfaces to be textured have the longitudinal grain flow in the same direction.

VARIATIONS IN STEEL ANALYSIS AND CLEANLINESS

There are always minor differences in the analysis of every steel to occur from one heat to another. In this context, two extremes in the analysis of *IMPAX SUPREME* were examined, but no differences in the results of the etching were observable. Normal variations in analysis of Uddeholm Tooling tool steels thus have no influence on photo-etchability.

The cleanliness of the steel, and especially its sulphur content, can affect the appearance of photo-etched patterns. *IMPAX SUPREME* prehardened mould steel is particularly suitable for photo-etching for two reasons: it has a very clean microstructure, being subjected to a vacuum degassing process during manufacture; it also has a very low sulphur content (max. 0,010%).

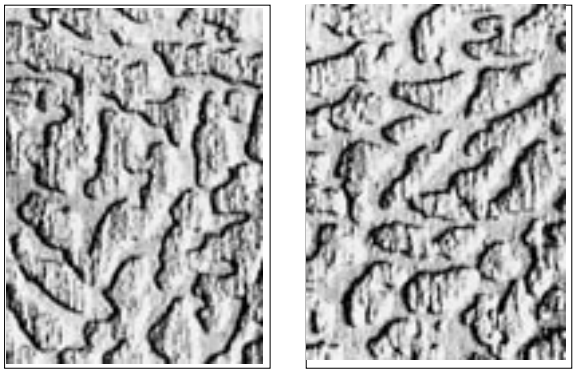
There are, however, similar types of steels with far higher sulphur contents (0,08%), which can give rise to streakiness in photo-etching, as evident from he following photograph.



The photograph shows streakiness in photo-etching of a pre-hardened mould steel with high sulphur content.

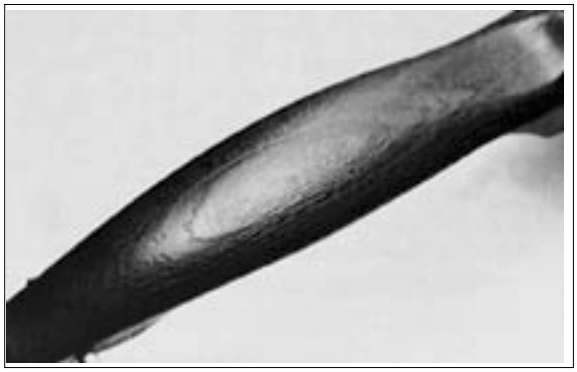
MATERIAL SIZE

When manufacturing materials in heavy sections differences in the microstructure of the material can be observed between the surface and the centre. In order to study the influence of these differences on the photo-etchability of *IMPAX SUPREME* in the size 500 mm (20") dia., specimens from the surface and centre were photo-etched.



Surface. *Centre.*
IMPAX SUPREME Ø 500 mm (20").

No difference between the two specimens was observable.



A wood-grain texture on a moulded handle for a sauce-pan.

Summary

Several different grades of Uddeholm Tooling tool steels have been tested for photo-etchability. The results of the etching tests and other experience gained can be summarized as follows:

- All of the grades eamined can be photo-etched with satisfactory results. There are certain microscopic differences, but these normally have no practical significance whatsoever.
- *ORVAR SUPREME, CALMAX, STAVAX ESR* and *ELMAX* should be etched by a special process.
- If nitriding is to be carried out it must be done after photo-etching.
- Flame-hardening prior to photo-etching should be avoided, since the pattern will be etched differently in the flame-hardened zone and in hardened and tempered base material.
- A welded tool can in certain circumstances be photo-etched, but this is conditional upon using the same material in the weld as in the parent material.
- Spark-machined surfaces should be ground or polished in order to be on the safe side. A poor etching result will be obtained on surfaces marred by residual traces of spark-machining.
- Areas of tools which have been flame-hardened, welded or spark-eroded should always be clearly indicated to the photo-etching company.
- If several parts are included in a tool and are to be photo-etched with exactly the same pattern, the same grade of material and the same grain flow direction should be chosen for all the parts.
- Normal variations in analysis for the same grade of steel have no adverse influence. Steels with a clean microstructure and low sulphur content give the most accurate and consistent pattern reproduction.
- Different sizes of starting material of one and the same grade do not usually show any differences.
- Initial machining operations should be followed by stress-relieving prior to finish-machining.
- Coarser abrasives than 220 grain must not be used on surfaces which are to be photo-etched.

Part of an automobile steering wheel produced from a photo-etched IMPAX SUPREME mould.

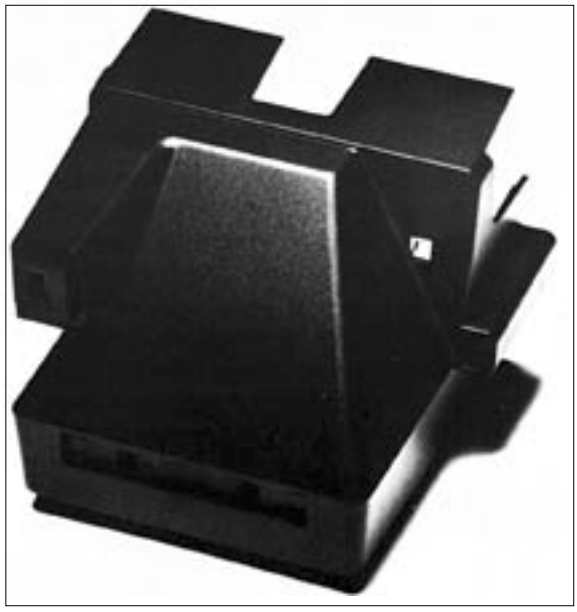


Photo-textured body for Polaroid instant camera. Mould material: STAVAX ESR.