Contemporary Engineering Sciences, Vol. 11, 2018, no. 79, 3921 - 3927
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/ces.2018.88402

Design of a Ball Burnishing Tool with Interchangeable Tip

Milton F. Coba Salcedo[1], Carlos Acevedo Peñaloza[2] and Gustavo Guerrero Gómez[3]

[1] Materials Engineering and Manufacturing Technology Research Group – IMTEF, Universidad del Atlántico, Carrera 30 Número 8-49
Puerto Colombia – Colombia

[2] Mechanical Engineering Department, Faculty of Engineering
Universidad Francisco de Paula Santander, Colombia

[3] Mechanical Engineering Department, Faculty of Engineering
Universidad Francisco de Paula Santander Ocaña, Colombia

Abstract

The following work was carried out with the goal of studying the functionality of a previously realized design of an interchangeable indenter tool for the ball burnishing process in a numerical control milling machine with several AISI 1045 specimens, to identify and corroborate changes in the final roughness obtained and the averages of the same material with the application of the process, in addition to finding improvements in the process times, to reduce the dead times that translate into lower costs, and an improvement in the surface finish.

Keywords: Roughness, burnishing, Milling machine

1. Introduction

Due to the high demand and the established requirements, the technification has become a necessity for all the industrial processes, in which the purpose is to reach better properties in the raw material (materials), tighter tolerances, and last but not least an optimization as for the design confers.

At present, the diversity of operations is quite high for the machining processes, among which milling is the most important, due to the fact that it is the process with the greatest use in the metal-mechanic industry [1]. This consists of the detachment of material with a multi-edged tool (teeth), called a milling cutter, which is in constant rotation and the movements to be treated are carried out by the workpiece [2]. The milling machine has many qualities, and its use is quite versatile due to the fact that it can machine parts with flat, complex geometries [3].

Many machine elements, after being worked by conventional machining methods, require improving their physical-mechanical properties, this because these methods introduce irregularities in the part and wear the surface of it [4], so they are subjected to a surface finishing process which is beneficial to improve their final properties. Among the processes for surface finishing, the most commonly used in the industry are hand polishing and grinding [5], but it has been shown that the implementation of this type of process represents a large part of the total machining time, unlike a process known as burnishing can be incorporated into the same machines that machine, such as a milling machine or a lathe, and thus greatly reduce the times associated with production. In addition, this process is very easy to operate and generates excellent quality final surfaces [6].

2. Methodology

Plastic surface deformation (DPS) is a method of surface treatment of parts to increase their physical-mechanical qualities, specifically hardness, surface finish and compressive residual stresses taking advantage of the plasticity of metals, which increases resistance to wear, fatigue and corrosion.

There are several procedures for the use of plastic deformation as an alternative for the surface finishing of mechanical parts, being burnishing a simple, simple and easy to apply process and it is possible to apply it to different types of parts and metals.

2.1. Review of the concepts: Burnishing

Burnishing is a cold forming surface finishing process as shown in Figure 1, that involves the application of controlled pressure to a surface by means of an indenter, either a ball or roller indenter [7]. Both procedures have the same purpose, the difference being that ball burnishing is used more for flat or complex surfaces on a milling machine and roller burnishing is used to treat cylindrical surfaces on a lathe. The roller and the ball must be made of a material with a high hardness between 58 and 65 HRC [8], the pressure exerted by the indenter plastically deforms the irregularities of the treated piece, achieving a leveling of the ridges and valleys without the need to remove the material [9].

2.2. Burnishing characteristic

Burnishing stands out among the different surface finishing processes as it not only improves the roughness of the treated part considerably, between 0.05 to 0.0 but also improves its roughness to 5 μm [10], also shows some improvements in the mechanical properties of the work piece, it has been found that it increases the useful life of the pieces due to the compressive stresses applied to the surface, due to the increase in the resistance to fatigue [7], [11], resistance to corrosion [12], resistance to wear [13], surface hardness, among others, achieving these improvements depending on the process variables.

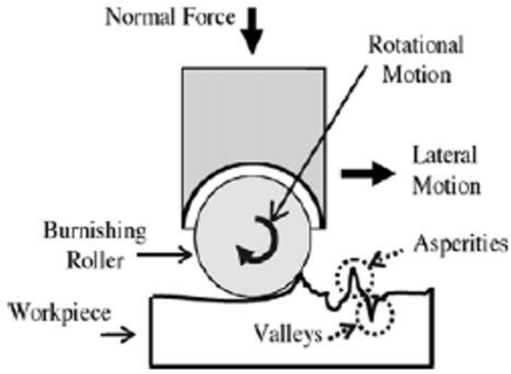

Figure 1. Burnishing process description [14]

2.3. Burnishing advantages

Burnishing stands out from other machining techniques due to its ability to increase wear resistance due to the leveling of heights and depth of the valleys on the surface to be worked. On the other hand, it also helps to remove imperfections such as porosity, fingerprints, or cracks left by the machine during the process. The burnished piece, usually has tight tolerances, surface hardening, prevents the propagation of cracks, among others.

2.4. Tool functionality test

The tests were carried out with AISI 1045 specimens, due to their wide use and utility, to form various elements in the industry. The specimen as shown in Figure 2 is 10 cm long, 7 cm wide and 1.6 cm thick.

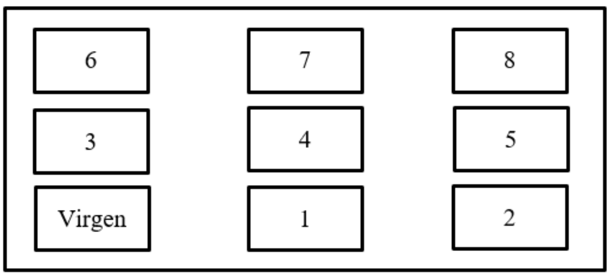

Figure 2. Distribution of zones on the surface of the specimen [15]

The dimensions of the specimen was intended to burnish 9 equal areas, ranging from the virgin area to zone 8, as shown in Figure 3.

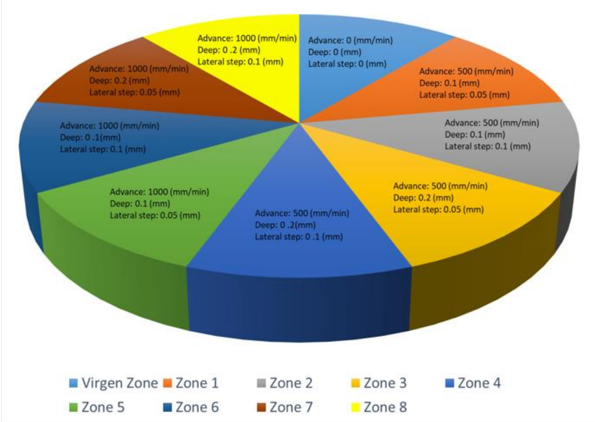

Figure 3. Buffing parameters per zone

3. Results and Discussion

In each of the areas studied, a total of 3 measurements were made to see how the *R*a, *Rq Rpk* and *Rvk* parameters influence as the 12 mm diameter indenter zones were changed [15]. In Figure 4, it is observed that of the 3 measurements taken for the roughness parameter Ra, the highest average value is given for zone 8 with a value of 3.132, in addition to finding the highest value in zone 5 and 8 3.484.

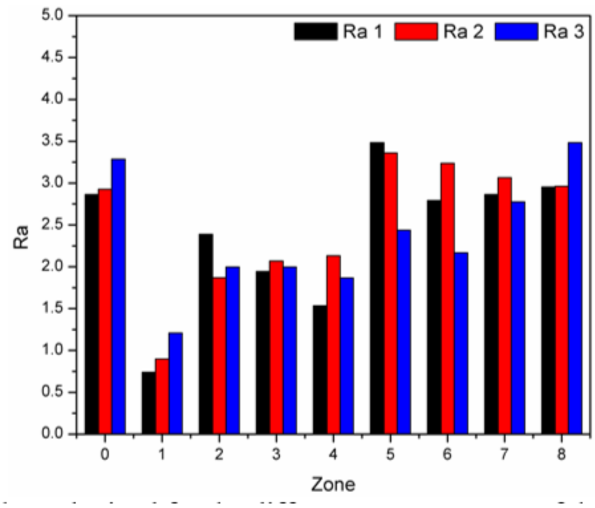

Figure 4. *Ra* values obtained for the different measurements of the different zones

The highest average value of the 3 measurements was found in zone 5 with a value of 3.904, followed by zone 8 with a value of 3.743 and ending the top with the virgin zone with 3.725, the above is shown graphically as shown in Figure 5.

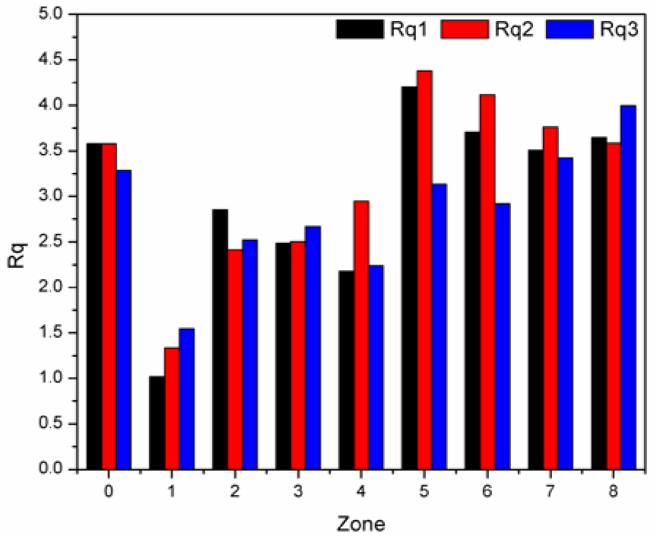

Figure 5. Values obtained from *Rq* for the different zones

Figure 6 shows that the Rpk parameter undoubtedly had a greater effect on the virgin zone than any other zone, meanwhile its next zone, 1, had the lowest average value of 1,308.

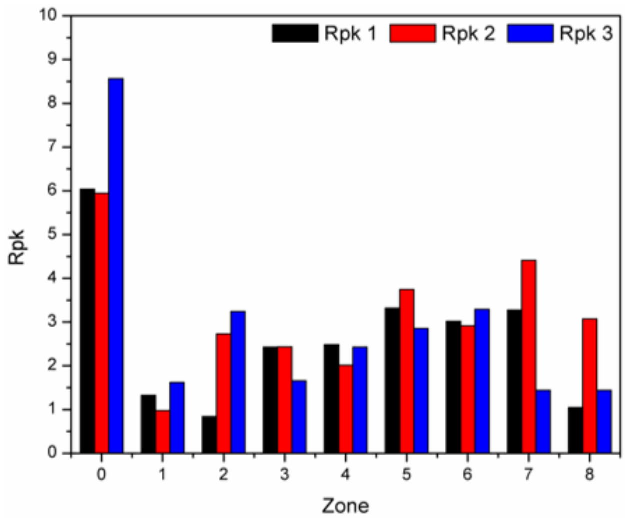

Figure 6. Values obtained from the *Rpk* study parameter for all zones

From the roughness parameters studied, the one that stood out most in terms of improvement was the Rvk factor, showing excellent measurements in the last areas studied, as shown in Figure 7. Specifically, zone 6 with an average of 8,851, however, the highest value can be seen in the first measurement of zone 4 with a value of 10,684.

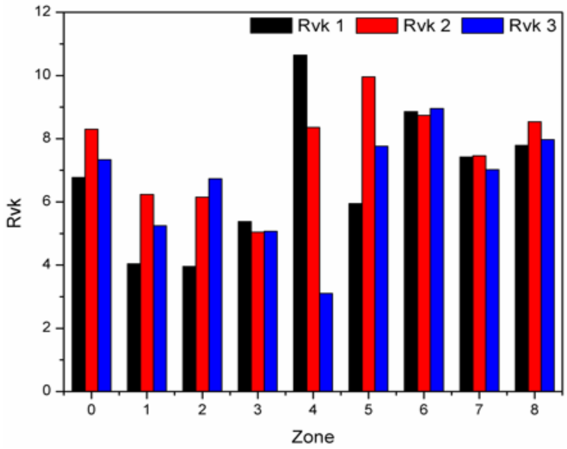

Figure 7. Values obtained from the roughness parameter *Rvk* for the different zones

4. Conclusions

Based on the conclusions obtained by the different authors, the starting point was the development of an optimal conceptual design, with which the existing characteristics were improved, offering versatility in addition to the wide field of use. To verify the properties obtained, the cutting tool was used on AISI 1045 steel specimens to improve the ratio between the reductions of the values of the surface roughness parameters. The best results were obtained in terms of reducing surface roughness when the process was executed with the 12 mm diameter spheres, 500 mm/min feed rate, 0.1 mm depth radius and 0.05 mm lateral pitch, which correspond to zone 1. Of the specimen, where an improvement of 64% and 69% was observed in the *Rpk* and *Ra* parameters respectively, in relation to the initial roughness of the specimen surface.

References

[1] L. Norberto López de Lacalle, F. J. Campa and A. Lamikiz, Milling, Chapter in *Modern Machining Technology*, Elsevier, 2011, 213–303. https://doi.org/10.1533/9780857094940.213

[2] T. Gomez, E. Águeda, J. L. García and J. Martín, *Mecanizado Básico Para Electromecánica*, 1st ed., España, 2011.

[3] B. Singh, R. Khanna, K. Goyal and P. Kumar, Optimization of Input Process Parameters in CNC Milling Machine of EN24 Steel, *International Journal of Research in Mechanical Engineering and Technology*, **4** (2013), 40–47.

[4] N. S. M. El-Tayeb, K. O. Low and P. V. Brevern, Enhancement of surface quality and tribological properties using ball burnishing process, *Mach. Sci. Technol.*, **12** (2008), no. 2, 234–248.

https://doi.org/10.1080/10910340802067536

[5] F. Klocke, S. Barth and P. Mattfeld, High Performance Grinding, *Procedia CIRP*, **46** (2016), 266–271. https://doi.org/10.1016/j.procir.2016.04.067

[6] A. Rodríguez, L. N. L. De Lacalle, A. Celaya, A. Fernández and U. J. Ugalde, Aplicación del bruñido con bola para el acabado de superficies complejas en máquinas multieje," *XVIII Congr. Nac. Ing. Mecánica*, (2010), 1–8.

[7] H. Hamadache, L. Laouar, N. E. Zeghib and K. Chaoui, Characteristics of Rb40 steel superficial layer under ball and roller burnishing, *J. Mater. Process. Technol.*, **180** (2006), no. 1–3, 130–136. https://doi.org/10.1016/j.jmatprotec.2006.05.013

[8] J. A. Travieso Rodríguez, *Estudio Para La Mejora Del Acabado Superficial De Superficies Complejas, Aplicando Un Proceso De Deformación Plástica (Bruñido Con Bola)*, PhD Thesis, Universitat Politècnica de Catalunya, 2010.

[9] A. Ghodake, R. D. Rakhade and A. S. Maheshwari, Effect of Burnishing Process on Behavior of Engineering Materials- A Review, IOSR *J. Mech. Civ. Eng.*, **5** (2013), no. 5, 9–20. https://doi.org/10.9790/1684-0550920

[10] D. Stephenson and J. Agapiou, *Metal Cutting Theory and Practice*, 2nd ed. New York: CRC, Press, 2005.

[11] P. Balland, L. Tabourot, F. Degre and V. Moreau, Mechanics of the burnishing process, *Precis. Eng.*, **37** (2013), no. 1, 129–134. https://doi.org/10.1016/j.precisioneng.2012.07.008

[12] K. Pałka, A. Weroński and K. Zaleski, Mechanical properties and corrosion resistance of burnished X5CrNi 18-9 stainless steel, *Journal of Achievements in Materials and Manufacturing Engineering*, **16** (2006), no. 1, 57–62.

[13] D. Mahajan and R. Tajane, A Review on Ball Burnishing Process, *Int. J. Sci. Res. Publ.*, **3** (2013), no. 4, 1–8.

[14] P. Kumar and G. K. Purohit, Design and Development of Ball Burnishing Tool, *Int. J. Eng. Res. Tech.*, **6** (2013), no. 6, 733–738.

[15] K. Lopez, E. Sanchez, M. Coba, *Diseño Y Fabricación De Una Herramienta Para Bruñido Con Indentador Esférico Intercambiable*, PhD Tesis, Universidad del Atlantico, 2017.

Received: August 21, 2018; Published: September 18, 2018