RESEARCH ON TOPOGRAPHY OF STAINLESS STEEL SURFACES AFTER ABRASIVE TREATMENT IN A CENTRIFUGAL SMOOTHING CONTAINER MACHINE

Paulina KURĘDA

Wydział Mechaniczny, Katedra Inżynierii Produkcji
Politechnika Koszalińska, Ul. Racławicka 15-17, 75-620 Koszalin,
e-mail: paulina.kureda@s.tu.koszalin.pl, p.kureda@wp.p

SUMMARY

The article presents the reaserch results of the geometric structure of the AISI 304L stainless steel samples treated in the abrasive smoothing process using loosely rotating or moving due to the centrifugal force Avalon ceramic fittings with parameters 06PP10 using the AVALON EC6 smoothing container machine. The top layer structure of the surface of steel samples was tested depending on the different exposure times of the treatment for the operation of ceramic inserts at a constant rotational speed of the rotational-cascade smoothing machine. The parameters of surface roughness, contact angle and adhesion energy values, surface isotropy were analyzed as well as a visual assessment of the gloss of the treated surface in relation to machining time was performed.

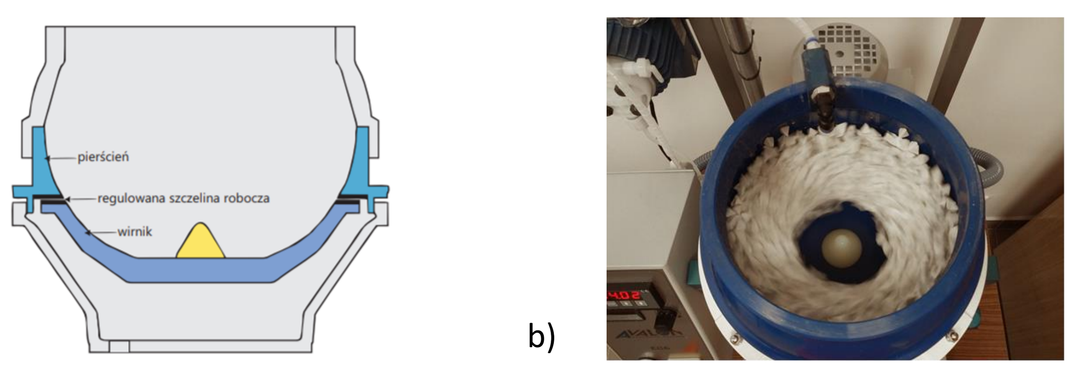
INTRODUCTION

Surface treatment in container smoothing machines is nowadays a developing technology that is widely available due to low implementation costs. This type of smoothing machines of are easy to use and do not require special knowledge or pro-tections (eg protective clothing) for their service compared to electrochemical treatment or sandblasting. Such features give this technology a very wide spectrum of use.

To carry out the research presented in the article, the Avalon EC6 smoothing ma-chine was used. It is a rotational-cascade machine in which the working drum consists, among others, the fixed housing of the tank located above the ring and the rotating bottom of the container, which sets abrasive devices together with the workpieces (Fig. 1). Due to its relatively small size, this model is ideally suited for cleaning, grinding and polishing small-sized parts with a total weight of up to 0.5kg per one-off batch. This smoothing machine will find its application for the treatment of jewelery details, small screws or buttons.

Smoothing containers have a wide range of applications. It is possible to remove surface layers - purification of deposits, rust, impurities; deburring, rounding of sharp edges, as well as reducing surface unevenness by abrasive, finishing or polishing. Va-rious materials can be processed, such as metals (steels, aluminum, zinc, magnesium, copper or titanium alloys), gold, silver, plastics, articles made of wood and minerals, amber, as well as rubber elements. Depending on the desired effect, type of material, size and shape of the object, a suitably selected working medium is used, from cera-mic, resin, porcelain, steel and natural plant media.

The aim of the research presented in the article was to obtain a non-targeted isotropic surface and to assess the condition of the surface layer of stainless steel samples subjected to the abrasive smoothing process in a rotational cascade smoothing machine depending on the processing time using one type of operating medium at a constant rotational speed of the machine drum. The analysis of the influence of the change of machining time on surface roughness values, adhesion energy and visual properties of the tested elements was analyzed.



a) b)

Fig. 1. Reaserch stand - AVALON EC6 smoothing machine a) Construction of the working drum (www.avalon-machines.pl, 2018), b) The drum during smoothing with the use of ceramic fittings

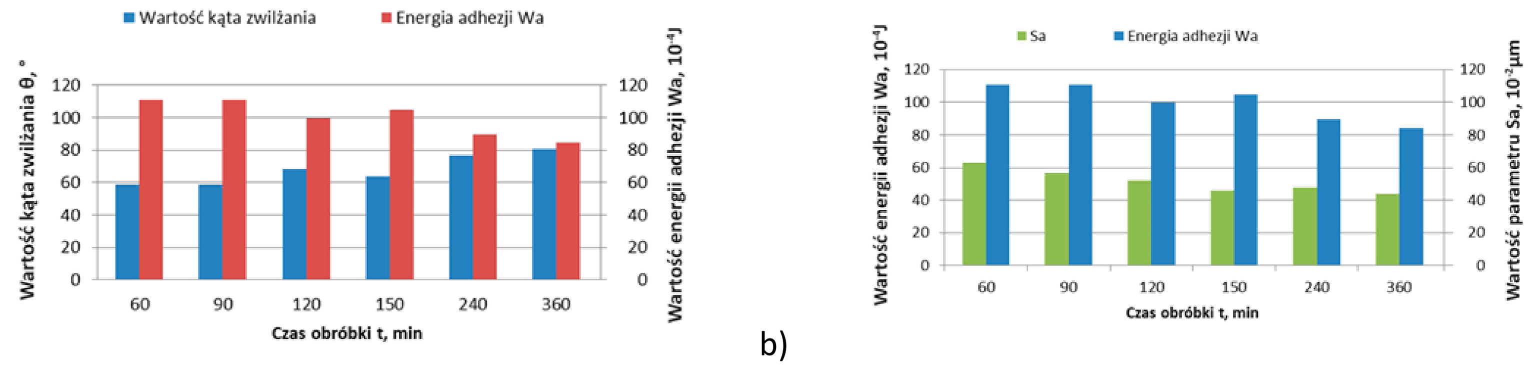
RESEARCH RESULTS AND THEIR ANALYSIS

A summary of the results of the tests carried out below. Table 1 presents the chan-ge in the value of various height parameters for steel surfaces (Sa - mean arithmetic deviation, Sq - mean square deviation of surface ordinates, Sk - core roughness height), significant in terms of surface roughness analysis relative to the machining time. The change in the contact angle and adhesion energy for a given sample determined by the treatment time in a smoothing machine was also presented.

Tab. 1. The results of the research on structure changes of the surface layer of AISI304L stainless steel versus processing time with the use of ceramic inserts 06PP10 by Avalon

Tooling time t, min	60	90	120	150	240	360
Parameter Sa, µm	0,631	0,565	0,519	0,455	0,447	0,439
Parameter Sq, µm	0,835	0,765	0,722	0,636	0,574	0,572
Parameter Sk, µm	1,938	1,679	1,516	1,373	1,41	1,329
Surface isotropy, %	19,404	33,703	59,381	49,152	19,738	41,076
Contact angle value ,°	58,57	58,96	68,33	63,59	76,86	80,69
Adhesion energy Wa, 10^{-3} J	11,08	11,03	9,97	10,52	8,93	8,46

The results of the contact angle measurement indicate that the range for the tested samples is within the range 0o < θ < 90o, which means that the liquid moistens the solid well. However, after 6 hours of processing, the result is much closer to θ = 90o, where liquid molecules attract solid particles with a force equal to half of their mutual attraction (Thomsen, 2008; Żenkiewicz, 2000). Analyzing the above results and pro-perties for the size of contact angles, it can be concluded that the surface after the lon-gest processing time will be much less susceptible to water adherence, as a result of which higher corrosion resistance will be possible. This surface can be easier to clean and more resistant to dirt.

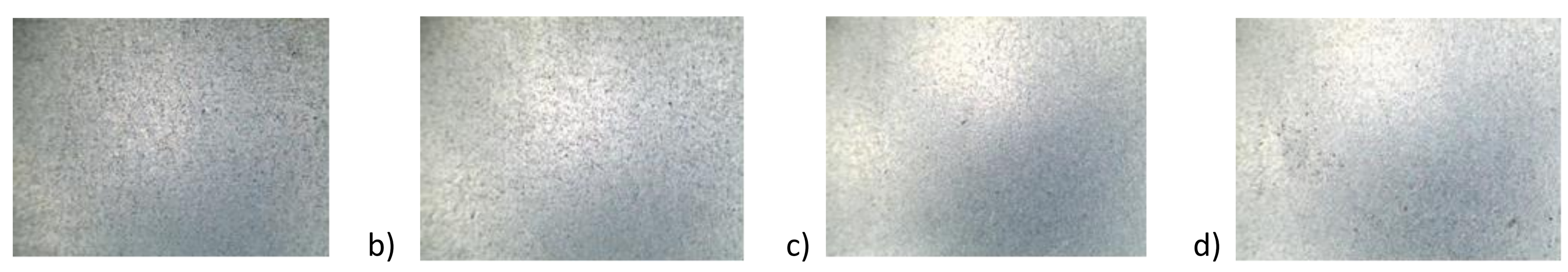


a) b)

Fig. 2. a) Relation between contact angle and adhesion energy versus treatment time, b) Relation between mean arithmetic surface deviation Sa and energy of adhesion with respect to machining time

The graphs show the relationships between selected research results. In graph a), the relationship between the energy of adhesion and the surface parameter Sa is visible. On the other hand, in graph b) the relationship between the value of the contact angle and the adhesion energy for the tested samples is shown depending on the processing time.

Changes were also observed in the number of peaks occurring on the surface of the tested steel. After the first hour of treatment, the peak height ranged from approx. 6 µm to 11 µm, while after 6 hours the range changed to 3-6 µm. Peak grain size has also been reduced.



a) b) c) d)

Fig. 3. Surface view under the Capture Digital Microscope a) after 1 hour of treat-ment, b) after 2 hours of treatment, c) after 4 hours of treatment, d) after 6 hours of treatment

There were also visual changes that took place in subsequent stages of smoothing (Fig. 3), which could also be noticed without the use of specialized equipment.

CONCLUSION

The following conclusions can be drawn on the basis of the research and analysis of the results obtained:

1. The geometrical structure of the surfaces subjected to smoothing to a thinner in a container smoothing machine with the use of ceramic inserts undergoes changes as a function of time and shows a tendency to shape a non-targeted structure.
2. With the elongation of the machining time, the roughness of the surface decreases, eg Sa for t = 60 min is 0.631µm to Sa = 0.439µm with a 360 min machining time.
3. The longer the smoothing time, the greater the wetting angle of the workpieces being processed, and the adhesion energy is reduced, which may lead to increased corrosion resistance of the surface and more favorable cleaning conditions, as well as less tendency to adhere to contamination..
4. As the machining time increases, the greater glossiness of the stainless steel sur-face is visible.

LITERATURE

1. https://www.avalon-machines.pl/files/download/1065/wygladzarki-odsrodkowe-przemysl.pdf (dostęp: maj 2018)
2. https://www.avalon-machines.pl/produkty/media-scierne/na-mokro/ksztaltki-ceramiczne/ (dostęp: maj 2018)
3. Kłonica M.: Modyfikacja warstwy wierzchniej materiałów konstrukcyjnych w atmosferze ozonu, s. 1-4
4. Liber-Kneć A., Łagan S.: Zastosowanie pomiarów kąta zwilżania i swobodnej energii powierzchniowej do charakterystyki powierzchni polimerów wykorzystywanych w medycynie. Prace Oryginalne, Polim. Med. 2014, 44, 1, s. 30-35
5. Oczoś K. E., Liubimov V., Struktura geometryczna powierzchni, Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów 2003.
6. Przygocki W., Włochowicz A.: Fizyka polimerów. PWN, Warszawa 2001.
7. Rogowska R.: Uproszczony sposób wyznaczania swobodnej energii powierzchniowej powłok osadzanych techniką Arc-PVD. Problemy Eksploatacji, 1/2013, s. 85-100.
8. Thomsen F.: Custom-made models: from contact angle to Surface free Energy. Practical Contact Angle Measurement (5), December 2008, s. 1-5
9. Woźniak K.: Obróbka powierzchni w wygładzarkach pojemnikowych. Wydawnictwo naukowe PWN, WNT, 2017, s. 36, 75.
10. Żenkiewicz M.: Adhezja i modyfikowanie warstwy wierzchniej tworzyw wielkocząsteczkowych. Wyd. Naukowo-Techniczne, Warszawa 2000.