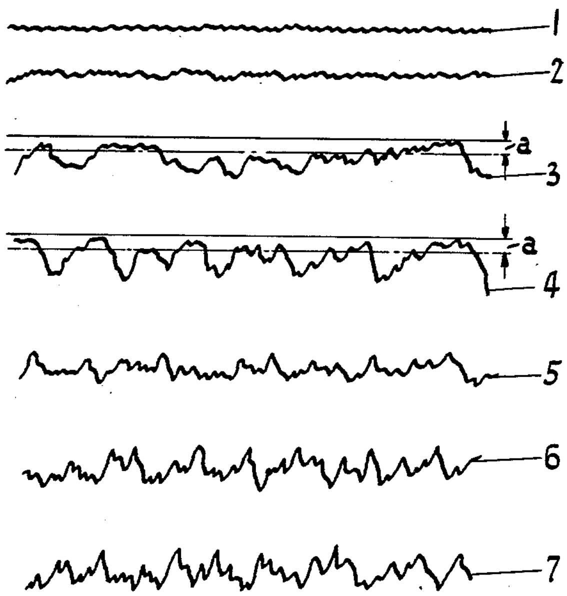
HEAT TREATMENT FOR THE PRODUCTION OF A LOW CARBON STEEL SUITABLE FOR DEFORMATION WITHOUT CUTTING

Filed March 6, 1961 2 Sheets-Sheet 1

FIG.1.



	R_{max}		R_a	
	μ	μ(inch)	μ	μ(inch)
1	1,6	64	0,3	11
2	2,5	100	0,5	21
3	7,8	312	1,6	64
4	8,7	348	1,9	78
5	6,2	248	1,0	40
6	8,2	328	0,9	37
7	8,9	356	1,2	48

FIG.2.

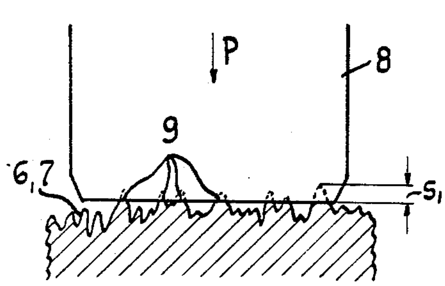
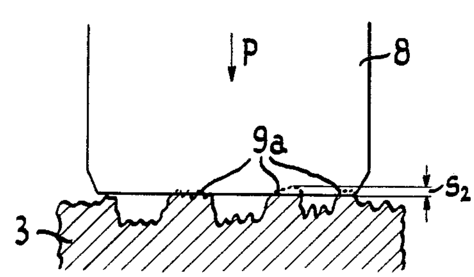


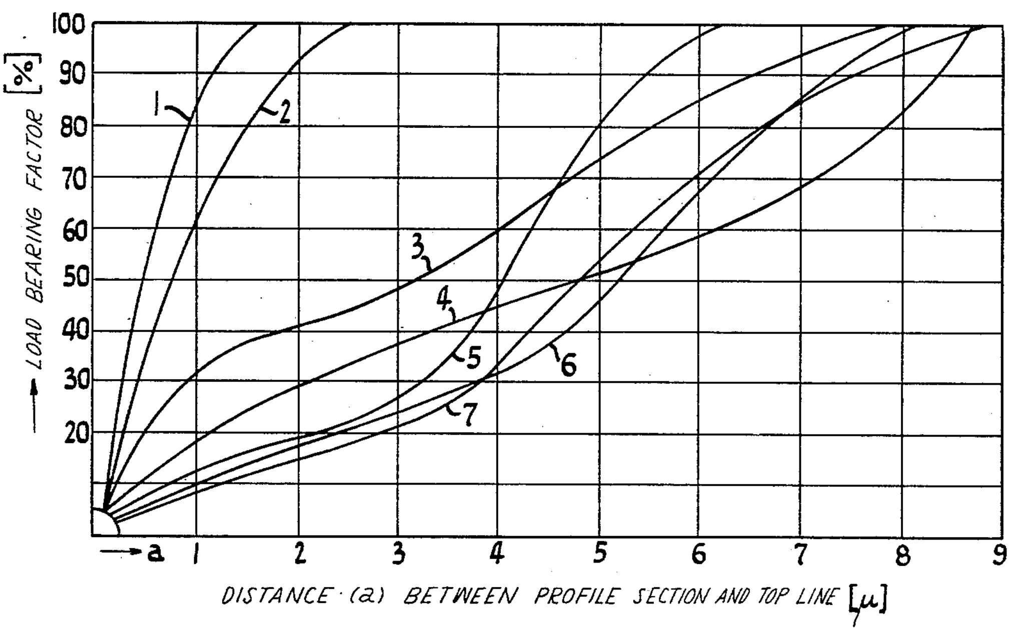
FIG.3.



INVENTORS
KARLHEINZ SCHMITT-THOMAS
FRITZ FISCHER
BY VINCENZ SEUL

Woodhams Blanchard and Flynn
ATTORNEYS

FIG.4.



INVENTORS.
KARLHEINZ SCHMITT-THOMAS
FRITZ FISCHER
BY VINCENZ SEUL

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ATTORNEYS

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HEAT TREATMENT FOR THE PRODUCTION OF A LOW CARBON STEEL SUITABLE FOR DEFORMATION WITHOUT CUTTING

Fritz Fischer, Irlich, Karlheinz Schmitt-Thomas, Mainz (Rhine), and Vincenz Seul, Andernach (Rhine), Germany, assignors to Rasselstein Aktiengesellschaft, Neuwied (Rhine), Germany, a corporation of Germany

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The continuously increasing demands that are made in respect of the capability of sheet metal for being worked in deep drawing and pressing operations make it necessary for the manufacturer to examine by test all suitable ways of making the material suit the said demands.

In the case of sheet metal intended for deep drawing or stamping or pressing the following features are regarded as particularly significant for qualified working:

(1) Analysis (carbon content, degree of purity and elements added to prevent ageing).

(2) Grain size and grain shape.

(3) Yield point (numerical value and in particular development of the yield point range).

In addition, however, the influence of the microsurface on the deep drawing procedure has been recognised to an increasing extent. In unfavourable cases this influence can be so great that with other optimal properties prescribed qualified deep drawing is hardly possible.

Up to the present time attempts have been made to relate a picture of the surface profile obtained by feeling and recording and measurements obtained therefrom (roughness value) to the subsequent course of events in deep drawing. In practice this led to conflicting opinions and to results which were variable and could not be reproduced. An explanation of this state of affairs is to be found in an analytical consideration of the friction effects which occur in deep drawing.

Summarising, the mechanism of the friction is as follows:

(1) The two bodies that are in contact in deep drawing penetrate so far into one another under suitable pressure that suitably loaded points of the two surface profiles provide static equilibrium.

(2) Upon the subsequent application of a horizontal force they are finally shifted relatively to one another. The forces necessary for this are composed of shearing forces which are occasioned by the mutual shearing action of contacting and inter-engaging points, and of cutting forces which arise from the drawing of one surface through the other. With this there is associated a further inter-penetration of the two contacting bodies.

The action of the micro-surface on the drawing operation is composed of the following components:

(1) The shape and composition of the surface and the behaviour specifically associated with this geometry.

(2) The mechanical properties, especially strength, hardness and yield point of the loaded points which in deep drawing determine the following features:

(*a*) The extent of penetration of the surface of a tool acting on the surface of the work material under the influence of forces due solely to pressure;

(*b*) The magnitude of the horizontal force which when sliding occurs is composed of shearing and cutting forces.

Exhaustive experiments have shown that for the purpose of shaping without cutting, in particular for the deep drawing of the best suited materials there is required a quite definite surface characteristic, which forms the basis of the present invention. This surface characteristic is determined not only by the geometrical form of the surface profile but also by the technological properties thereof. It was found that the surface best suited for shaping without cutting, especially by deep drawing, must have a characteristic having the following features:

(1) The geometrical form and composition of the surface profile must comprise as large a number as possible at uniformly distributed narrow peaks such that with increasing distance of the profile section from the envelope the increase in the load-bearing portion (fraction) is relatively small.

(2) The material of the surface profile must have such a good capability for deformation, i.e., must have suitably low values of yield point, strength and hardness, such that at the pressure employed the tool penetrates relatively deeply into the surface profile, this pressure is taken up by a plurality of substantially uniformly distributed peaks which are flattened by the deformation, and the forces required for drawing the two surface profiles under pressure one through the other are relatively small.

It follows from this surface characteristic that not only is a definite roughness of the surface, which was previously regarded as essential, of decisive importance for the deep drawing procedure, but that in addition to a definite geometric profiling of the surface the technological properties are essential.

In the process according to the invention substantially only the surface profile is treated, without affecting the underlying material, so that this surface profile becomes more suitable for deformation due to reduction in hardness, strength and yield point. This treatment may advantageously be effected by subjecting the surface profile and, if desired, the layer which is bounded by the surface profile, to a short heat treatment such that the heat penetrating into the underlying material causes no change therein. In order to avoid such influencing of the underlying material this heat application may advantageously be effected by using inductive heating at suitable high frequency and in certain cases also by high frequency resistance heating. For example, the desired effect on the surface profile can be produced by high frequency inductive heating with a frequency value of 0.5 megacycle and a high frequency power of 30 kilowatts, the duration of treatment being from 0.01 second to 0.1 second. The effects can be verified by X-ray analysis. These results were obtained with a soft sheet metal, that is, low carbon steel, for deep drawing of 0.01182 inch (0.3 mm.) to 0.01965 inch (0.5 mm.) thickness. In order to improve the capability of deformation further there may be effected simultaneously with the heat application decarbonising and/or denitrogenising of the surface profile in a reducing atmosphere.

The results or advantages of the process according to the invention will now be explained with reference to the accompanying drawing, in which

FIG. 1 shows seven various surface profiles with corresponding maximum roughness value R_{max} and mean arithmetic roughness value R_a,

FIGS. 2 and 3 show two different surface profiles with a tool or punch in contact with them, and

FIG. 4 shows curves related to the load-bearing portions of the profiles shown in FIG. 1.

If a tool with a smooth surface is brought under pressure into contact with the profile 1, 2 or 3 of FIG. 1, then the tool surface will immediately meet with large contact surfaces and upon increase of the pressure of application will sink only slightly with a further enlargement of the surface elements that are in contact. These profiles 1 to 3 are therefore unsuitable for deep drawing, having regard to the surface characteristic referred to above, since folds may form or the material may tear.

The surface profiles 5, 6 and 7 show a plurality of substantially uniformly distributed slender peaks. For the same technological properties as the profiles 1, 2 and 3 the surface of a tool which is brought into contact with the profiles 5, 6 and 7 meets with peaks at a relatively large number of places which peaks when the pressure on application is increased flatten out and permit the surface of the tool to sink further into the profile with a corresponding enlargement of the load-bearing surface elements. This is shown by FIG. 2. It is apparent that the tool 8 sinks relatively deeply into the surface profile which corresponds say to the profile 6 or 7 i.e., by the amount s_1, the load-bearing surface elements 9 being approximately uniformly distributed over the surface. In contrast, the extent of penetration s_2 in the case of the surface profile shown in FIG. 3, which may correspond to the profile 3 of FIG. 1, is relatively small since the applied tool 8 immediately encounters large load-bearing surface elements 9*a* which in accordance with the nature of this profile are less uniformly distributed over the whole surface.

The distances of penetration s_1, s_2 shown in FIGS. 2 and 3 correspond in FIG. 1 to the distance *a* between profile section and envelope. FIG. 4 shows the load-bearing fraction in relation to this distance *a*.

The curves 1 to 7 correspond to the profiles 1 to 7 shown in FIG. 1. FIG. 4 shows that in the case of the surface profiles 1 and 2 with a small distance *a*, i.e., with low penetration of the tool, the load-bearing fractions are high, whereas in the case of the profiles 5, 6 and 7 the same load-bearing fractions are obtained only for an appreciably large distance *a*, that is to say with a longer distance of penetration. According to FIG. 4 therefore, the profiles 5 to 7 have the above-described desired surface characteristic, since with increasing distance of the profile section from the envelope the increase in the load-bearing fraction is relatively small.

From the foregoing explanations it will be appreciated that the surface profiles 5 to 7 shown by way of example in FIG. 1 correspond to the geometrical component of the surface characteristic mentioned. These surface profiles which are the most suitable for deep drawing cannot always be produced in practice because due to wearing of the rollers employed for the final rolling of the sheet or again due to unfavourable flow of sand during sand blasting surface profiles are produced which correspond for example to the profiles 3 and 4 of FIG. 1.

These profiles which in themselves are unsuitable can now be made suitable for deep drawing by using the process according to the invention, i.e., by improvement of the profile. On the other hand a material which is less suitable for deep drawing because of its unsuitable mechanical properties, e.g., too great hardness, strength and too high yield point, can, by using the process according to the invention, be given a surface characteristic which makes it suitable for use for qualified deep drawing.

It is further to be noted that sheet metal for deep drawing has its surface profile imparted to it by the final rolling operation. This causes strengthening of the surface profile, viz., a raising of the yield point and an increase in the hardness and strength of the surface profile relative to the underlying material, so that this rolling operation impairs the surface characteristic (component 2 of the above-mentioned characteristic). If now the process according to the invention is used then not only is the strengthening of the surface that was caused by the rolling operation above but in some cases the surface profile has its capability for deformation increased and improved relative to the underlying material.

From the foregoing it will be seen that when using the process according to the invention there is obtained an improvement in profile which in all cases improves its suitability for deep drawing, i.e., deep drawing sheets of the most varied surface profiles can be used. If however it is desired to obtain an optimum surface characteristic then in accordance with the invention the surface profile to be subjected to the profile improving operation should be so geometrically formed and composed that as large a number as possible of uniformly distributed slender peaks are formed of such kind that as the distance of the profile section from the envelope increases the increase in the load-bearing fraction is relatively small. If therefore there are employed surface profiles such as are illustrated by way of example in FIG. 1 at 5 to 7, and if furthermore by using the profile improving process according to the invention the capability for deformation of this surface profile becomes outstanding, then an optimum surface characteristic is obtained.

When using a material which exhibits such an optimal surface characteristic it is then possible to manufacture difficult deep drawing parts more easily than before, also to save working steps and also to attain working speeds which previously were not attainable. As is generally realized the surface profile of sheet metal is obtained as a negative impression of the roller surface during the final rolling operation. In order to obtain a negative impression corresponding to the surface profiles 5–7 in FIG. 1 the rollers must be accordingly treated with a blasting material. To obtain these surface profiles a blasting material consisting of relatively fine and small grains is required, this material being projected on the roller surface at a high speed, i.e., with a high kinetic energy.

The treatment of the material suitable for deformation without cutting, in particular for deep drawing, in accordance with the invention can be effected not only by the action of heat but if desired in other ways, e.g., by chemical treatment of the surface profile.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process for treating a sheet of low carbon steel so as to make it suitable for deformation without cutting, particularly by deep drawing and pressing operations, which comprises: subjecting the sheet steel to high frequency, induction heating for a period of time not substantially in excess of 0.1 second so that the heating effect is confined substantially to the surface profile of the sheet steel whereby the hardness, strength and yield point of the surface profile are lowered and the remainder of the sheet steel is substantially unaffected.

2. A process for treating a sheet of low carbon steel so as to make it suitable for deformation without cutting, particularly by deep drawing and pressing operations, which comprises: providing sheet steel having a surface profile composed of as large a number as possible of uniformly distributed, slender peaks; subjecting the sheet steel to high frequency induction heating, the induction heating being carried out at a frequency of about .5 megacycle, at a power of about 30 kilowatts for from about 0.01 second to 0.1 second, so that the heating effect is confined substantially to the surface profile of the sheet steel whereby the hardness, strength and yield point of the surface profile are lowered and the remainder of the sheet steel is substantially unaffected.

3. A process for treating a sheet of low carbon steel so as to make it suitable for deformation without cutting, particularly by deep drawing and pressing operations, which comprises: providing sheet steel having a surface profile composed of as large a number as possible of uniformly distributed, slender peaks, the maximum roughness value of the surface profile being between 6.2 and 8.9 microns and the mean arithmetic roughness value of the surface profile being between 0.9 and 1.2 microns; subjecting the sheet steel to high frequency induction heating for a period of time not substantially in excess of 0.1 second so that the heating effect is confined substantially to the surface profile of the sheet steel whereby the hardness, strength and yield point of the surface profile are lowered and the remainder of the sheet steel is substantially unaffected.

4. A process for treating a sheet of low carbon steel so as to make it suitable for deformation without cutting, particularly by deep drawing and pressing operations,

which comprises: providing sheet steel having a surface profile composed of as large a number as possible of uniformly distributed, slender peaks; subjecting the sheet steel to high frequency induction heating for a period of time not substantially in excess of 0.1 second so that the heating effect is confined substantially to the surface profile of the sheet steel whereby the hardness, strength and yield point of the surface profile are lowered and the remainder of the sheet steel is unaffected.

5. A process according to claim 4 in which the induction heating is carried out at a frequency of about .5 megacycle and at a power of about 30 kilowatts for a time period of from 0.01 second to 0.1 second.

References Cited in the file of this patent

UNITED STATES PATENTS

2,679,466	Spendelow el al.	May 25, 1954
3,099,592	Garber	July 30, 1963