Analysis of the Parameter of the Electro-discharge Texturing

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Analýza parametrov elektroiskrového textúrovania

This paper deals with analysis of the electro discharge texturing (EDT) parameter impact to micro-geometry of the cylinder surface. Micro-geometry of the cylinder surface results has significant influence to final quality of rolled metal plate used to different industry. Micro-geometry evaluate is based on measurement of the surface roughness average (Ra) and peak count (Pc). In this paper is evaluated electro discharge texturing parameters and their impact to Ra and Pc. From the measured values follow that value of the texturing current, impulse on-time and impulse off-time most influence to Ra and Pc. In this paper is described design, realization and results of the model for estimation of the texturing current, impulse time and technological pause for Ra or Pc required value.

***Key words:** quality control system, measurement, mathematical model*

Introduction

Automobile manufacturers require always-hard requirements for micro-geometry parameters of the rolled metal plate from contractor of body sheet metal. Micro-geometry of the cylinder surface results has significant influence to final quality of rolled metal plate. Every manufacturer has specific requirements. For example automobile factory Ford requires that the values of Ra on both side of metal plate be from 1,1 to 1,7 μm and Pc must be greater than $50 cm^{-1}$. These requirements are required mainly for the good metal plate compressibility, varnishibility, and for achievement of desired metal plate durability in automobile industry.

Metal plate individual parameters are succeeding by the sheet rolling with texturing (roughening) cylinder. Several technological parameters have significant influence to cylinder surface quality that is described in the next.

Micro-geometry of the cylinder surface

Parameters used to describe micro-geometry of the surfaces include:

Roughness average – Ra is the most commonly used parameter to describe the average surface roughness and is defined as an integral of the absolute value of the roughness profile measured over an evaluation length (Fig. 1):

$$Ra = \frac{1}{L}\int_0^L \left| y(x) \right| dx \qquad (1)$$

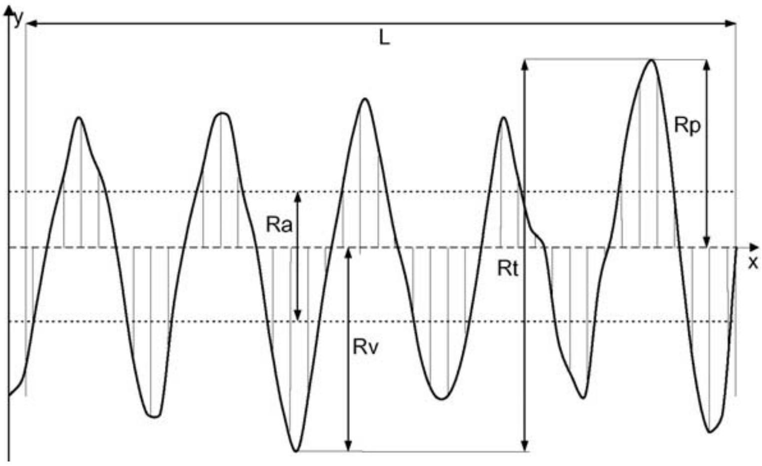

Fig. 1. Surface micro-geometry parameters.

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Root mean square (RMS) roughness – Rq

$$Rq = \sqrt{\frac{1}{L}\int_0^L y^2(x)\,dx} \tag{2}$$

Maximum height of the profile – Rt is height of maximum profile valley depth (Rv) plus maximum profile peak height (Rp), i.e.

$$Rt = Rv + Rp. \tag{3}$$

Peak count – Pc is number of the peaks that intersecting defined high and down level of layer (cm^{-1}) (Veles, 1989; Pluhař, 1989; Dzierwa, 2006).

Electro-discharge texturing

Electro-discharge texturing (EDT) is process where cylinder material is removing due to time and space separated discharge. Discharges are between electrode and cylinder (Fig. 2). Electrode is dipped in dielectric liquid during processing. Melting-down and evaporation of cylinder and electrode material is coming up after breakdown of working distance. Around created discharge channel is formed gas bubble. Gas energy proportionally increase to discharge current and gas bubble extends. Gas energy dive after then current value is maximal, but expansion of gas bubble proceeding specific time on the grounds of inertia. Subsequent press inside bubble dive too. As a result of melt and hot metal boiling in crater and eject from crater how to small drop. Distance between electrode and cylinder surface is given voltage between electrode and cylinder.

Process result is texturing and stochastic surface, with undirected, randomly crater allocation after discharge (El-Menshawy, 1991; McGeough, 1992).

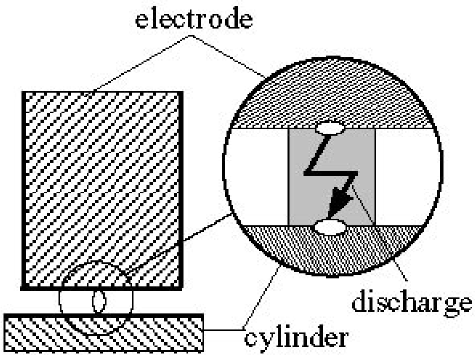

Fig. 2. Electro-discharge texturing principle.

Impact parameters analysis

The measurement data shows that significant is follow impact:

- current texturing,
- pulse on-time,
- pulse off-time.

Current texturing impact

Value of current texturing has principal impact to achieved roughness Ra. From the measurement data is evident, that current texturing value is directly proportional to roughness Ra. In case of constant pulse on-time is the growth of Ra value insignificant after achieve specific Ra value. On the basis of this determination is possible to observe that in case of need to achievement advanced Ra value is necessary enlarge pulse on-time from point of view of efficiency electro-discharge process and increase value of current texturing. For measurement data (Fig. 3) was created non-linear regress model with method of least squares (index of correlation is 0,8661):

$$Ra = -0{,}0015\ C^2 + 0{,}1493\ C + 0{,}6362 \tag{4}$$

Where *Ra* is roughness average [m], *C* is current texturing [A].

Current texturing value has reverse influence to Pc value then influence to Ra this is value of current texturing is indirectly proportional to peak count Pc by reason of crater area expansion. From the specific value of current texturing is stopped fall in value Pc in case of constant pulse on-time (Fig. 3). Regression dependence for Pc and C is following

$$Pc = 0{,}1317\ C^2 - 7{,}5978\ C + 179{,}82 \quad (5)$$

Where *Pc* is peak count [m^{-1}] and index of correlation is *0,9313.*

Pulse on-time impact

Pulse on-time value principal approach influence to roughness Ra. The roughness Ra is rising on the basis of increases in value of pulse on-time. From the specific value of pulse on-time is slowed down and next is stopped growth of value Ra in case of constant current texturing. This value is directly proportional to current texturing (Fig. 4).

$$Ra = -0{,}0015\ C^2 + 0{,}1493\ C + 0{,}6362 \quad (6)$$

Where *Ra* is roughness average [m], *C* is current texturing [A].

On the basis of measurement data evaluation is evident decrease in Pc value by the increasing pulse on-time value. The increasing is stopped after achievement specific Pc value in case of constant current texturing (Fig. 4).

$$Pc = 0{,}1317\ C^2 - 7{,}5978\ C + 179{,}82 \quad (7)$$

Where *Pc* is peak count [m^{-1}] and index of correlation is *0,9313.*

Pulse off-time impact

The measurement does not confirm direct impact of pulse off-time to roughness Ra. It proved that in case of reduction of pulse off-time do not rebuild of electro-discharge channel and it begins effect of the so-called cylinder burn. The cylinder burn is non-acceptable defect from quality point of view. Optimum value of pulse off-time relate to value of current texturing and value of pulse on-time. In general is possible constatation that with current texturing growth it is necessary increase of pulse off-time value.

The measuring data do not confirm direct impact of pulse off-time to peak count Pc (Gombár, 2006).

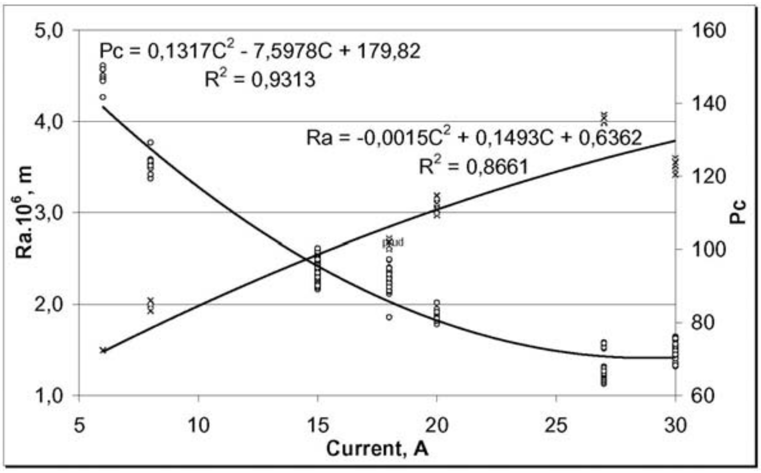

Fig. 3. Current texturing impact.

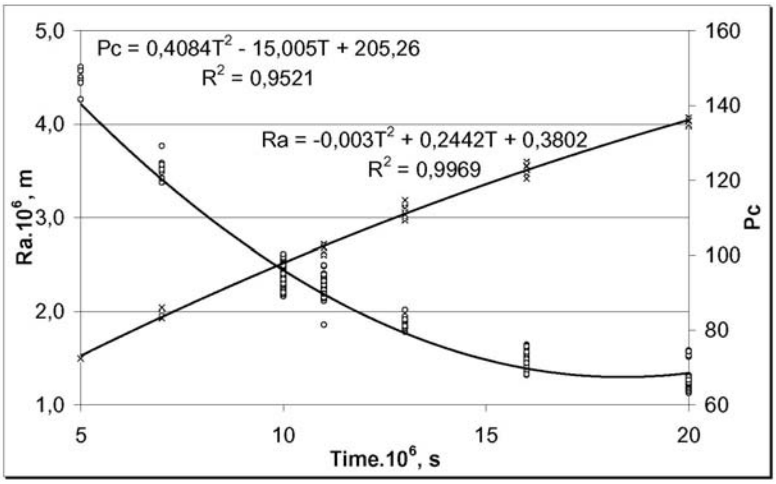

Fig. 4. Pulse on-time impact.

Conclusion

The results show that value of current texturing and value of pulse on-time have maximal impact to quality of the texturing process of the cylinder surface intended for rolled metal plate. The result is also mathematical model (Fig. 3 and 4) that can be used to design of current texturing value and pulse on-time value in the case of new production programme, i.e. new requirement of value Ra and Pc.

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References

Dzierwa, A.: Chosen Properties of Chromium Coating After Pneumatic Ball Peening. *In: Manufacturing engineering, Vol. 5, No. 1, 2006, p. 62-65. ISSN 1335-7972.*

El-Menshawy, F., Snaith, B.: Advances in Electro-Discharge Texturing for Cold Mill Work Rolls. *In Iron and steel engineer, 1991, Vol. 68, No. 8, pp. 57-59, ISSN 0021-1559*.

Gombár, M.: Statistical model of the Surface Roughness in MATLAB. *In: Manufacturing engineering, vol.5, no.1, 2006, p.14-17, ISSN 1335-7972*.

McGeough, J. A., Rasmussen, H.: A model for the Surface Texturing of Steel Rolls by Electrodischarge Machining. *In Proceedings: Mathematical and Physical Sciences, Vol. 436, No. 1896 (Jan. 8, 1992), pp. 155-164, ISSN: 00804630.*

Palenčár, P., Halaj, M.: Metrologické zabezpečenie systémov riadenia kvality. *Bratislava: STU, 1998, p. 140., ISBN 80-227-1171-3*.

Palenčár, P., a kol.: Systém riadenia merania Bratislava, *STU, 2001, p 210. ISBN 80-968449-7-0*.

Pluhař, J. a kol.: Náuka o materiálech. *Praha : SNTL, 1989, p. 375*.

Veles, P.: Mechanické vlastnosti a skúšanie kovov. *Praha : SNTL, 1989, p. 375*.