Experimental Study of Effective Parameters on Honing Process of Cast Iron Cylinder

Saeed Saki Entezami[1*], Masoud Farahnakian[2], Ali Akbari[2]
[1]Department of Mechanical Engineering, Jasb Branch, Islamic Azad University, Delijan, Iran
[2]Department of Mechanical Engineering, Najafabad branch, Islamic Azad University, Isfahan, Iran
[*]Email of Corresponding Author: saeed.s.entezami@gmail.com
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Abstract
Honing is a process for finishing surfaces to obtain smooth surface. This process is used for final polish of inner parts such as engines cylinders. Optimizing this process has always been a big challenge for mass production of cylinder blocks of internal combustion engines. Honing process has some variable parameters, thus to get their optimum rates the automobile cylinders were tested. In this research, experiment design was done using Taguchi method and to make input constant parameters of the test consistence, cylinder was bored using boring machine and in the next phase, cylinder was honed according to the design of experiment. Abrasive particles were selected from the material of carbide silicone stone and the variable parameters considered in this test were tangential speed, grain size, and the number of tools course. In order to measure surface quality of each cylinder, roughness tester machine was used and surface quality considered as output parameters of machining. Then, the results of the test were studied and analyzed on software environment. According to the tests conducted, the optimum values of mesh stone of honing and optimum values of numbers related to the course number and rotation were identified on the best state.

Keywords
Honing, Cast iron cylinder, Honing parameter, Design of experiment

1. Introduction

Honing is a process for finishing surfaces to obtain smooth surface. This process is used for final polish of inner parts such as engines cylinders. After achieving proper wall surfaces, this process is implemented to achieve ideal topography so that the pre-determined dimensional tolerances are matched with the surface roughness. This process is done by common machining processes such as drilling and boring [1]. The friction between the piston assembly and cylinder liner surface accounts for about a half of the total frictional losses in the IC engines and it should be minimized withproper topography. Additionally, the noxious emissions like HC–, CO–, CO_2 and NO_x are controlled by this method [2]. Cylinder liner production accounts for a significant fraction of the total cost of engine manufacture, so reduction in bore honing time with a great quality is necessary. Therefore, optimization of this process is very important [3]. This process is done by means of a honing head provided by abrasive stones.Simultaneous linear and rotational movement cause material removing and lead to a cross-hatch roughness pattern that is used as a channel net for oil distribution on the interior surface of a cylinder [4]. In addition to increasing the life of the engines, the flow of oil in grooves causes the ease of movement of moving partsin honed cylinder. Figure 1 illustrates the process of honing. The stones fixed on the honing tool are activated on 3 axes: a rotation $\omega(t)$, an axial translation z(t) and a radial expansion r(t). This axial expansion aimed at applying the stones to the surface of the cylinder bore can be conducted according to position, using a position control with an electromechanical activator, or through pressure using a hydraulic jack [5].

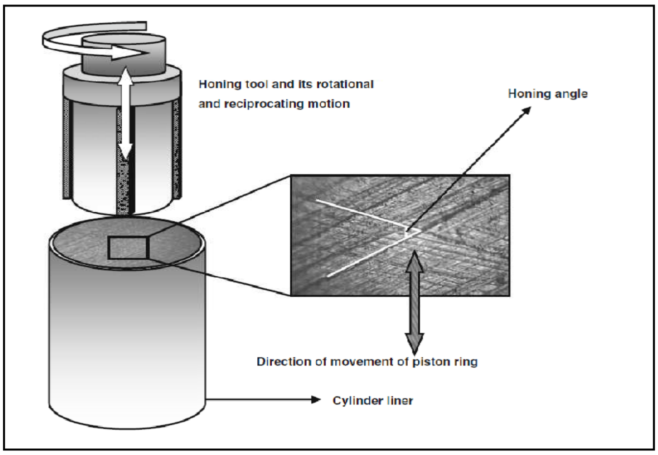

Figure1. Honing process schematic [6]

Several factors influence surface roughness and material removal rate in internal honing. On the onehand, parameters related to the honing machine like linear speed, tangential speed, pressure of abrasive stones on the workpiece anda kind of coolant are used. On the other hand, parametersrelated to abrasive stones are type of abrasive, grain size of abrasive, type of binder and density of abrasive. The high number of parameters influencing the smoothness in this process complicates the possibility of simulating and analyzing of it. So, this process is studied practically in most of the researches[4]. It is well known that a reduction of abrasive grain size decreases surface roughness in honing processes. In the usual range of honing pressure, a higher pressure increases surface roughness, and increasing tangential speed decreases roughness slightly. Roughness variability has been reported in different machining processes, in which the performance of several measurements will result in different values. A large variability in roughness measurements is commonly identified, especially in machining processes like grinding and honing in which abrasive tools are used. This occurs not only due to the distribution size of original abrasive grain used in manufacturing the abrasive tool, but also because of the following phenomena: material side flow, built up-edge phenomena and vibrations, as well as the fact that some abrasive grains which are removed from the abrasive tool surface may remain embedded in the workpiece surface producing a crater on the workpiece surface [1].
Many researches have been done on the honing process up to now. In 2003 Gouskov [7] and in 2009 Voronov [8] simulated and examined tool's vibration behavior in this process. In 2009 Pawlus and his colleagues evaluated parameters governing honing process and the effect of pressure on this process [9]. In 2013 Goeldelet al. examined and studied the effect of acceleration and velocity parameters on the quality of the surface obtained from honing process [5]. In this study, to achieve optimal values of the honing process variable parameters, they were studied on a cast iron cylinder through Taguchi method and then the results were analyzed in a software environment, and also the optimal values of honing stone mesh and the optimal value of numbers related to course number and tangential rotational speed were identified in the most appropriate condition.

2. Materials and equipment

This research was done on a vehicle cylinder made from cast iron with internal diameter of 87 mm and length of 200 mm. Cast iron is a prominent material in building vehicle cylinders. The kerosene is used as honing fluid and abrasive used was SiC (silicon carbide) in all tests.

For boring the holes, a portable boring machine Khodayar model AP4 with 47-100 mm diameter, maximum machining length of 220 mm, spindle speed of 350 rpm, and feed of 0.11 mm were used [10].For the implementation of the process, Vch 500 Korgholi honing machine with maximum diameter of 300 mm and a vertical stroke with length of 1370 mm and a spindle speed 40-300 RPM were used.

Roughness of each cylinder was measured at 10 mm from thecylinder's end, in order to avoid effect of acceleration/decelerationof the honing head on roughness. Three measurements were taken along a circumference in the internal surface of the cylinder.A M2 petro meter roughness meter was employed at a measuring speed of 0.5 mm s^{-1}. In this measurement, three parameters of Ra- Rz were evaluated. In order to reduce variability among values measuring the value at three points from the same internal circumference, which are separated by 120◦ and then by using the mean value, was obtained for each workpiece.

3. Experimental procedure

To study the variable parameters of machining on honing process, Taguchi design of experiment was used. The variable parameters in the honing process are as following: tangential speed of the cylinders V_t (m/min), abrasive grain size and course number. Honing pressure and cross-hatch angle were considered constant and linear speed of the honing head was determined according the cross-hatch angle of 45 degree.

3.1 Taguchi design of experiment

In this study, based on the recommendation of technical papers and several primary experiments, three levels for cutting parameters were selected. The Taguchi design used is a standard L9 orthogonal array (OA). The levels of the factors and the L9 standard orthogonal array are presented in Tables 1 and 2, respectively. The process of boring is shown in Figure 2.

Table1. Levels of variables affect the machining

Parameters	tangential speed (m/min)	grain size(mesh)	course number
1	22	150	10
2	33	180	15
3	44	220	20

Table2. placement of Parameters test

Vc	M	C
80	150	10
80	180	15
80	220	20
120	150	15
120	180	20
120	220	10
160	150	20

160	180	10
160	220	15

Figure2. Boring process

Next, the process of honing cylinder openings was conducted in accordance with the design (Figure3). Each of the series of experiment is done. After the honing process, the measuring of surface quality of each opening separately is done as described in Figure 4.

4. Results and discussion

After performing all the steps of measuring the results of quality of test, results were considered as the output which is shown in Table 3. With respect to the above test, diagrams of the rotation number (C1), mesh number (C2), and the number of cycles (C3) can be illustrated as shown in Figure 5.

Table3. Experiment results

V_t (m/min)	Mesh size	course number	Surface roughness (Ra)	ROW
80	150	10	1.37	1
80	180	15	1.35	2
80	220	20	1.28	3
120	150	15	1.9	4
120	180	20	0.86	5
120	220	10	1.3	6
160	150	20	1.56	7
160	180	10	1.74	8
160	220	15	1.4	9

Figure3.Honing process

Figure4. Measuring surface roughness

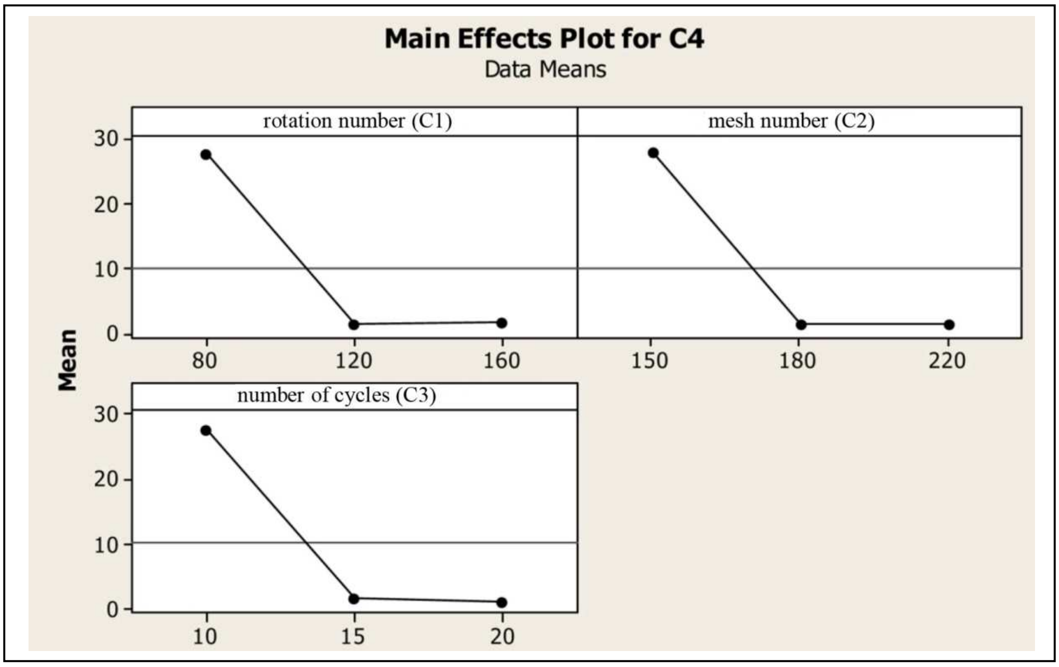

Figure5. Relations between surface roughness and experiment factors

Results indicate that by increasing tangential speed, the surface roughness is decreased and by decreasing tangential speed, the honing stone wear is increased. Coral et al. in a research came to this conclusion that the tangential speed has a little effect on the roughness, thus to measure the coarse and moderate size of grain, higher tangential speed causes a lower roughness and this is because cutting is occurred at a higher speed. Conversely, to measure a small grain, roughness is increased to a very low extent with a tangential speed for many roughness parameters. When a small size of grain is used, surface roughness resulted from geometry factors is low.

Thus, the effect of other factors such as vibrations would be significant. Vibrations effects for a higher tangential speed values in relation to the lower speeds would be more important and led to a higher roughness [1]. In the number of rotation at number 80, level of surface quality isminimum and by elevating the number of rotation at about 120 rpm,the value of surface quality remains constant and minimum. The quality is the bestwhen mesh is 180 and it can be concluded that the turning components in this stone mesh are at the best state for the cast iron. Coral et al. also came to this conclusion in their studies that the coarser is the size of the grain, the more will be the surface roughness so that when the size of grain is higher, the signs left on the surface of the part become deeper and the surface roughness will be increased [1]. In addition, it was observed that by increasing the rates of mesh and rotation number, the tools will be worn and geometric defects in the honing cylinder openingwill be resulted.

5. Conclusion

In this research, in order to select optimal rates of mesh and optimal values of numbers related to the number of course and tangential rotation in honing process, the following results were achieved:

Regarding the obtained diagrams in the paper, it may be said that at the rotation number of 80, the rate of the surface quality is at the lowest mode and by increasing the rotation number about 120 rpm, the rate of the surface quality is reminded as almost the lowest state and constant. When the mesh value is 180, the quality has the best state and it may be concluded that the cutting components in this stone mesh is at the best state for cast iron. Higher values in mesh and the rotation number not only do not cause the surface quality but also the possibility of more wear of the tools is as well as the generation of geometric imperfection in the openings being honed. The suitable number of cycles is one of the factors which have much effect on the surface quality. Therefore, with respect to the resulted diagrams, the suitable number of cycle is 15 cycles.

6. References

[1] Buj-Corral, I. and Vivancos-Calvet, J. 2011. Roughness variability in the honing process of steel cylinders with CBN metal bonded tools, Precision Engineering, 35, 289–293.

[2] Dimkovski, Z., Anderberg, C., Robert Ohlsson, B. and Rosén, G. 2011. Characterisation of worn cylinder liner surfaces by segmentation of honing and wear scratches, Wear, 271, 548–552.

[3] Sabri, L., Mezghani, S. and El Mansori, M. 2010. A study on the influence of bond material on honing engine cylinder bores with coated diamond stones, Surface & Coatings Technology, 205, 1515–1519.

[4] Buj-Corrala, I., Vivancos-Calveta, J. and. Coba-Salcedo, M. 2014. Modeling of surface finish and material removal rate in rough honing, Precision Engineering, 38, 100– 108.

[5] Goeldel, B., El Mansori, M. and Dumur, D. 2013. Simulation of roughness and surface texture evolution at macroscopic scale during cylinder honing process, Procedia CIRP, 8, 27–32.

[6] Lawrence, D. K. and Ramamoorthy, B. 2011. An accurate and robust method for the honing angle evaluation of cylinder liner surface using machine vision, Int. J. Adv. Manuf. Technol., 55, 611–621.

[7] Gouskov, A. M., Voronov, S. A., Butcher, E. A. and Sinha, S. C. 2003. Influence of honing dynamics on surface formation, Proceedings of the ASME Design Engineering, Technical Conference, 5C, 2239-2245.

[8] Voronov, S. A., Gouskov, A. M. and Bobrenkov, O. A. 2009. Modeling of bore honing, International Journal of Mechatronics and Manufacturing Systems, 2(5-6), 566-579.

[9] Pawlus, P., Cieslak, T. and Mathiac, T. 2009. The study of cylinder liner plateau honing process, Journal of Materials Processing Technology, 209, 6078–6086.

[10] Web site: http://www.khodayarco.com