

A Review on Evaluation of Geometric Characteristics of VMC Machined Components

¹Akash B. Patel, ²Prof. (Dr.) P. M. George, ³Prof. C. P. Mazmudar

¹M. Tech. Student, ²Professor & Head, ³ Assistant Professor

¹Department of Mechanical Engineering,

¹B.V.M. Engineering College, V. V. Nagar, Anand, India

Abstract: Various researchers have investigated the effect of predominant machining parameters namely cutting speed, feed rate, depth of cut and depth to establish their influence on responses like cylindricity, perpendicularity and circularity on the reamed hole featuring size on Aluminium 6082-T6. Analysis of variance (ANOVA) was carried out for cylindricity, perpendicularity, circularity and their contribution rates determined optimum cutting conditions for least cylindricity, perpendicularity and circularity defect obtained by using design of experiments (DOE) methodology. Since each responses has different optimal setting of machining parameters, it is required to identify the optimal level of factors that will be common for all responses, by using grey relational analysis (GRA).

IndexTerms - Reaming, Cylindricity, perpendicularity, circularity, Design of experiment, grey relational analysis (GRA), Analysis of Variance

I. INTRODUCTION

Precision reamers are used to size and correct the geometry of drilled holes either blind or through holes. Reamed blind holes are used for dowel pins meant for location. Dowel pin made from aluminium is used for part alignment in surgical instrument in medical field, molds and dies, miniature motors in manufacturing industry, hydraulic valves in aerospace, agriculture, and automotive industry, component alignment of cameras and microscopes in the research field. Greater attention has been given to dimensional accuracy as well as surface roughness of functional features by industries. However, industries experience has taught that not only dimensions but also geometry is important, probably geometry is more significant vis-a-vis function. Drilling and Reaming poses many problems encountered include GD&T requirements, surface roughness, and higher tool wear due to hardness that decrease the quality of holes. In order to minimize these machining problems, there is need to develop scientific methods to select cutting conditions to minimize the adverse effects of processes like drilling and reaming.

Geometric Dimensioning & Tolerancing (GD&T) is a system of symbols developed and used to define part shapes, feature form, orientation, run out, profile and location. It uses a symbolic language on engineering drawings and computer generated three dimensional solid models that explicitly describes theoretically perfect geometry and its allowable variations. It tells the manufacturing staff and machines what degree of accuracy and precision is needed on each controlled feature of the part. GD&T is used to define the theoretically perfect geometry of parts and assemblies, to define the allowable variation in form and possible size of individual features, and to define the allowable variation between features. It is a system based on function and interrelationship of mating features while keeping in mind manufacturing and inspection capabilities. Economy and repeatability are also key consideration given when applying geometric controls. ^[14]

II. LITERATURE REVIEW

A. A. Bezerra, A. R. Machado, A. M. Souza Jr., E. O. Ezugwu ^[1] evaluates the diameter, roundness, cylindricity and surface roughness of reamed cylindrical holes using K10 cemented carbide welded blade reamers. By using suitable cutting parameters like depth of cut, cutting speed, feed rate, helix angle, number of blades, margin size and rake face finishing of reamers. Power consumption during the reaming operation was also recorded. The best dimensional stability, surface finish as well as the lowest power consumption can be achieved when reaming at lower cutting speed of 25 m/min. The roundness and cylindricity of reamed holes can be improved by reaming at feed rates between 0.20 and 0.40 mm/rev. Machining with reamers with a helix angle between 0° and 7° produced holes with better roundness and cylindricity values. Machining with reamers with a small margin gave excellent results in relation to hole diameter accuracy, surface roughness and cylindricity.

Rattanakit Rattachanai, Soo Sein, Aspinwall David, Harden Peter, Haffner Brenden, Zhang Zhu, Arnold Dick et al. ^[2] evaluate the influence of tool material and cutting speed on tool wear, cutting forces/torque and hole quality, when reaming pre-drilled blind holes in cast, heat treated C355 aluminium alloy. All of the reamers were 5.08 mm in diameter with trials undertaken at a constant feed rate of 0.12 mm/rev. A full factorial experiment was performed to assess the influence of tool material (4 levels) and cutting speed (2 levels) when reaming pre-drilled 4.8 mm diameter blind holes in C355 aluminium alloy. Geometrical parameters roundness, cylindricity and parallelism were assessed on a Taylor Hobson Talyrond 300 system. The internal hole surface roughness (Ra) was measured on a Taylor Hobson Form Talysurf 120L fitted with a 2 µm radius diamond tipped stylus. Work piece surface finish generally improved at the higher cutting speed.

Saurin Sheth, P. M. George ^[3] investigate the effect of machining variables like cutting speed, feed rate and depth of cut (canned cycle) and optimized using grey relational analysis (GRA). Reliable experiments are conducted based on a 3³ full factorial,

replicated twice. Second order regression models are developed for predicting cylindricity and perpendicularity. Cylindricity is minimal at lower spindle speed while perpendicularity is minimal at higher spindle speed, which leads to multi objective optimization using grey relational analysis (GRA). The largest value of grey relational analysis (GRA) is achieved at the spindle speed of 1600 rpm, feed rate of 100 mm/min and depth of cut of 1 mm. Thus machining at this combination optimizes cylindricity and perpendicularity.

M. Soratgar ^[4] investigate the surface finish and dimensional accuracy were the dependent variables with speed, feed, tool diameter, and elapsed time being the independent variables. The secondary operation of reaming was also investigated to determine the increase in surface finish and accuracy versus the amount of machining time required to perform the reaming operation. From study, it is concluded that reaming improved the average surface finish and dimensional accuracy with larger diameters, drilling speed has a significant effect on the surface finish and drilling feed has no significant effect on the dimensional accuracy of reamed holes, and reaming feed has a significant effect on reamed holes.

K. Schutzer, M. Roth, E. Abele, T. Hauer ^[5] investigate the influence of process errors and tool geometry on the resulting hole quality while reaming valve guides made of sintered steel alloys. There is particular emphasis on the guiding function of reaming tools with regard to varying chamfer dimensions and back taper ratios at the secondary cutting edge. The experimental results indicate that an enlarged contact zone between the secondary cutting edge and the work piece material will lead to improved straightness tolerances.

Roshani U. Shingarwade, M. S. Harné ^[6] carried out reaming operation to determine optimum conditions for surface roughness during reaming of grey cast iron of grade SAE D7003. Taguchi L9 orthogonal array was used for the experimental design. Spindle speed, feed rate, reverse feed rate were considered for machining parameter. The optimum result can be achieved during reaming by employing high spindle speed, low feed rate and low reverse feed rate.

Reddy, Y.R.M., Prasad, B.S. et al. ^[7] the effect of cutting parameters on the hole quality and tool wear during the drilling of Al7075 and Ti-6Al-4V specimens with HSS and carbide insert drills have been investigated. A coordinate measuring machine (CMM) is employed to measure the hole diameters, circularity, and cylindricity. It is found that an increase in cutting speed led to an increase in form tolerance due to increased tool wear on the cutting edge. Hence, both the roundness error and cylindricity error values increased. Besides, it also observed that both roundness error and cylindricity error are influenced by feed rate.

Reddy Sreenivasalu, Dr. CH. Srinivasa Rao et al. ^[8] the effect of cutting speed, feed rate, drill diameter, point angle and cutting fluid mixture ratio surface roughness and roundness error were investigated in drilling of Al 6061 alloy with HSS twist drill. Grey relational analysis was employed to minimize surface roughness and roundness error via L18 (3*5) orthogonal array experimental design. Minimum surface roughness and roundness error were obtained at 25.13 m/min cutting speed, 0.3 mm/rev feed rate, 10 mm drill diameter, 110 degree point angle, 12% cutting fluid mixture ratio. Confirmation experiments showed that Grey relational analysis precisely optimized the drilling parameters in drilling of Al6061 alloy.

Chen-Chun Kao, Albert J Shih et al. ^[9] five form characteristics, the cylindricity, diameter, roundness, straightness, taper of a micro-hole using a Werth Video Check HA 400 coordinate measurement machine (CMM) with a combination of optical and contact sensors were conducted in this study. The micro-holes, about 160 μm in diameter and 0.9 mm in depth, were fabricated using the electrical discharge machining process for diesel fuel injectors.

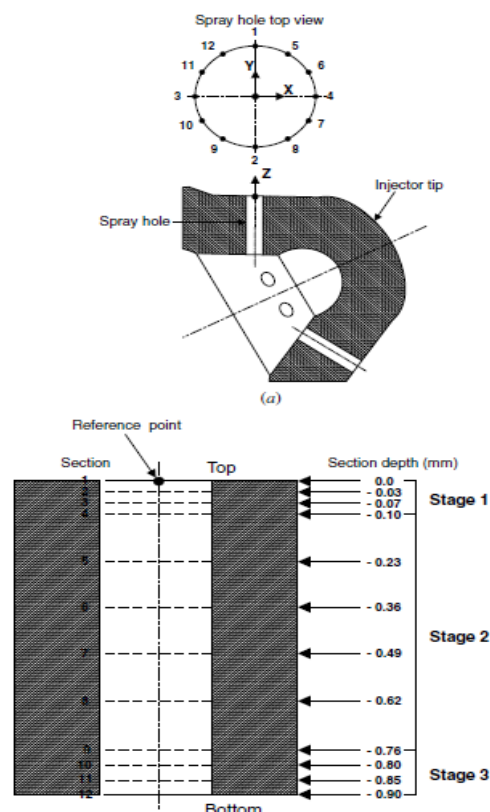


Figure 1 Shape measurement of micro-holes: depths of different section according ^[9]

Evren Kabakli, Melih Bayramolu, Necdet Geren ^[10] analyzed that various response parameters (i.e. perpendicularity, cylindricity) are affected by different controlled factors (i.e. hole diameter, hole depth, feed rate and peripheral cutting speed) due to which the deflection of tool increases and concluded that hole depth is insignificant on drilling and feed rate is insignificant mostly on cylindricity.

Saurin Sheth, P. M. George ^[11] carried out 2³ full factorial with four center points experimental design. ANOVA has been carried out to know the significance of input parameters. Achieve the desire quality more focus should be made in the selection of spindle speed and feed. The presence of curvature effect in ANOVA implies that still a higher order of regression model may lead to better results.

B. P. Patel, P. M. George, V. J. Patel ^[12] reports an experimental investigation of a full factorial design (using Minitab 16 software) performed on EN8 and EN31 materials using HSS drill with point angle 118° and helix angle 30° by varying the drilling parameters such as spindle speeds, feed and coolant ratio to determine optimum cutting conditions. It is concluded that from above result that irrespective of the material, Spindle feed is the most significant variable affecting perpendicularity in drilling operation.

III. CONCLUSION

Literature survey have revealed that the significant variables are cutting speed, feed rate, depth, depth of cut and hole diameters are optimized using optimization methods like Design of Experiments (DOE), Grey relational analysis (GRA), Taguchi method and using efficient software Minitab (Analysis of Variance (ANNOVA)), using measuring instrument like Coordinate measuring machine (CMM), Surface roughness tester, roundness tester. So, we can obtain optimum response parameter such as cylindricity, perpendicularity, circularity, roundness and surface roughness.

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