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ROLL TEXTURING BY ELECTRONIC DISCHARGE TEXTURING MACHINES "EDT" AND SUPERFINISHING UNIT[1]

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Abstract
Automobile manufacturers demand a certain surface roughness on the sheet in order to have smooth deep-drawing and painting operation. Deep-drawing requires a coarse structure whereby oil pockets are formed to prevent the metal sheet from 'cold welding' to the die shoe tool. Painting requires a fine structure to achieve a surface finish with a high quality; on the other hand lacquering requires a defined roughness to have an excellent cling to the sheet. In addition to these requirements the costs for rolls are increasing but with the Superfinishing Unit it is possible to increase the life time of the rolls and to improve the surface quality as well as to reduce the cost due to a longer life time of the rolls. A generator switches on the erosion impulse. The conducting particles in the dielectric oil form a dipolar bridge which produces intermittent charge of current to be passed onto the roll. A bowl shaped particle is brought to its melting point and a gaseous by product bubble is formed at the discharge duct area. After the erosion impulse is completed, the discharge duct collapses and the melted particle is expelled. A through-shaped surface structure remains. Comparing the shot blasting and EDT methods with regard to the distance of peaks from one another, EDT is significantly higher. Furthermore the Superfinishing Unit, which does not change the geometry of the roll, cut off only the highest peaks. This process based on the honing process and the stock removal is only a few microns. The texturing process results can be programmed and reproduced with great regularity and narrow tolerances. Comparing the shot blasting and EDT methods with regard to the distance of peaks from one another, EDT is significantly higher. The texturing tolerance of the preselected roughness is: From 0.5 Ra to 3.5 Ra ± 4 %; From 3.5 Ra to 8.0 Ra ± 5 %; From 8.0 Ra to 15 Ra ± 5 %. Surface qualities with an average coefficient of roughness Ra between 0.5 and 15.0 micrometers and 240 to 25 peaks per cm (Pc) can be achieved. In combination with the Superfinishing Unit the EDT-machine allows particularly the reduction of roll changes in the mill as well as constant roughness of the sheet during the rolling process.
Key words: Texturing; Superfinishing; Surface; EDT.

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1 INTRODUCTION

Automotive cold rolling flat products need special grades and production applications in the cold milling process. Common customer specifications are often limited to width, thickness, metallurgical grade and surface quality. Up to 80 % of all flat products for the automotive industry will be galvanized after finish rolling. The below mentioned table is an example for the requirements of the automotive industry regarding O3 and O5 sheet whereupon O3 sheet for inside panels and O5 sheet for outside panels are used.

Table 1. Example for the requirements regarding the characteristics of sheet for automotive

Quality	Grade	Dimension	Roughness Ra	Peaks
O5 sheet (outside panel)	IF	0.5 … 0.8 mm	1.1 … 1.5 µm	≥ 60 Pc/cm
O3 sheet (inside panel)	ZSTE	0.6 … 1.0 mm	1.3 … 1.7 µm	≤ 50 Pc/cm

The influence of the total cold rolling process relies on these specific tolerances and starts in the tandem mill (Figure 1) where either four or five pairs of work rolls are in contact with the strip surface.
This indicates that a sufficient work roll surface is necessary for high quality flat products in the automotive industry. In the cold rolling process, the work rolls in the different stands of the tandem mill and in the final skin pass mill are in contact with the strip several times. Therefore, it is necessary to prepare them to the highest standards in profile and surface quality. If the work rolls develop surface defects or lose their profile during the rolling process, they must be replaced.

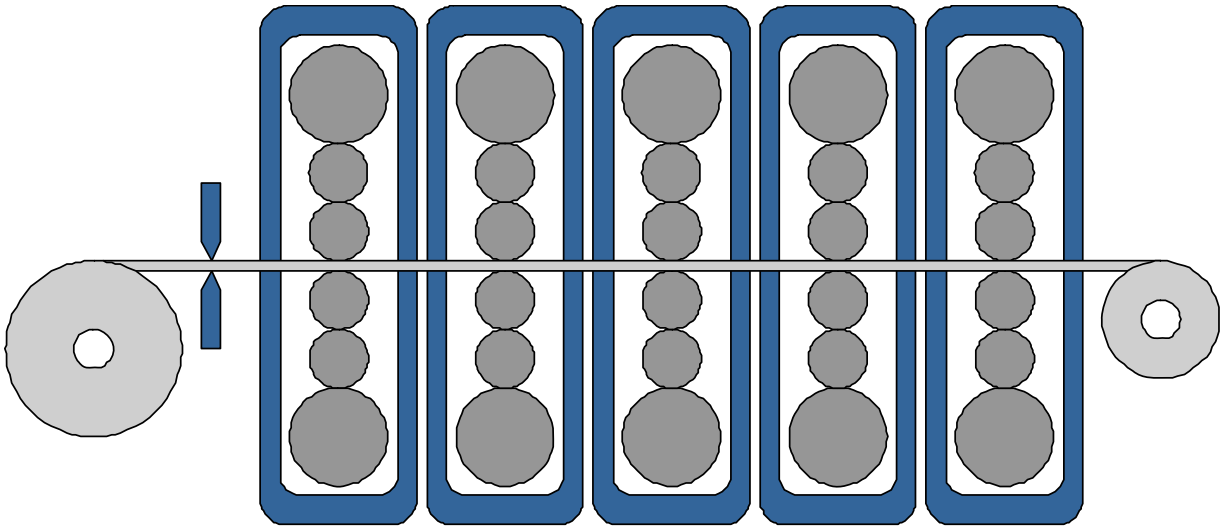

Figure 1. Principle sketch of a tandem mill with five stands and 6-high, source: own illustration.

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2 WORK ROLLS FOR COLD MILLING

In the tandem mill and also in the skin pass process, forged rolls with 3% or 4% chrome will be used. The diameter and the length of the barrel depend on the application from the mill and the diameter is normally between 500mm and 560mm. The barrel is deep hardened over the total work range from 820HV for a new roll to 750HV for a scrapped roll. In the first stands of the tandem mill the work roll will be chrome plated after grinding to get higher hardness on the surface and get better performance results in the production. The last stand and also all work rolls for the skin pass have to be textured after grinding. These textured rolls give between 40% and 60% of the roughness to the sheet surface. The following figure shows the surface of a textured work roll. The illustration of 1mm² of the barrel surface gives an impression about the complexness of textured rolls. The red-marked areas are high mountains or rather the green-marked areas are deep valleys (Figure 2).

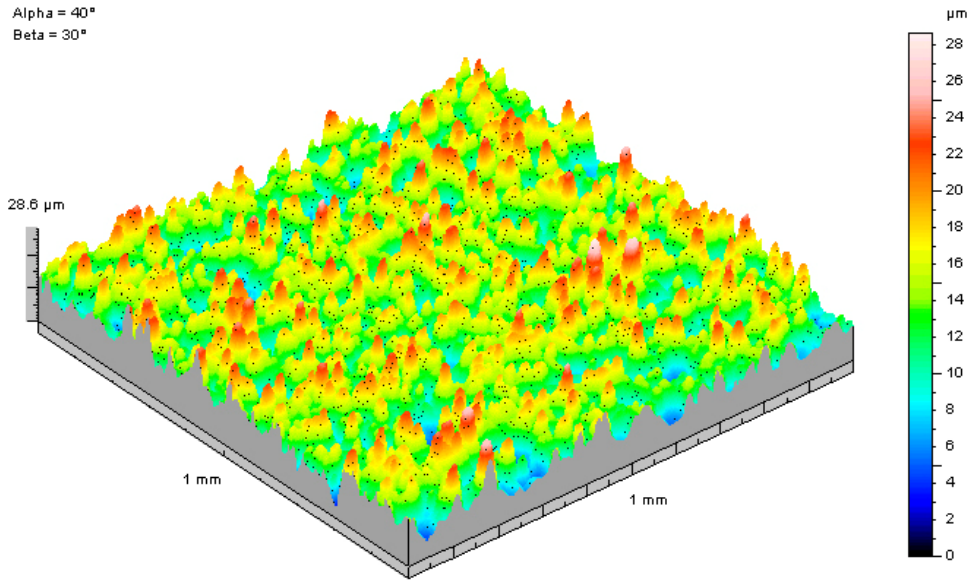

Figure 2. An Example for a section of the barrel surface of a textured roll, source: WaldrichSiegen.

3 METHODOLOGY

For the treatment of roll surfaces, a spark erosion machine was developed by WaldrichSiegen which permits the selection and production of a uniform roll surface roughness and defined peak count.

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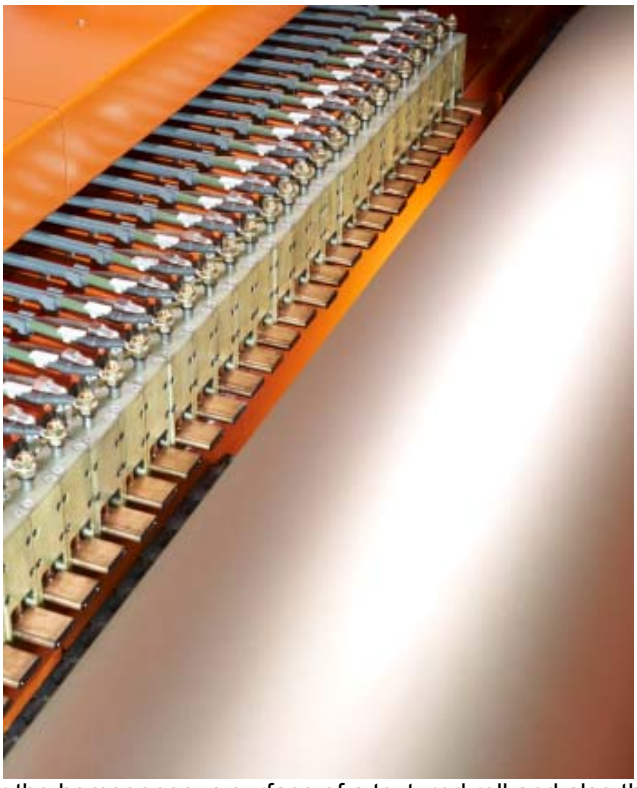

Figure 3. An Example for the homogeneous surface of a textured roll and also the arrangement of the electrode heads with the copper made electrodes, source: WaldrichSiegen.

Deep-drawing requires a very coarse structure whereby oil pockets are formed in a way to prevent the metal sheet from 'cold welding' to the die shoe tool.
In contrary painting requires a fine structure in order to achieve a surface finish with a high quality. On the other hand, painting also requires a defined surface roughness to adhere properly to the sheet.
An optimum compromise between both requirements is strived for in the practice. This means that a certain roughness factor with a higher uniformity over the sheet surface and a higher reproducibility must be used.
An electric erosion technique provides the solution to this requirement. This process called EDT - Electrical Discharge Texturing - makes roll texturing possible through CNC controlled spark erosion. Over 80 EDT-machines have been manufactured by WaldrichSiegen and are successfully in operation world-wide.
The generator sends current impulses to the electrodes which then discharge the electrical energy onto the roll over a distance of 0.002 to 0.02 mm from the workpiece, thus through the resistance of the dielectric oil (figure 3). In this process, tiny metallic particles from the barrel are melted and then flushed away by a dielectric oil stream passing through the electrode. There can be up to 400,000 electrical discharges per second on one generator (one electrode).
The generator switches on the erosion impulse and the conducting particles in the dielectric oil form a dipolar bridge which produces intermittent charges of current to be passed onto the roll. A bowl shaped particle is brought to its melting point and a gaseous by product bubble is formed at the discharge duct area.

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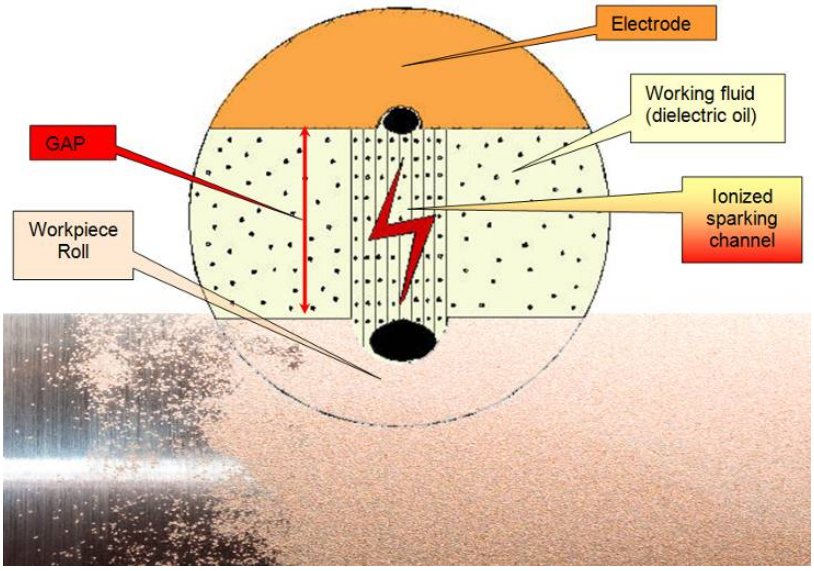

Figure 4. Function discharge electrical energy, the barrel has a textured surface on the right side, source: WaldrichSiegen.

After the erosion impulse is completed, the discharge duct collapses and the melted particle is expelled. A trough-shaped surface structure remains. The texturing process results can be programmed and reproduced with great regularity and narrow tolerances. Comparing the shot blasting and EDT methods with regard to the distance of peaks from one another, EDT is significantly higher. The texturing tolerance of the pre-selected roughness is ± 4%. The figure below shows a principle arrangement of the different devices of an EDT-machine.

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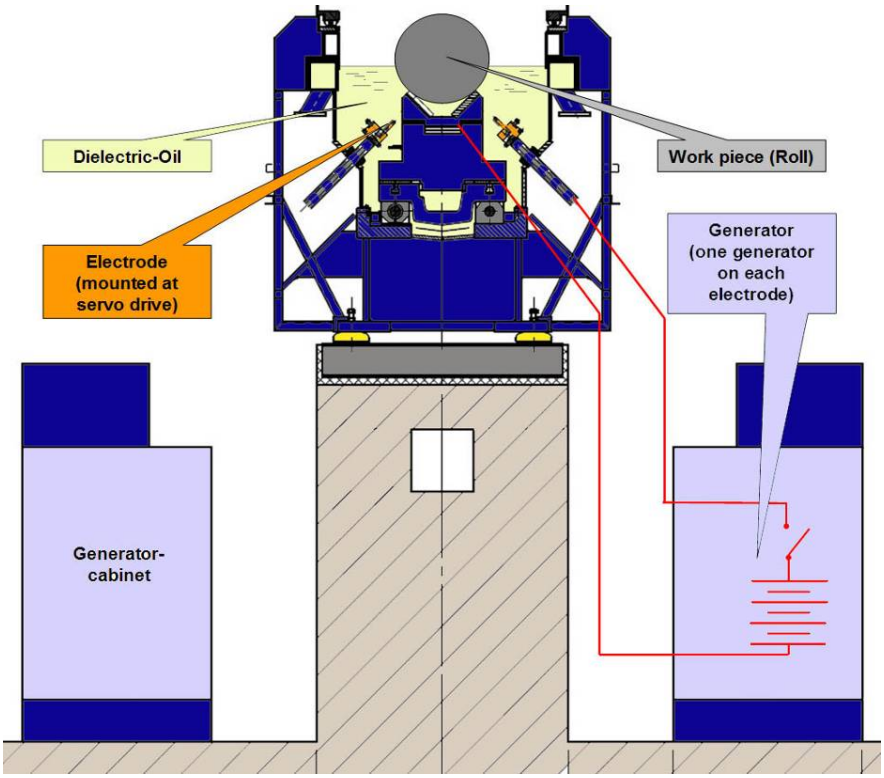

Figure 5. Principle sketch of the arrangement of an EDT-machine, source: WaldrichSiegen.

4 ACHIEVABLE RESULTS OF TEXTURING PROCESS

Surface qualities with an average coefficient of roughness between Ra 0.5 µm and 15.0 µm and 240 to 25 peaks per cm (RPc) can be achieved. Eight modes are availabe for the different requirements of the surface. Especially for fine surfaces like roughness of Ra 0.5 µm a big range of different numbers of peaks is possible (figure 5). Besides the four modes which can be used with positive and negative polarity it is also possible to use electrode made of graphite instead of copper. The using of graphite electrodes allow to reach more peaks in comparison to copper electrode at the same roughness.

The polarity influences the design of the craters which will be produced by the texturing process. The positive polarity in the pulse+ mode for example generated a homogenous impact which is contrary compared to a negative polarity which is much bumpier.

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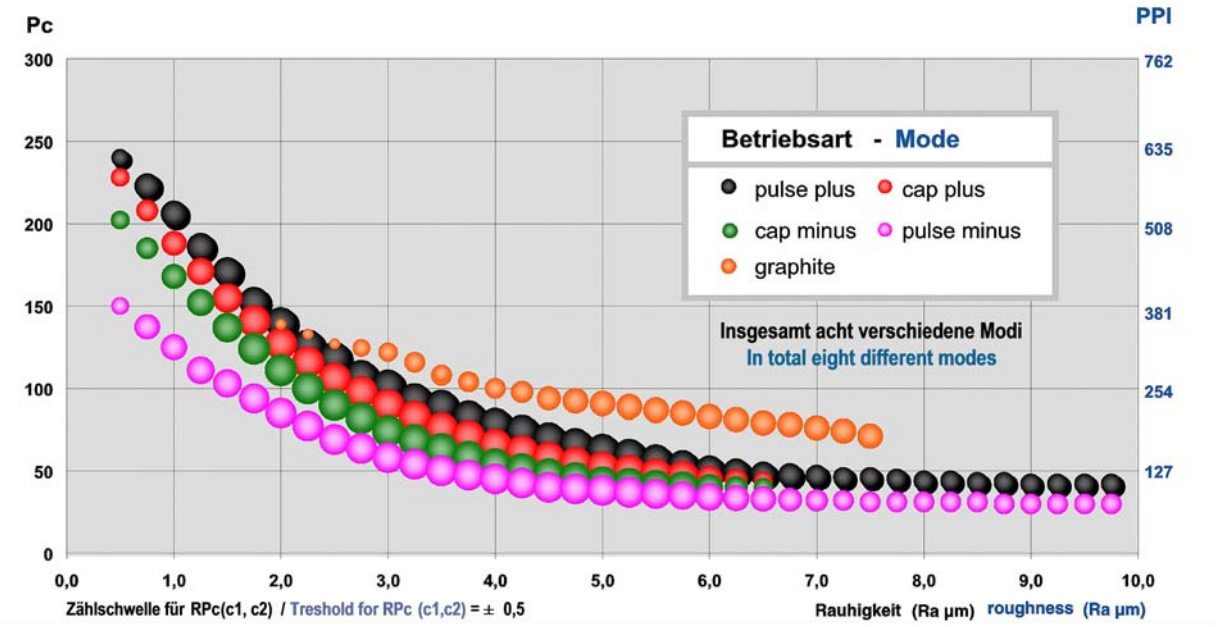

Figure 6. Diagram for checking the achievable results (roughness and numbers of peaks) with the different modes, source: WaldrichSiegen.

5 SUPERFINISHING UNIT[1]

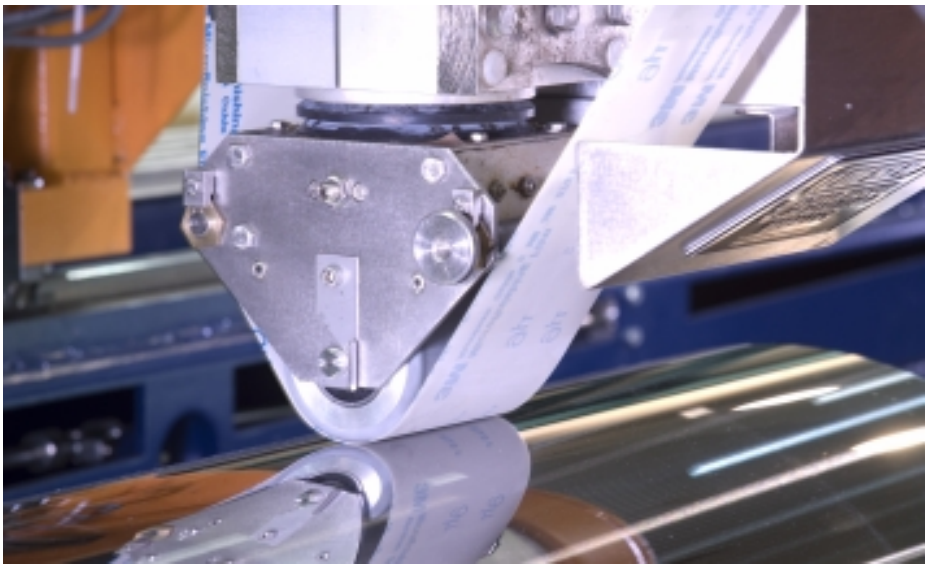

Figure 7. Superfinishing Unit in contact with the roll barrel during the superfinishing process, source: WaldrichSiegen.

During the rolling process with textured rolls or rather with textured barrels some high peaks of this surface break or bend under the load of the mill. These small particles

[1] *This technology was jointly developed in co-operation with Court Holdings Ltd., Beamsville, Ontario/Canada and a co-patent (No. 7,189,145) has been filed in a number of countries.*

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are picked up by the strip and the result is the so called flittering. This dirt causes rejection of the initial production runs which can effect up to 50 tons.
In addition to the break of the peaks and therefore the mill gap pressure changes due to the changing of the numbers of peaks. This reduction of the number of peaks causes to a reduction of the lifetime in the mill.
Besides that the roll roughness goes down substantially over production run and special cleaning equipment in the mill is required. Therefore WaldrichSiegen in co-operation with Court Holdings, Canada has developed the patented Superfinishing of textured surface as integrated part of the EDT-process. Superfinishing cuts off the highest peaks to avoid pick-up of dirt and increases the contact surface (higher negative RSK-values).[2] The RSK-value provides a simple but effective figure to evaluate the surface profile form. A negative RSK-value means a plateau-like profile with deep valleys. Superfinishing guarantees constant stock removal rate over the full barrel width due to a constantly new superfinishing belt in use.

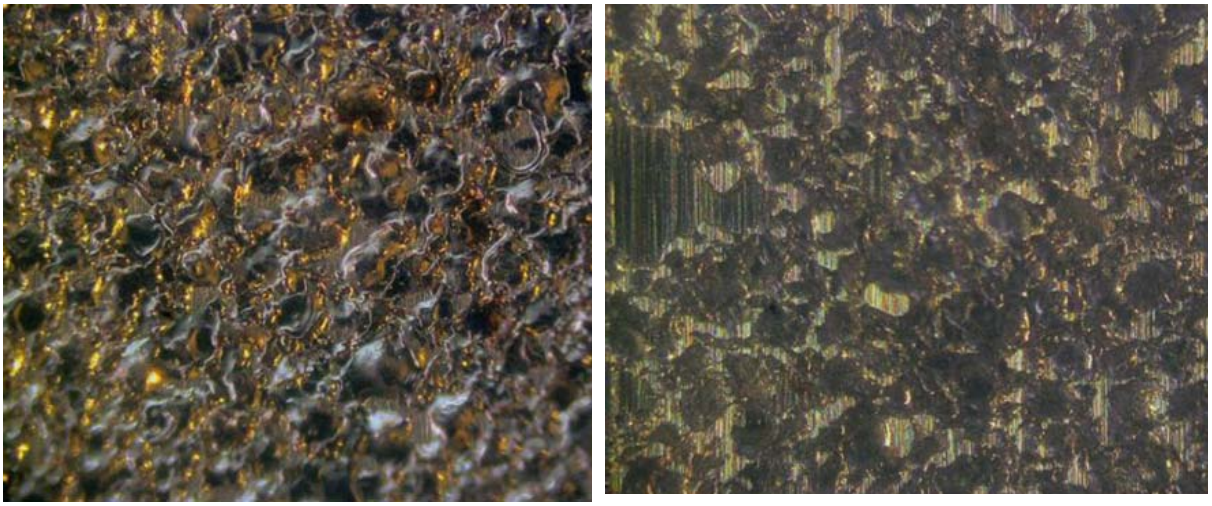

Figure 8. Detail figure of a textured surface without superfinishing on the left side and a superfinished surface on the right side, source: WaldrichSiegen

This profile increased the contact area with regard to a non-superfinished profile. Due that superfinish process based on the honing process and cuts only the highest peaks, there will be no geometrical charge. The reason is that the stock removal is only few microns. Of course there are a lot of parameters which can be adjusted similarly to the texturing process like the speed in Z-axis, speed of the film and so on. These settings depend on the application.

6 RESULT

Today, almost all important automotive manufactures and some other industries like white goods manufactures (e.g. bathtub with enamel coating) use textured rolls for a homogenous surface of the sheet. Due to this reproduceable surface of the roll barrel and resulting a constant quality of the sheet, allows the automotive industry to reduce

[2] *Cf. for further information DIN EN ISO 4287*

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the portion of color for painting and therefore savings. Besides the economical part the reduction of color is also a protection of the environment.
The Superfinishing unit is a fully automatic device integrated in the EDT-machine and it increases the roughness bearing ratio and also the contact area. The most important thing to use superfinished roll is that there is an increasing of the lifetime in the mill up to 3 times. A German customer reported that they produced with one set of roll about 300 tons, but with the superfinished rolls 1,600 tons - more than 5 times.
The advantages for mill user are savings due to constant sheet quality with a reduction of low-grade sheet and therefore a better income on the end product side and also savings on the production side due to longer lifetime of the rolls with the aid of using the Superfinishing unit.

REFERENCES

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