CONTRIBUTION TO EVALUATION OF FUNCTIONAL SURFACES OF BALL VALVE BODY

ČEPOVÁ Lenka[1], SADÍLEK Marek[1], ČEP Robert[1], ŠOKOVÁ Dagmar[1]

[1]*VSB - Technical University of Ostrava, Faculty of Mechanical Engineering, Ostrava, Czech Republic, EU,*
lenka.cepova@vsb.cz, marek.sadilek@vsb.cz, robert.cep@vsb.cz, dagmar.sokova.st@vsb.cz

Abstract

The article deals with the evaluation of the functional surfaces of the ball valve body, which are different from other parts of the ball valve. First is the requirement of decreased roughness of the machined surface of the catch surfaces and areas where it will be used a special sealing element, and also in dimensional tolerances and, ultimately, the position tolerances as coaxiality, parallelism and perpendicularity.

Keywords: Surface roughness, position tolerances, machining, ball valve

1. INTRODUCTION

The cryogenic ball valve is a special shut-off valve operating at very low temperatures. From standard valves, it is distinguished by a number of details, both in the machining process, the sealing system used and the input semi-finished product from which it is made. It is only used to fully open or close the flowing media, not to allow throttling. Such fittings are installed in pipelines where the working substance is in the range of negative temperatures from -42 ° C to -273 ° C. They are designed for non-aggressive and aggressive liquids and gases without mechanical impurities.

The term cryogenic armature is used for devices that carry working materials that are gaseous at room temperature around 20 ° C but condense to a liquid at certain minus temperatures. The temperature limit of cryogenic fittings is the boiling point of propane, ie -42 ° C. In the cryogenic armature, when coupled to the higher temperature substance, vapors are formed, thereby increasing the volume and increasing the pressure.

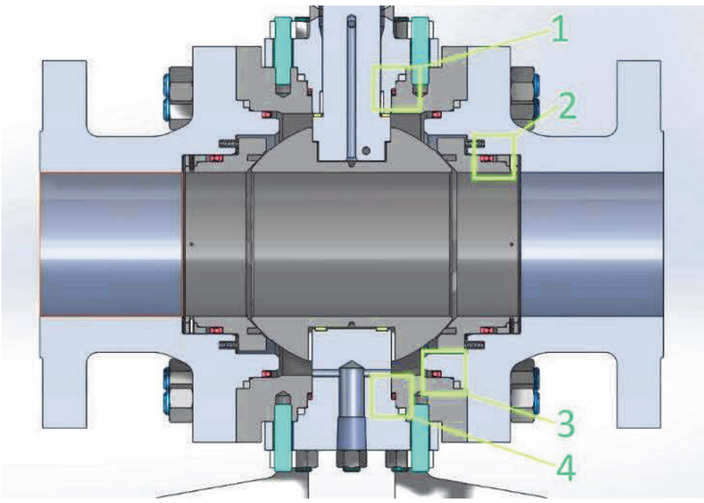

Figure 1 Cut ball valve with marked structural units
1st area - extension / body; 2nd area - saddle / lid; 3rd area - lid / body; 4th region - lower pin / body

Therefore safety is very important during fitting construction. Production as such can be called standard production, but requirements for increased precision, geometric accuracy and surface roughness are required in the design documentation. In the drawing documentation is required parameter Ra = 0.1 to 0.2 μm (Ra is the arithmetical mean deviation of the assessed profile). A special Omni-Seal sealant that resists these low temperatures will be used here. This seal can be used provided that, in addition to very good machining of the bearing surfaces, high dimensional accuracy has to be ensured. The tolerances of the sealing diameters are determined according to the manufacturer's recommendations. Areas where the drawing documentation prescribes parameter Ra = 0.1 to 0.2 µm are shown in **Figure 1**.

2. FINISHING METHODS APPLICABLE TO CRYOGENIC BALL VALVES MACHINING

It can be reached with the use finishing machining parameter Ra = 0.4 to 0.8 µm and tolerance IT 4 to 6. This parameters can be reached by cubic boron nitride, ceramics or diamond cutting tools during high cutting speeds. The following finishing options can be proposed.

Variants using the existing machinery (machine tools) of the company:

1) Original solution - Polishing on the existing 5-axis Hermle C60 or the SP430 CNC.
2) Polishing on an existing machine where was used prefinishing operation (Hermle C60, SP430 CNC).
3) Polishing using an auxiliary device on a carousel lathe.
4) An additional superfinishing device on SP430 CNC lathe.

Variants without material removal:

5) Diamond-tip polishing tool on SP430 CNC lathe / or 5-axis Hermle C60 milling center.
6) A diamond tip polishing tool on another machine tool.

Variants with the use a new machine tool:

7) Round grinding + polishing - new machine tool.
8) Superfinishing - new machine tool.

With regard to specifications and requirements, it was decided to deal with the variant without material removal. In proposed technology was used a polishing tool with a diamond tip. For lubrication can be used cutting oil or emulsions. The tool can be used for internal and external diameters. The head can be tilt to the different angles for different surface possibilities to cut (flat surfaces, different shapes or cones). The technology is applicable after turning operations, ie on surfaces without grinding, which is also a prerequisite. The tool consists of a diamond tip and spring (supplied in several designs according to hardness). It is necessary to choose a suitable spring hardness. Two tool paths (cuts) are expected for this proposed technology [1].

Figure 2 External reaming tool with diamond tip

Figure 3 Internal reaming tool with diamond tip [2]

3. MEASURING OF PARAMETERS

Measurement of geometric deviations and surface roughness was performed on the prototype body, see **Figure 4**. It was a cryogenic ball valve DN100.

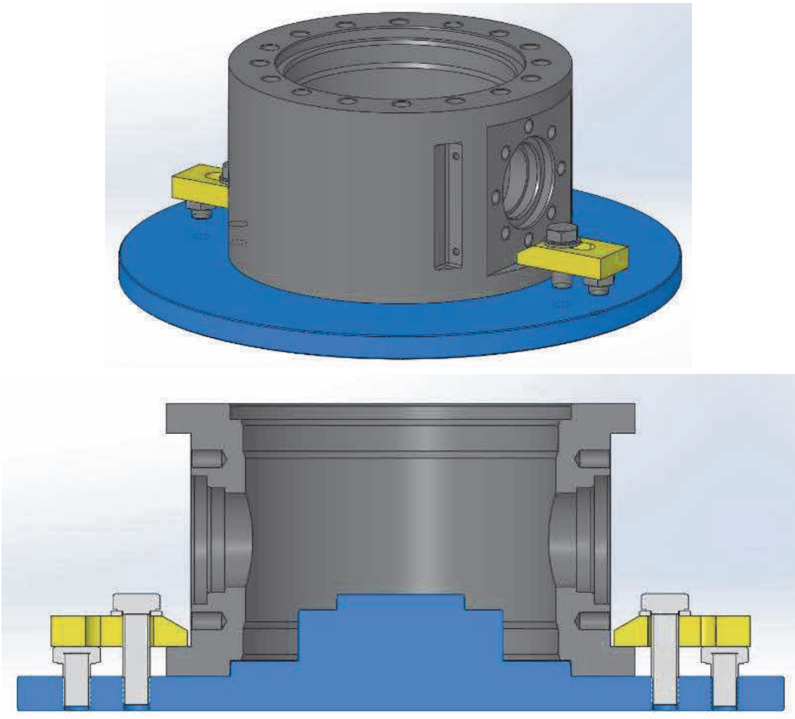

Figure 4 A preview of the cryogenic ball valve DN 100

3.1. Surface Roughness

Figure 5 shows areas where roughness parameters were measured. The parameters Ra, Rz and RSm were measured during the surface roughness measurement (according to ČSN EN ISO 4287).

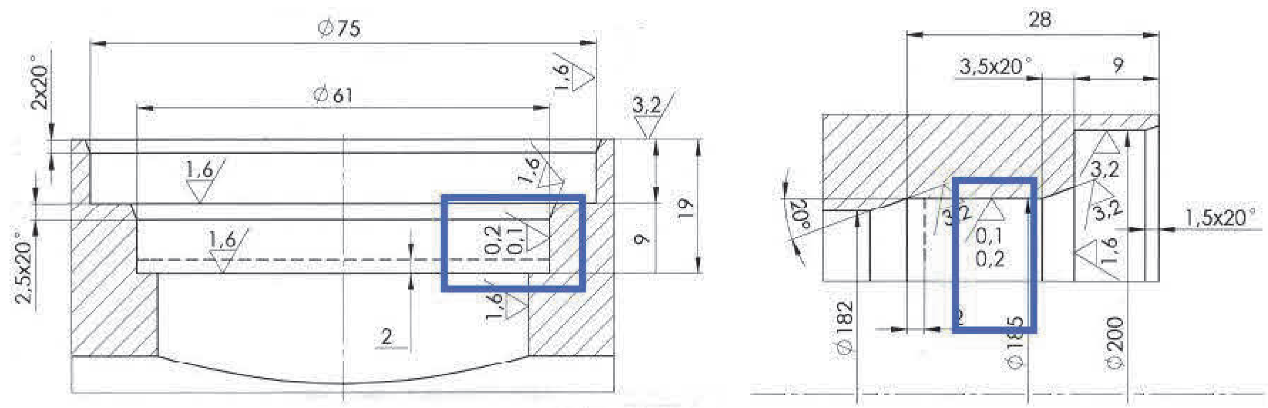

Figure 5 Designation of surfaces with low Ra parameters requirement

Measurement analysis was determined with a standard uncertainty of type A (u_A), a standard uncertainty of type B (u_B) and a combined standard uncertainty (u_C) which is a positive square root of the sum of quadrates of standard uncertainties u_A and u_B [3], [4]. Furthermore, an expanded uncertainty U was determined, which is a multiple of the combined uncertainty u_C. The results of the measured surface roughness parameters are given with the expression of the expanded combined uncertainty U_C.

Table 1 Cover position - Average values including uncertainty

	Cover Position	Note	Rz	±	Uc	Ra	±	Uc	RSm	±	Uc
			[μm]			[μm]			[μm]		
1	Side 2	λc=0.8 μm	1.60	±	0.48	0.16	±	0.05	22.83	±	21.95
2	Side 1	λc=0.8 μm	1.32	±	0.20	0.18	±	0.02	125.37	±	21.92
Variance of Values [μm]			0.28			0.02			102.53		

Table 2 Pin position - Average values including uncertainty

	Pin Position	Note	Rz	±	Uc	Ra	±	Uc	RSm	±	Uc
			[μm]			[μm]			[μm]		
1	Side 2	λc=0.8 μm	0.98	±	0.12	0.10	±	0.01	119.87	±	33.52
2	Side 1	λc=0.8 μm	2.68	±	0.13	0.13	±	0.01	89.42	±	13.74
Variance of Values [μm]			1.7			0.03			30.45		

The measurement results are shown in **Table 1** and **Table 2**. The resulting values, shown in the tables, confirms proposed variant for finishing. This variant is suitable for compliance a requirements of the technical documentation. Values are within the specified range of parameter Ra.

3.2. Geometrical Tolerances

Prototype body (see **Figure 6**) tolerance deviations were measured: orientation (perpendicularity, parallelism) and position (alignment) (see **Figure 7**). It was measured on the Wenzel LH65 X3M Premium coordinate measuring machine, see **Figure 8**. Machine accuracy is MPEe = 1.6 + (L / 350) μm, MPEp = 1.6 μm, MPEthp = 2.2 μm [4]. Measurements were made during temperature 20 ° C ± 0.5 ° C and it was used motorized indexable head PH10M, scanning probe: SP25, module SM25-1, touching ø D = 5 mm for L = 50mm. All geometric tolerances, according to the drawing, were measured under the same conditions.

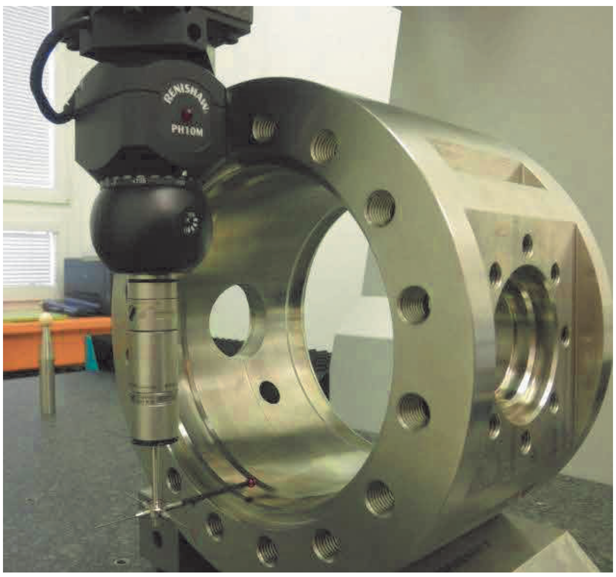

Figure 6 Measured prototype body

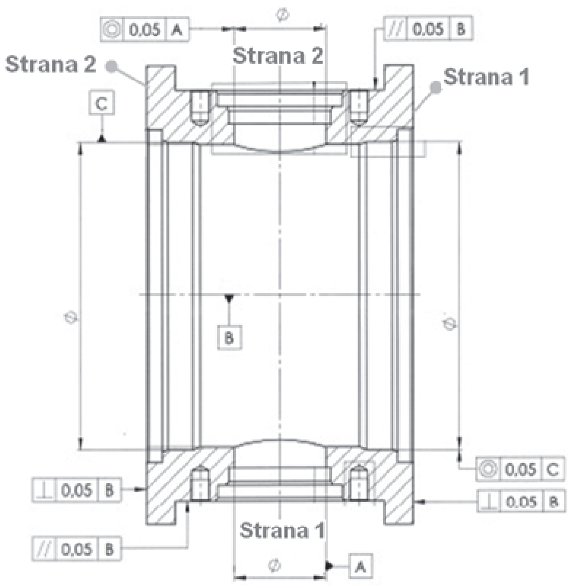

Figure 7 Geometrical Tolerances of the body

Figure 8 Wenzel LH65 X3M Premium coordinate measuring machine

Coaxiality ◎

The coaxiality measurement was checked according to the drawing documentation, which is in **Figure 8**. It was measured at the WENZEL LH65 X3M Premium Coordinate Machine. Co-ordination to base A and base C was assessed, where the packaging elements (cylinders) were measured by the MCCI (minimum circumscribed circle) method for assessing the outer surfaces. The tolerance value is max. 0.05 mm, for both cases. Both diameters were metered in three sections, for large diameters with 180 points and for small diameters with 96 points. Measured results for alignment are recorded in **Table 3**.

Table 3 Table of Measured Values for Coaxiality

Coaxiality	Tolerance [mm]	Deviation [mm]	Deviation [%]	Graphical
Base „A“, Side 2	0.05	0.019	39	
Base „C“, Side 1	0.05	0.041	82	

Perpendicularity ⊥

The perpendicularity measurement was performed on the CMM under the same conditions. The faces from the component front were evaluated from the left and right sides of the component. The assessed areas were scanned with a score of 36 points and evaluated to the base "B" (line to plane) as shown in **Figure 8**. The measured perpendicular results are recorded in **Table 4**.

Table 4 Table of Measured Values for Perpendicularity

Perpendicularity	Tolerance [mm]	Deviation [mm]	Deviation [%]	Graphical
Base „B“, Side 2	0.05	0.075	150	
Base „B“, Side 1	0.05	0.076	152	

Parallelism //

The measurement was performed on the CMM under the same conditions as in the previous cases. The surfaces from both sides of the component were scanned with 12 points, and the deviation of the parallelism was evaluated to base "B". The measured results are recorded in **Table 5**.

Table 5 Table of Measured Values for Parallelism

Parallelism	Tolerance [mm]	Deviation [mm]	Deviation [%]	Graphical
Base „B“, Side 1	0.05	0.015	30	
Base „B“, Side 2	0.05	0.007	13	

4. CONCLUSIONS

The analyzed surfaces show a large variance of measured surface roughness parameters. The range of values is determined as the difference between the maximum and minimum values of a given roughness parameter. High scattering points to flawed or unstable process conditions for the production of the component.

For the following investigations, it is appropriate to analyze other roughness parameters such as Rp and Rv, which talk about the height of the projections and the depth of the recesses, and other parameters of Rk and Rsk, which refer to the spikes and obliquities of the given surface and which account for the nature of the bearing surface. Multiple parameter evaluation of the surface has a higher predictive value for surface functionality [3].

A very important aspect is the tracking of the roughness of pre-finished surfaces after turning. It is important to concentrate on achieving and ensuring repeatable roughness of the surface after this before completion (below Ra = 1 μm). This enables the final designed operation to provide suitable and uniform input conditions to complete the given surfaces to a desired roughness of Ra = 0.1 to 0.2 μm.

The evaluation of geometric deviations: coaxiality, perpendicularity and parallelism showed that the alignment for base "A" and base "C" are within tolerance, perpendicularity for base "B" are not within tolerance and parallelism for base "B" It appears that the error occurred in the production technology, which affects the accuracy of the manufactured component [5], [6], [7], [8], [9]. The resulting values are shown in **Table 3** to **Table 5**.

ACKNOWLEDGEMENTS

This paper was supported by project MPO TRIO FV10717 Development of new series of cryogenic ball valves, their manufacturing technology and testing and from the means of state budget of the Czech Republic and by project Students Grant Competition SP2017/147 and SP2017/149 financed by the Ministry of Education, Youth and Sports and Faculty of Mechanical Engineering VŠB-TUO.

REFERENCES

[1] SADÍLEK, M., KRATOCHVÍL, J., PETRŮ, J., ČEP, R., ZLÁMAL, T., STANČEKOVÁ, D. Cutting tool wear monitoring with the use of impedance layers [Nadzor trošenja reznog alata upotrebom otpornih slojeva]. (2014) *Tehnicki Vjesnik*, 21 (3), pp. 639-644.

[2] SUPFINA GRIESHABER. [online]. [cit. 2011-13-10]. Available from z: http://www.supfina.com/Bilder/Supfina_90_e.pdf

[3] BÁTORA, B.; VASILKO, K. *Obrobené povrchy - technologická dedičnosť, funkčnosť.* Trenčín: Trenčianská univerzita, 2000. s 183, ISBN 80-88914-19-1.

[4] ČEPOVÁ, L., ŠOKOVÁ, D., MALOTOVÁ, Š., GAPINSKI, B., ČEP, R. (2016). Evaluation of cutting forces and surface roughness after machining of selected materials. *Manufacturing Technology*. Vol.16, No.1, pp.45-48. ISSN 1213-2489.

[5] DRASTÍK , F. Přesnost strojních součástí podle mezinárodních norem. Tolerování rozměrů a geometrických vlastností. Montanex 1996. 271 s.

[6] DRBÚL, M., ŠAJGALÍK, M., ŠEMCER, J., CZÁNOVÁ, T., PETŘKOVSKÁ, L., ČEPOVÁ, L. *Strojárska metrológia a kvalita povrchov vytvorených technológiami obrábania.* Žilinská univerzita v Žilina, Strojnícka fakulta, Katedra obrábania a výrobnej techniky. Available from z: http://projekty.fs.vsb.cz/064/docs/metrologie.pdf

[7] ČSN EN ISO 1101. Geometrická specifikace výrobků - Geometrické tolerování - Tolerance tvaru, orientace, umístění a házení. Praha: Leden 2014. 120 s.

[8] ČSN EN ISO 5459. Geometrická specifikace produktu (GPS) - Geometrické tolerování - Základny a soustavy základen. Praha: 2012. 80 s.

[9] MACKO, M., ILIĆ, S., JEZDIMIROVIĆ, M. The influence of part dimensions and tolerance size to trigger characteristics (2012) *Strojniski Vestnik/Journal of Mechanical Engineering*, 58 (6), pp. 411-415.