A NEW GENERATION OF ELECTRICAL DISCHARGE TEXTURING MACHINES[1]

Igor Oberding[2]
Karl-Heinz Adamek[3]

Abstract
A spark erosion machine, for surface treatment of cold rolling mill rolls, that permits to pre-select and produce a uniform roll surface roughness at defined peak count was long ago first developed by WALDRICH SIEGEN. Now a new concept of an optimized and more flexible machine was borne. This paper intends to describe the new developments of this kind of machines. Automobile manufacturers, as well as white goods and home appliance manufacturers, demand a certain surface roughness on the metal sheet in order to improve deep-drawing properties and painting quality. These requirements on the surface structure are reciprocal. 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 the press and from sticking during the coiling process. Painting requires a very fine structure in order to achieve a high quality surface finish. On the other hand, painting requires a defined roughness to have an excellent cling to the sheet (DOI: Distinction Of Image). An optimal compromise between both requirements is strived for in practice. This means that a certain roughness factor with a higher uniformity over the sheet surface and a higher reproducibility must be used. An electrode 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 74 WALDRICH SIEGEN EDT machines are successfully in operation worldwide.
Key words: EDT; Texturing machines; Spark erosion; Surface roughness.

UMA NOVA GERAÇÃO DE MÁQUINAS DE TEXTURIZAÇÃO POR DESCARGAS ELÉTRICAS

Resumo
Uma máquina de erosão por arcos elétricos (*electro discharge texturing* - EDT), para a composição de superfícies de cilindros de laminação a frio, e que permite uma pré-seleção e produção de surperfícies com rugosidades homogêneas e quantidade de picos por área bem definidos já foi pioneiramente desenvolvida pela Waldrich Siegen a muitos anos atrás. Agora foi criado um novo conceito de uma máquina otimizada e mais flexível. Esse trabalho descreve os novos desenvolvimentos e tendências nestes tipos de máquina. A indústria automobilística, bem como o setor de eletrodomésticos (linha de chapa branca), demanda certas rugosidades superficiais na chapa de metal, a fim de otimizar propriedades de conformação plástica e qualidades da pintura. Essas exigências à superfície da chapa são antagônicas. Enquanto processos de conformação plástica exigem uma extrutura rugosa, onde bolsas de óleo são formadas de forma a evitar um encruamento da chapa junto ao molde base e durante o processo de bobinamento da chapa, processos de pintura requerem uma superfície lisa, com baixa rugosidade, a fim de obter uma superfície de alta qualidade e brilho. Além disso, os processos de pintura exigem da superfície metálica uma certa rugosidade superficial bem definida para uma aderência ideal, com baixo consumo de tinta. Um compromisso entre estes requisitos antagônicos à rugosidade da superfíce da chapa metálica é o que se procura nos processos práticos. Isto significa, que uma determinada rugosidade superficial com uma maior uniformidade sobre toda a superfície e uma maior taxa de repetibilidade no processo deve ser almejada.
Palavras-chave: EDT; Máquinas de texturização; Eletroerosão; Rugosidade superficial.

[1] *Technical contribution to the 46th Rolling Seminar – Processes, Rolled and Coated Products, October, 27th-30th, 2009, Santos, SP, Brazil.*

[2] *Mechanical Engineer, Project Manager Marketing Roll Machining Equipment at Waldrich Siegen. Waldrich Siegen GmbH & Co. KG. Daimlerstrasse 24. D-57299 Burbach, Germany. Tel. +49-2736-493-364/Fax +49-2736-493-706. E-mail: igor.oberding@waldrich-siegen.de*

[3] *Production Engineer, Project Manager Marketing Roll Machining Equipment at Waldrich Siegen. Tel. +49-2736-493-331/Fax +49-2736-493-706. E-mail: karl-heinz.adamek@waldrich-siegen.de*

INTRODUCTION

After the higher quality of sheet metal produced with textured rolls has been demanded by the automotive industry and some special customers in the first place, this quality standard has become customary during the recent years for many products produced out of flat material. More and more aluminum parts are used in the automotive industry as well, requiring textured surfaces too.
The machine described in this paper is the most economic solution to satisfy this market needs. The concept of the machine is cut to size for all application ranges which require a high-quality texture for work rolls.
Special engineering features assure an efficient operation in a wide ranges from flat and middle strip applications as well as for the aluminum industry. Furthermore, the machine can also be installed in service centers which are not directly connected to a steel mill. Thus also some other applications, for example rolls for the plastic or food industry, can be provided with textured rolls.
All of the WALDRICH SIEGEN experience and know-how, built-up by manufacturing electrode discharge machines for more than twenty years is incorporated in these new generation of texturing machines.

PRINCIPLES

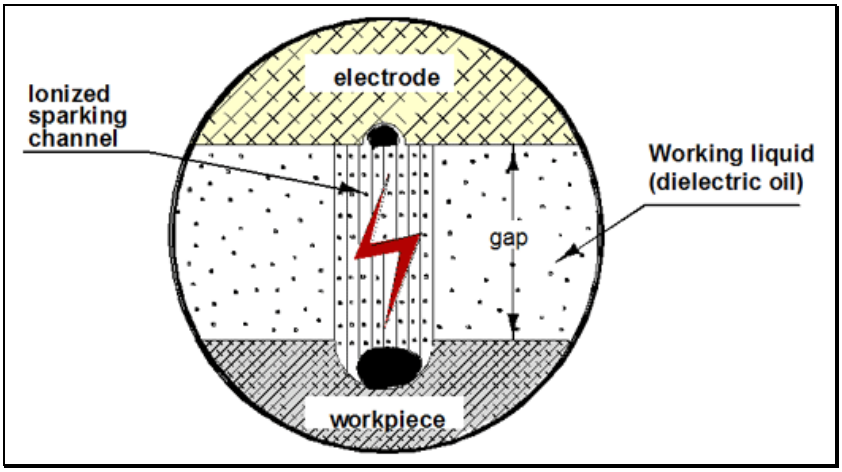

Figure 1: Principle of spark erosion.

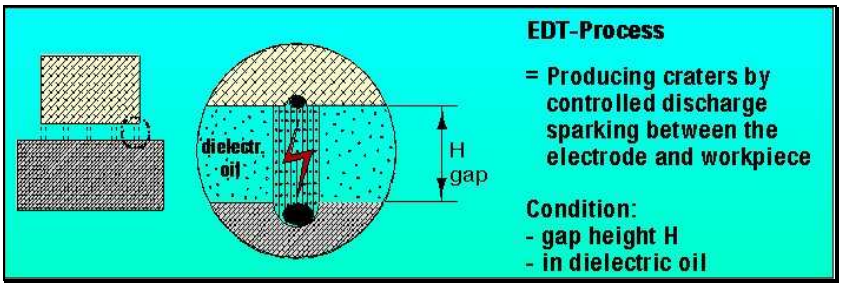

Figure 2: principle of an EDT machine.

The generator switches on the erosion impulse and the conducting particles in the dielectric oil forms a dipolar bridge that 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.

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. Surface qualities with an average coefficient of roughness Ra between 1.0 and 15.0 micrometers and 240 to 25 peaks per cm (Pc or RPc) can be achieved.
The generator sends current impulses to the electrodes which then discharge the electrical energy onto the roll over a distance of 0.02 to 0.2 mm from the workpiece, thus through the resistance of the dielectric oil. 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).

OPERATION MODES TO ACHIEVE SELECTED ROUGHNESS

In order to meet customer requirements for flat products, several modes of operation are available. In this way a wide range of surface finishes ranging from 1.0 to above 15 µm Ra can be achieved very effectively. Pulse and capacitor modes can be implemented so that maximum use is made of the available circuitry. The following description should help to explain the technology involved for all modes.
The parameters for all modes are automatically selected by the control so that the operator only needs to select the required finish and peak count. The different programs are stored in the CNC / PLC. The following four (4) modes of operation are therefore available:

Pulse Mode with Constant Current Length (1. Negative / 2. Positive)

A fixed voltage (100 V power and 250 V ignition) is applied via a programmable constant current source to the electrode. The control senses the ignition point and then starts the programmed ON time so that the actual current pulse length is almost constant. The max. roughness that can be achieved is 15 microns.
The pulse mode is better suited for achieving finishes with high peak count and has the following advantages:
The peak count is 15 to 20 % higher than for the available CAP-Mode.

- Pulse mode negative gives the lowest peak count (for copper electrodes).
- Pulse mode negative with graphite electrode gives a high peak count.
- The relatively low current ensures a more uniform surface finish.
- The electrode wear is very low.
- A rough finish (> 6,0 µm Ra) is possible only in pulse mode.

Capacitor Mode with Constant Charging (3. Negative / 4. Positive)

A capacitor is charged from a constant source current to a pre-selected voltage that is programmable between 100 and 230 V DC. The charging current is also programmable. The capacitor is charged constantly until ignition occurs and after ignition, the programmed OFF time will be started. Because of the constant charging this mode is more efficient than the pulsed charging mode. The combination of max. capacitance and max. voltage results in a max. achievable roughness of approx. 6 microns (Ra).
For the explanation of the different technology between capacitor (cap) and pulse mode please refer to the following sketch.

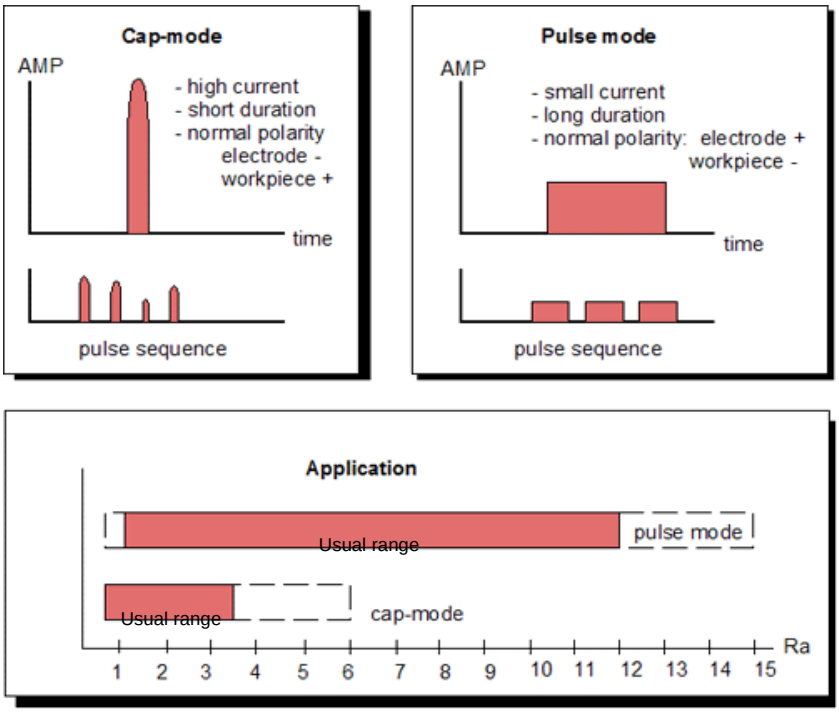

Figure 3: Comparison between cap mode and pulse mode.

The capacitor mode supplies a very short, relatively high current pulse and is therefore especially suited for achieving fine finishes. The gap is larger in cap mode, which results in better flushing and higher efficiency, but lower peak count. Current breakdown is almost non-existent because of the high discharge current. The cap mode has the following advantages:

- The fine finish is optically more uniform.
- Necessary for medium number of peaks (Pc).
- Faster for the roughness below 1.0 Ra.

IMPROVEMENTS

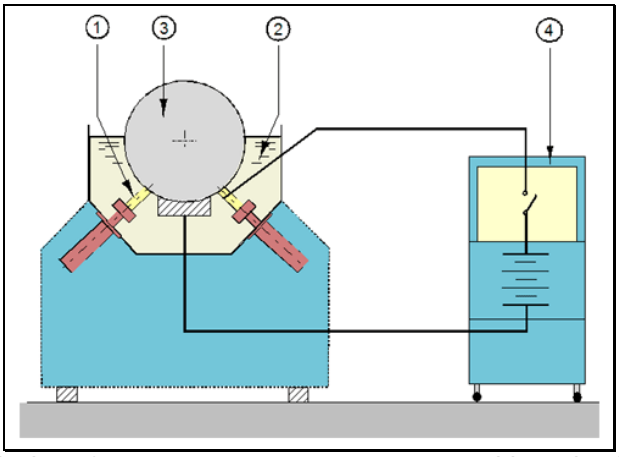

Figure 4: Former design of a WALDRICH SIEGEN EDT machine, simplified cross section.

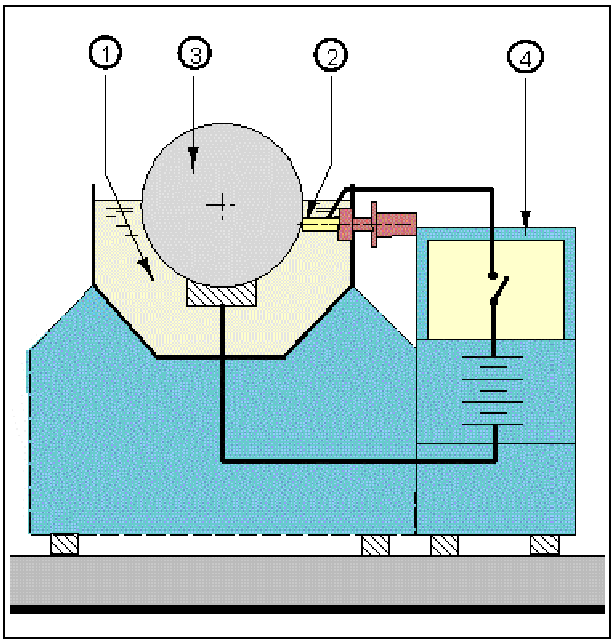

Figure 5: New design of a WALDRICH SIEGEN EDT machine, simplified cross section.

Legend

- (1) Dielectric oil
- (2) Electrode (mounted at servo drive)
- (3) Roll
- (4) Generator

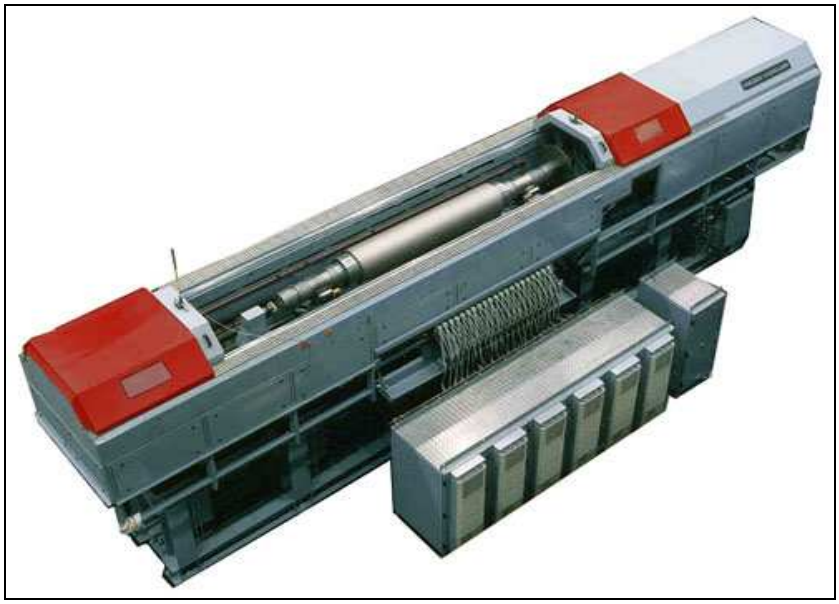

Figure 6: Former design of a WALDRICH SIEGEN EDT machine.

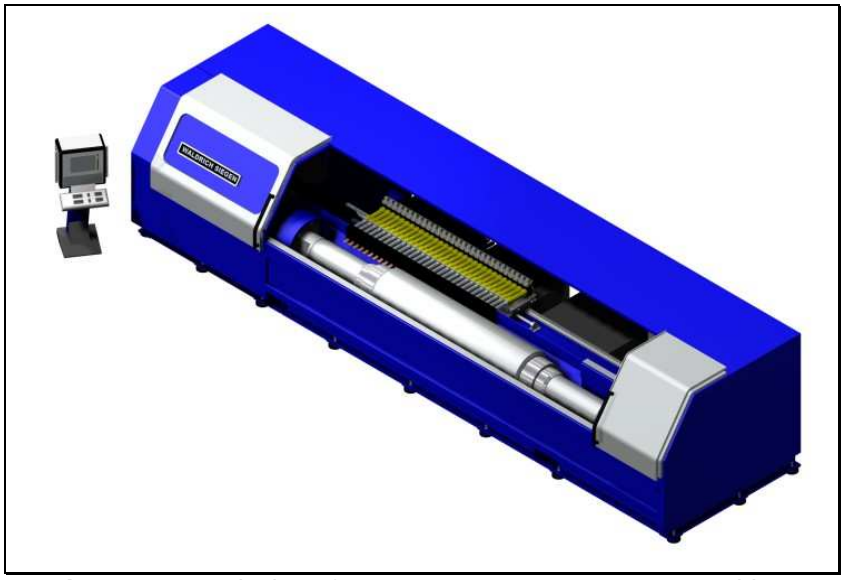

Figure 7: New design of a WALDRICH SIEGEN EDT machine.

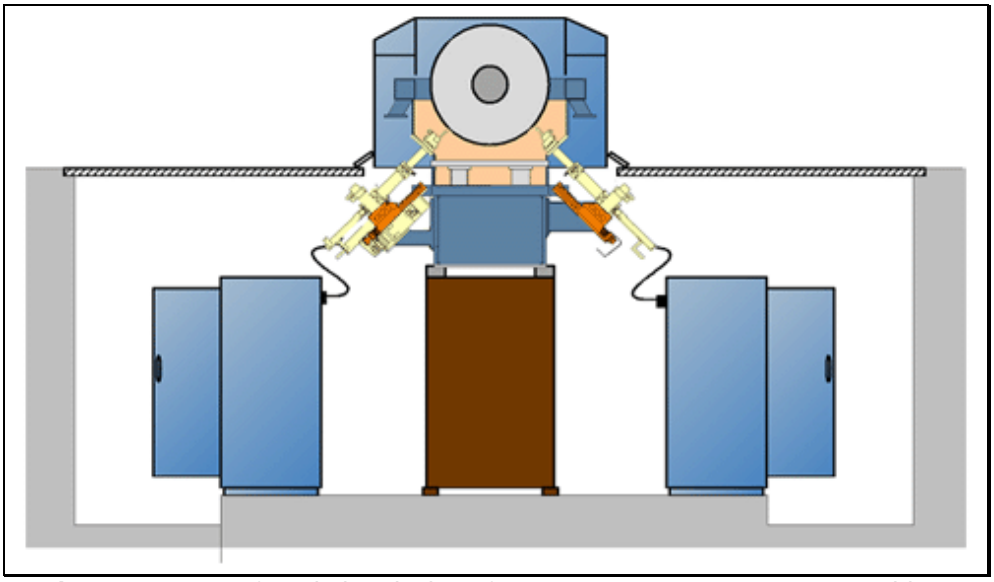

Figure 8: Former foundation design of a WALDRICH SIEGEN EDT machine.

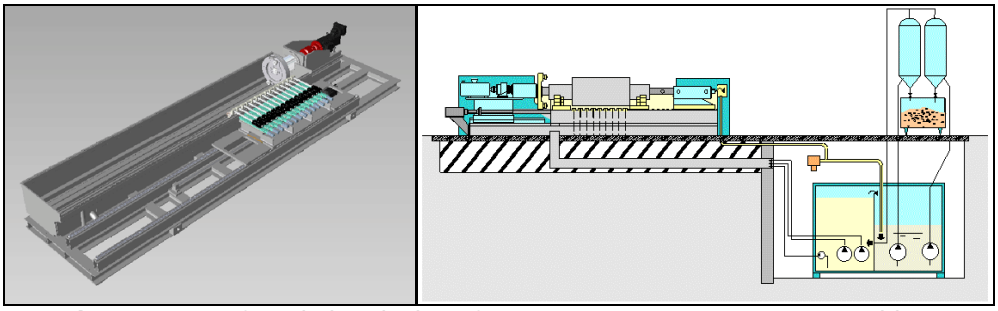

Figure 9: New foundation design of a WALDRICH SIEGEN EDT machine.

The above pictures from 4 to 9 show some comparisons between former design and new design and consequently, of the main improvements, that are also compared and resumed on the following table:

Table 1: Comparison of WALDRICH SIEGEN EDT machines of different generations

Machine part	Former design	New design
Machine support sub-frame	Welded steel construction.	Directly on industrial floor. ***Advantages**:* • *Smaller shipping cases* • *Easier installation*
Adjustment of electrodes	Hydraulic servo cylinder actuated by servo valve.	High-precision linear servo drive. ***Advantages**:* • *Faster / higher dynamic* • *Less maintenance compared to servo hydraulics* • *Less possibilities for leakages*
Hydraulic unit	Relatively large size due to usage of hydraulic servo cylinders.	Compact design due to renunciation of servo hydraulics. ***Advantages:*** • *Smaller footprint* • *Less possibilities for leakages*
Generator	Maker is company Kleinknecht, Germany.	Maker is company Schäfer, Germany. ***Advantages:*** *Complete new development, therefore higher efficiency and smaller design.*
Operation modes of generator	Eight (8) operation modes: • Capacitor (CAP) mode, plus, new • Pulse mode, plus, new • Capacitor (CAP) mode, minus, new • Pulse mode, minus, new • Capacitor (CAP) mode, plus, old • Pulse mode, plus, old • Capacitor (CAP) mode, minus, old • Pulse mode, minus, old actually only four (4) modes were effectively used (“new” capacitor and pulse mode, plus and minus)	Based on the latest generator technique four (4) different operation modes are possible: • Capacitor (CAP) mode, plus • Pulse mode, plus • Capacitor (CAP) mode, minus • Pulse mode, minus for different applications and in combination of roughness and number of peaks.

Machine part	Former design	New design
Available roughness range	0,5 to 15 µm Ra	1 to 15 µm Ra *Roughness below one (1) µm Ra are nowadays not required anymore. Therefore the roughness range was optimized.*
Cooling of generator	Air condition, integrated in generator cabinet.	Liquid cooling, integrated in generator cabinet.
Control of EDT	Hardware: SIEMENS 115U PLC Communication: Analogous (drives) / CAN-Bus (generators)	HCC/KPM PTC10 control with SoftPLC (BECKHOFF TwinCAT PLC). Communication digitally via EtherCat. ***Advantages:*** • *Everything out of one hand (total integration)* • *Reduced spare parts stock due to SoftPLC and even more reduced spare parts stock in connection with roll grinders.* • Easy diagnosis
Drive system	SIEMENS 611A converter, 1PH7 main spindle drive and 1FT6 servo drive.	Baumüller “b maXX” drive system and DSC servo motors. ***Advantages:*** • *Digital drive system, thus higher protection against malfunctions by changeover from analog signals to digital signals* • *Reduction of installation expenditure*
Control of loader	Separate SIEMENS PLC	Integrated in EDT control PTC10. ***Advantages:*** • *Total integration* • *Higher availability*

SUMMARY

One of the great benefits that the new generation of EDT machines provide is the optimized production capacity that can be adjusted to the exact demands of the customer. Depending on the number of rolls to be textured in a month, the machine can be equipped with more or less electrodes and the texturing process will be faster or take more time accordingly. Due to the variable oscillation length of the electrodes along the barrel of the roll and to the flexible number of electrodes the texturing

process is fine tuned with the production capacity demanded and the capital expenditure optimized. A future production capacity increase can be implemented at any time without great efforts by an increase of the electrodes number and changing of the oscillation length. The changing of the hydraulic servo drive to a high precision linear servo drive eliminates leakage problems of the past and increases the dynamic response to maintaining the gap at a constant value. Due to all of the presented optimizations, the texturing technology gained in flexibility accordingly to customers needs and the resulting machine guarantees high degree of quality and repeatability in the texturing processes.

Acknowledgement

The authors like to thank the company WALDRICH SIEGEN in Burbach, Germany for its support, collaboration and technical assistance in the development of this research and work.