Effect of Various Process Parameters during Face Milling on Flatness and Surface Roughness in Dual Plate Check Valve – A Review

Mayank Patel[1], P. M. George[2], Dhara Trivedi[3], Saurin Sheth[4]

[1]Research Scholar, [2]Professor, [3]Assistant Professor

Department of Mechanical Engineering, BVM, V. V. Nagar, Gujarat, 388120 India

[4]Associate Professor

Department of Mechatronics Engineering, GCET, V. V. Nagar, Gujarat, 388120 India

Abstract

Milling process is one of the most widely used machining operation capable of producing various geometrical features as per the functional requirement. One among them is face milling operation, mainly used for flat geometrical features. The dual plate check valve is mainly rejected due to the leakage problem because of the valve plate and valve body do not seat accurately, owing to lack of flatness. This paper brings out the outcome of various investigations made on the effect of face milling process parameters like spindle speed, feed rate and depth of cut, which affects flatness and surface roughness. Flatness and surface roughness are important criteria for metal to metal seal of two flat components. Along with the face milling operation the hard facing, which could be achieved through MIG welding is also studied.

Keywords: *Face milling, Flatness, Surface roughness, Leakage*

INTRODUCTION

Nowadays, a large number of the components manufactured by machining. Machining processes are used to convert the work-piece created by the basic processes like forging, casting and rolling to the final product, as per the drawing, by removing excess material. The machined components require surface characteristics and dimensional accuracy to meet the functional requirement. Geometrical error occurs during the machining process and is influenced by different parameters likes work-piece hardness, tool geometry and cutting parameters such as cutting speed, feed rate and depth of cut etc., as well as machine tool capability. The CNC milling machine is one of the widely used machine tool in manufacturing process industry. To create a flat surface on the work-piece, face milling operation on CNC milling machine can be used. The surface roughness characteristic is an important criterion for product quality and functional requirements. GD&T plays an important role in the manufacturing process to produce work-piece features meeting functional requirements. GD&T enables controlling of geometrical error on machined feature of the work-piece.

Dual plate check valve is a type of non-return check valve. It is lightweight and small in size compared to conventional swing check valve or lift check valve. This kind of valves offer minimum pressure drop than conventional swing or lift check valve. This type of valves used in the cryogenic application, fire safe design, oil and petrochemical industry, water supply systems, etc. In the dual plate check valve leakage is occurs due to the valve plate do not seat accurately on the valve body as per the design standards (API 594 and API 6D). Control of flatness and surface roughness on the valve body and valve plate is required to overcome the leakage problem, which is an important criterion for metal to metal leak-proof seal.

FACE MILLING

Face milling is the most common milling operation to achieve flat or stepped surface on the work-piece. In the face milling operation, the machined surface of work-piece is perpendicular to the cutter axis.

GD&T

"GD&T is a symbolic language used to specify part shape, size, form, profile, runout, orientation and location". Features tolerance with GD&T reflected the actual relationship between two mating parts. By using GD&T drawing offers the best opportunity for uniform interpretation and cost-effective assembly. Geometric dimensioning and tolerancing was created to ensure the proper assembly of the mating parts as well as to improve quality economically. [1] Most of the manufacturing industry use GD&T standard ASME Y14.5-1994. [2]

FLATNESS

Flatness is a surface form control. A perfectly flat surface is defined as all its elements in the same plane. Flatness features control is not related to any datum, while tolerance zone is to be considered is the distance between two parallel planes is shown in *Fig. 1*. [3]

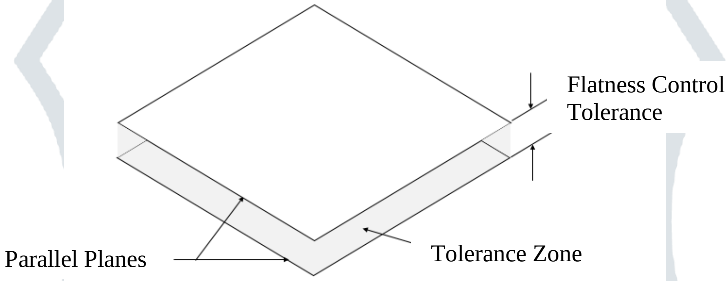

Fig. 1. *Flatness Tolerance*

Flatness measurement according to standard ISO 12781-1 in two categories: 1. Minimum Zone Reference Plane Method, 2. Least Square Reference Plane Method, which is used in most of the coordinate measuring machine (CMM).

SURFACE ROUGHNESS

"Surface roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If this deviation is large, the surface is rough and if they are small, the surface is smooth". Controlled surface finish, will facilitate good wear resistance of features, improve the fatigue resistance, reduce corrosion, reduce frictional wear and allows fine geometrical tolerances. Surface roughness also influences the flatness. If surface roughness is high then flatness inspection error will be high and for lower surface roughness, sampling point and flatness inspection error will reduce. Surface roughness is measured mostly using Talysurf surface roughness tester. [4]

In dual plate check valve, manufacturing process mainly focus on metal to metal seal to prevent leakage during the use of valve. WCB material is used as a base material of the dual plate check valve. Hard facing process is done on two mating surfaces of the valve (i.e. face of valve plate and seat of valve body) to increase the hardness of the material using Mig welding process. T Patel *et al*, [5] investigated welding parameters like welding speed, welding current and gas flow rate affects the weld height. The research revealed that contribution of welding speed 28.24%, welding current 25.19%, and gas flow rate 12.5% on welding height. S Sheth *et al*, [6] investigated effects of welding parameters welding speed, gas flow rate and welding current on the quality of weld joint. A fuzzy logic model has been developed to predicting weld width in the context of input parameters.

The face milled valve seatings are ground to achieve close geometrical and dimensioning tolerance. On the valve plate the grinding operation can be easily performed, but it is very difficult to perform grinding on the seat of the valve body. This leads to the face milling operation which is the most economical process to achieve the desired geometrical tolerances on the valve seat. Face milling process parameters having influence on the flatness and surface roughness. C Felho *et al,* [7] introduced the method and modeling procedure for calculating the measured and the theoretical roughness values. S Sheth *et al,* [8] investigated cutting parameters speed, feed and depth of cut were performed face milling operation of WCB material, while responses are taken as flatness and surface roughness. The experiment has been performed using 2^3 full factorials with four centre point design of experiments. It has been concluded that depth of cut having less influence on flatness and surface roughness than the spindle speed and feed rate. S Sheth *et al,* [9] optimized machining parameters will give the good dimensional and geometrical accuracy to meet the functional requirements. Face milling operation has been performed on WCB material. After the experimental results, the suggested optimal machining parameters like spindle speed of 1200 rpm, depth of cut as 0.1 mm and feed rate as 150 mm/min have been achieved using Grey Relational Analysis. Which gave the optimal value of flatness (0.019 mm) and surface roughness (2.1035 µm). P Chauhan *et al,* [10] inspected face milling parameters during machining of CF8M material using "2^3 full factorial design". The result indicated that the speed and feed has more significant parameters on the flatness, while speed has more significant parameters on surface roughness. S Rawangwong *et al,* [11] inspected the effect of depth of cut, feed rate and speed on the surface roughness during aluminium semi-solid 2024 face milling. This work is carried out on CNC milling machine with 63 mm diameters fine type carbide tool using completely randomized block factorial design. The result showed that the feed rate and speed having significant influence on surface roughness, while depth cut is less. Also concluded that higher level of speed and lower level of feed rate will give the optimal value of surface roughness. Patricia *et al,* [12] developed a geometrical model to predicting surface roughness during face milling using square inserts Input parameters are considered as: axial depth of cut, different values of tool nose radius, cutting speed and feed per tooth. This model allows decreasing trial and errors experiments and found optimal machining parameters for surface roughness. S Rawangwong *et al,* [13] studied that influence of milling parameters on the "tool wear and surface roughness" in face milling of AA-7075 material using 63 mm diameters fine form carbide tool. The result revealed that the speed and feed rate were most significant factors on surface roughness, while depth of cut effect was negligible. From the regression equation found that the mean absolute percentage error of surface roughness compared with experimental value, also found that the main impact on tool wear was feed rate and speed. The outcome also showed that lower feed and higher value of speed tends to decrease the surface irregularity. X Tian *et al,* [14] investigated the influences of cutting speed on cutting forces and tool wear during face milling of Inconel 718 using sialon ceramic tools. The result shows that cutting forces increase with increase of cutting speed.

P Franco *et al,* [15] investigated influence of axial and radial runouts on surface roughness in face milling using round insert cutting tools. Pimenov *et al,* [16] studied the effects of processing parameters (cutting speed, cutting edge angle, work-piece material, feed per tooth and the cutter overhang to its diameter ratio) and tool wear on elastic displacement of the technological system in face milling. Experimental values of total elastic displacement at various tool flank wear agree well with the mathematical model to validate the adequacy of the suggested model prediction. C Felho *et al,* [17] introduced a method for determining theoretical surface roughness during face milling operation considering the run-out of the inserts.

M Hadžistević *et al,* [18] investigated influence of surface quality on the assessing flatness error when inspection performed on coordinate measuring machine (CMM). Flatness error was estimated using different sample size and processing method of face milling and grinding. ANOVA was performed for determining the impact of the variables. It has been determined that the assessment of flatness error is affected by the processing method, the associative method and number of sample points used, but not by surface roughness. R Raghunandan *et al,* [19] examined the selection of sampling size, sampling point locations and nature of the manufactured surface will play a key role in the inspection of the machined surface. It has been concluded that the effect of surface quality in determining the sampling strategy for accurate determination of flatness error, while inspection on the CMM. Surface roughness value was large then increasing the sampling size and flatness inspection error also increased. S Lakota *et al,* [20] gives flatness measurement methods according to the standard “STNPCEN ISO/TS 12781-2: 2008”. There are different extraction strategy applied to taken points by randomly or patterned for inspection of flatness is shown in *Fig. 2*.

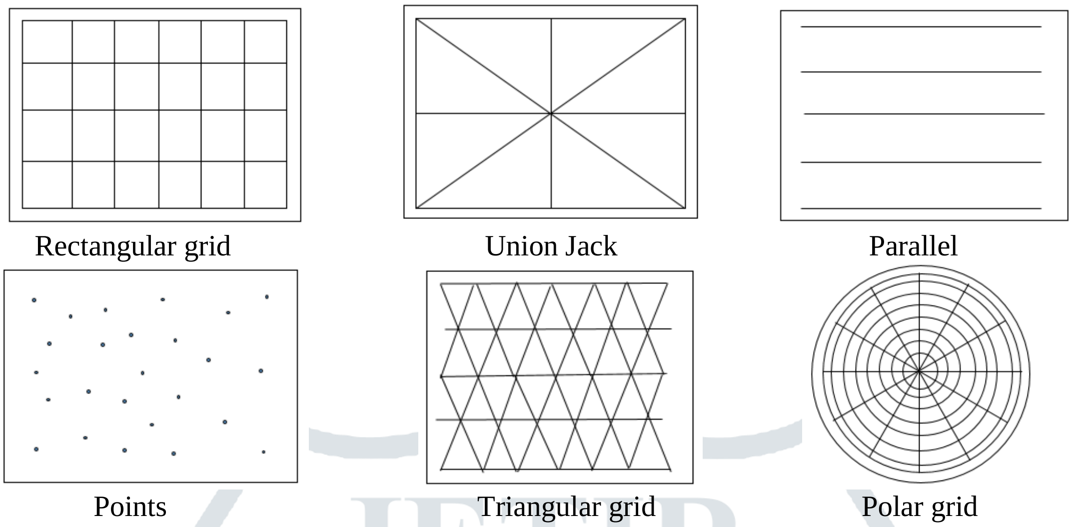

Fig. 2. *Points Extraction Strategy*

M Sukumar *et al,* [21] developed Artificial Neural Network (ANN) for predicting surface roughness. Face milling operation has been performed using Taguchi method with various process parameters like depth of cut, speed and feed rate. D Bajić *et al,* [22] optimized the cutting parameters feed rate, depth of cut and cutting speed have been examined in face milling. The mathematical model developed to predict the surface roughness using ANN and regression analysis. The result revealed that feed rate and cutting speed affect the surface roughness, but feed rate is more significant. While the depth of cut has a negligible effect on surface roughness. The minimum surface roughness can be attained by setting the cutting speed as high as possible and the feed as low as possible. S Kannan *et al,* [23] developed empirical models for predicting MRR and surface roughness in the context of input milling parameters. Optimum machining parameters are achieved for surface roughness using Genetic Algorithm (GA). For the better surface roughness, the lower level of depth of cut, lower feed rate and higher level of speed were recommended. M Selvam *et al,* [24] optimized the face milling parameters. Experiments was performed on the vertical CNC milling machine with 25 mm cutter diameter using coated carbide insert for machining of mild steel. The cutting parameters like feed rate, number of passes, speed and depth of cut were selected for experiments using Taguchi method. S Kannan *et al,* [25,26] investigated the milling parameters effects on the MRR and surface roughness during face milling operation of Inconel 718. The authors developed empirical model using regression analysis, while GA was used to found out the optimal input parameters combination for best surface roughness. Selection of machining parameters like feed rate, speed and depth of cut plays an important role in improving surface quality of the parts. The authors developed an empirical models with RSM for surface roughness and MRR of copper work-piece material. The better surface finish was achieved at the higher level of cutting speed, lower feed and depth of cut. Optimal machining parameters was achieved using Genetic Algorithm. S Sheth *et al,* [27] investigated effects of cutting parameters like speed, feed and depth of cut on flatness and surface roughness. Face milling operation have been performed using 2^3 full factorials with four centre points. Fuzzy logic model is developed for predicting surface roughness and flatness. From fuzzy surfaces, it is concluded that good surface roughness was attained at higher speed, higher depth of cut and lower feed rate, while flatness at higher speed, lower depth of cut and lower feed rate. P Kovac *et al* [28] studied the effects of machining parameters on the surface finish in face milling operation. They also developed regression & fuzzy logic models. The result accomplished that fuzzy logic model gives effective prediction of surface roughness during face milling.

CONCLUSION

From the literature review, it can be concluded that, machining process parameters like spindle speed, feed rate and depth of cut largely influence the flatness and surface roughness during face milling operation. The work-piece hardness, cutting edge geometry, tool wear, cutting tool insert, etc., also plays an important role on the surface finish in face milling operation. The significance of the milling process parameters will be concluded from the results of ANOVA. Input parameters are optimized using various techniques like GRA, GA, RSM, Taguchi, neural network to achieve optimal flatness and surface roughness. Developed fuzzy logic model for predicting flatness and surface roughness. In the future work, investigation of the machining process parameters on surface roughness and flatness during face milling of different materials like CF3M, CF8M, Monel, Aluminum Bronze, Inconel and Super duplex, which is used in the manufacturing of dual plate check valve.

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