UDC 621.91.04

ANALYSIS OF METHODS OF RECEIVING SPHERICAL SURFACES OF DETAILS

MARYIA KUZNECHYK, VITALI ANISIMOV, RUSLAN KHMIALNITSKI
Polotsk State University, Belarus

Typical parts with spherical surfaces, defined requirements for precision and quality, applicable to spherical surfaces, comparative analysis of methods of cutting of spherical surfaces, the proposed method of milling of spherical surfaces at high cutting speeds.

Introduction. Currently, machine-building industry produces a large range of parts with spherical surfaces. Such parts include ball finger car, pusher hydraulic valve, ferrule, tube ball valve, segment ball valve, spherical plain bearing, ball plug, ball lever, lens, etc.

Have parts like ball pin, the tip tube ball valve, segment ball valve, spherical plain bearing, the lens is focused on the requirements for precision and quality spherical surface. And the parts such as the ball cover and ball handle the requirements for aesthetic and ergonomic design of a spherical surface.

Analysis of methods of producing parts with spherical surfaces .In modern engineering with the goal of achieving high production efficiency and reducing the cost of manufacturing parts it is advisable to reduce the proportion of mechanical processing for improving the precision of the workpieces. In this regard, the use of rental as blanks for the manufacture of parts with spherical surfaces is only appropriate in a single production when the cost of rough machining, not comparable with the purchase of special equipment, dies or molds.

When the serial production of parts with spherical surfaces, it is advisable to use a billet obtained by casting, plastic deformation and powder metallurgy. These methods allow to obtain the billet with the shape and size closest to the finished part. Depending on the quality requirements and the accuracy of the details after receiving blanks these methods can produce mechanical processing.

For use as a method of obtaining the workpiece of the casting the part material must have certain physical and mechanical properties. Casting can be harvesting any spatial forms, in particular billets with spherical surfaces.

For example in [1] the method of producing blanks for tubes ball valve based upon receipt of a print in the mold on the model. The casting has the shape of a ball, gently rolling in a truncated cone, the upper base of which is the basis of profit. After crystallization, the profit dub.

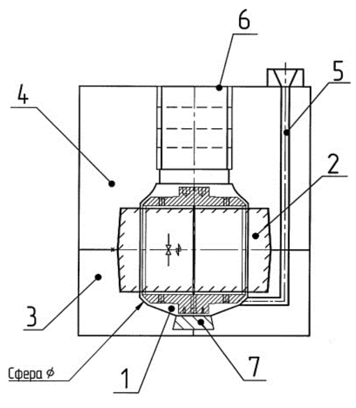


Fig. 1 – Mold for casting billet, tube ball valve

A method of manufacturing a spherical workpiece tube ball valve, schematically shown in figure 1, is as follows. Made a mold consisting of the following elements: 3 lower mold halves (for forming the lower hemisphere), the upper mold halves 4 (for forming the upper hemisphere) and the casting core 2 that is used for forming the holes of the main passage of the tube. For the manufacture of semi-molds 3 and 4 of the flask are installed on the model plate, the molding is filled with the mixture and seal it. After curing the molding sand of the mold halves is removed model. Received in proforma imprint corresponds with the future geometry of the casting, the axle tubes are "flooded" inside the sphere at the location of technological profits.

Casting rod 2 is produced by filling of the core box the core mixture with the subsequent consolidation and curing, then the rod corresponding to the diameter of the hole size of the main passage is extracted from the box.

Before assembly form on all formative elements put a layer of nonstick paint, shape collect. At the bottom floor set refrigerator 7, Gating-feeding system 5 make refractory articles, the terminal 2 is placed in the plane of the fret forms at the parting line.

The finished form through the feeding gate system is filled with molten metal the required grade. The resulting casting has the shape of a ball, gently rolling in a truncated cone, the upper base of which is the basis of profit.

After completion of the crystallization process of the casting 1 is removed from the mold, remove the Gating system 5 and 6 profit, produce a stump and the cleanup of the castings. In the end, to relieve residual thermal stress heat-treated castings obtained.

For the production of large workpieces spherical tube it is advisable to use a molten-welded method consisting of two stages: obtaining of castings of type "Hemisphere" and their subsequent Assembly by welding. For reducing metal casting can be manufactured with internal devastation (hollow), while depending on the size of the operating pressure during operation of the ball valve can be manufactured in the cavity of the casting of one or more ribs.

The use of the method of manufacturing a spherical workpiece tube ball valve allows to obtain blanks of spherical tubes with high quality precision and high utilization rate of metal, while the strength properties of the obtained billet is comparable to wrought iron.

Methods for producing blanks of plastic deformation can be divided into the following:

Open forging and stamping blanks (Fig. 2). Of the workpiece obtained by these methods are characterized by improved metal structure and high strength characteristics [2].

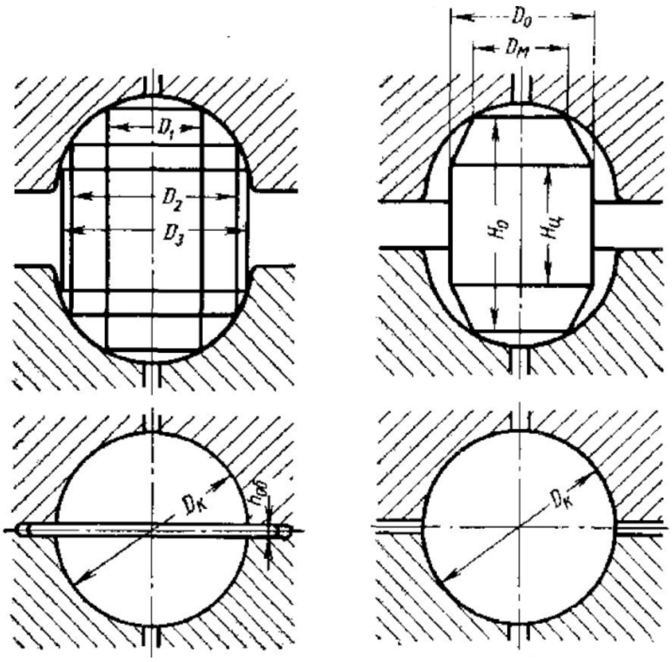
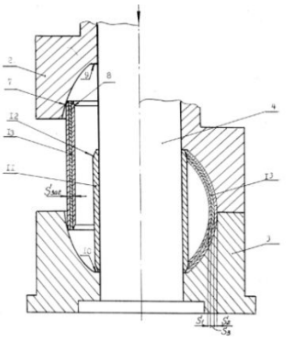


Fig. 2 – Transitions forming a spherical workpiece when stamping

In the production range of components with a large range of sizes should be making a costly special die tooling.

2. The forging of hollow billets [3–6]. This method is applicable for such items as tube ball valve. A method of producing a workpiece (Fig. 3) is that two billets, one of which is intended for the formation of a layered spherical shell, and the other to run through the passage in the sheath, placed in alignment one to another in two spherical volumetrico. Then the outer tubular blank is crimped with a cross-longitudinal motion of a spherical volumetric, deform the sphere and the ends close with internal entrance tube.

In the production of spherical workpieces in this manner is quite difficult to obtain high-quality spherical surface due to the low controllability of the boundary conditions changes of size parameters of pressed blanks and the possibility of the appearance of annular folds and undulations in the Equatorial part of the sphere. To prevent the annular folds in the Equatorial portion of the workpiece can be obtained from two welded hemispheres.



а

б

Fig. 3. The Process of stamping (*a*) and processing (*b*), obtained from the pipes:
1 – processing; 2, 3 – polimetrica; 4 – inner mandrel; 7, 8 – chamfer; 9, 10 – groove;
11 – internal feed-through pipe 12 and an external chamfer 13 is a multilayer pipe billet

3. Cross-wedge rolling [7]. Under cross wedge rolling of the two parts of the ball type pin (Fig. 4) the billet is heated and is fed automatically until it stops at the receiving prism wedge tool. When introducing the tool into the workpiece the groove is formed in the middle portion of the workpiece and formoobrazovanija two spherical surface of the ball studs on the wedges (section 1). Further formoobrazovanija cylindrical surface of the ball stud, and then by parallel rolling formoobrazovanija the conical surface of the ball stud (plot 2). Is the second transition, which is formed as a diameter (3 phase). In the final stage (phase 4) separated the waste end of the cutting knives, and then the workpiece along the Central groove is divided into two forgings with a knife. Blanks obtained by this method, and workpiece obtained by forging provide an improved structure of metal and high strength properties, also the accuracy of the diametral dimensions of the billet is within ±0.2 mm.

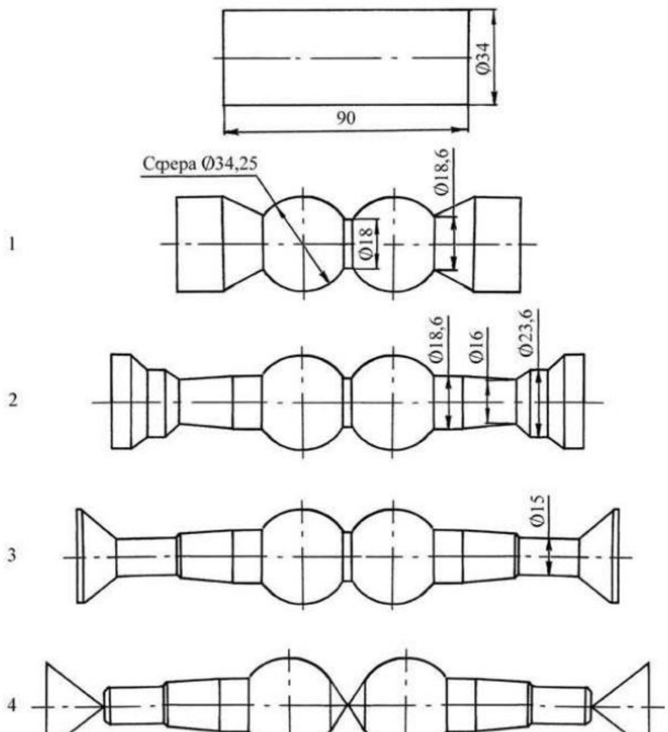


Fig. 4. Stages of cross-wedge rolling

Powder metallurgy allows to obtain products of various forms and purposes. In this method, in most cases, the utilization is about 100%. Typical technology of preparation production of goods by powder metallurgy method includes the following operations: receiving source material powder, molding of blanks, sintering.

One of the varieties of powder metallurgy is currently 3D printing on special installations. The difference of this method is that the material is sintered without step molding and extrusion billet. The shaping of the workpiece is carried out by applying substances to the surface of the Elevator, and sintered under the action of the laser beam in the solid layer corresponding to the parameters of the model and determining its form.

Spherical surfaces can be obtained by cutting. The evaluation of the methods of machining spherical surfaces showed [8–11] that:

– processing of specialized instruments, such as fittings, pipe cutter can result in the rejection of the shape of the surface in case it is not the tool manufacturer, and they have little versatility;

– treatment of non-core tool, for example a contour cutter, does not always give the required accuracy due to the discontinuity of the motion of the CNC machine, lack of rigidity copying machines and rotary fixtures;

– when processing tools on the site approximate to the longitudinal axis of the workpiece is formed over a high roughness due to the phenomenon of built-up edge during the machining process as the cutting speed starts to increase from zero value at the axis of the workpiece;

– devoid of these shortcomings, methods of treatment using a combination of head and special cutter in which the accuracy of formation of the spherical surface is determined by the accuracy of the trajectory of the workpiece and the tool, i.e. the kinematics of the process. From this we can conclude that to improve the quality and accuracy of obtaining spherical surfaces use the most cutting method, comprising cutting edge and abrasive processing.

From this we can conclude that to improve the quality and accuracy of a spherical surfaces, it is preferable to use a cutting method, comprising cutting edge and abrasive processing.

The use of the blade processing provides high performance, exception sergiovanni abrasive grains, the chemical saturation of the surfaces of various substances and other side defects. For these purposes, is increasingly used milling at cutting speeds comparable to the speed of the abrasive treatment, the so-called high-speed milling.

The Department of technology and equipment of machine-building production developed method of processing the partial spherical surfaces. The scheme of processing of spherical surfaces by way of covering high-speed milling is presented in figure 2. In this way of handling the tool reported rotational motion with a rotational speed n_1. After the installation movement of the work piece in the working position, in which the cutting blades in the tool, the work piece is reported rotational movement around its own axis with the rotation speed n_2.

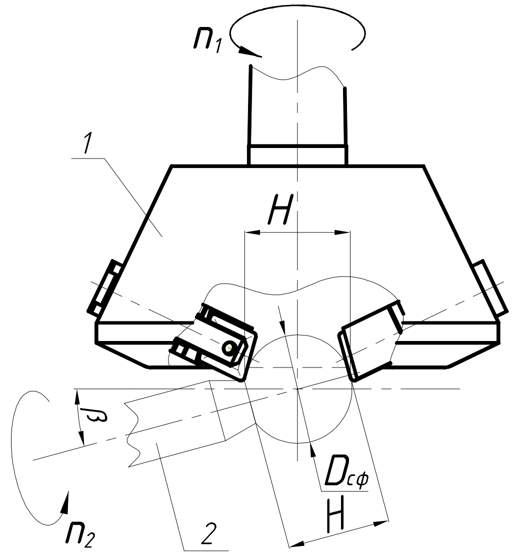


Fig. 5. The scheme of processing of the spherical surface by means of high-speed milling:
1 – cutting tool; 2 – the workpiece; n_1 – rotational speed of the tool; n_2 – rotational speed of the workpiece;
Dcф – diam spherical surface, H – height of the spherical surface; D – diameter of cutter setting;
β – the angle of the axis of rotation of the workpiece

Conclusions. Studies of this method of cutting has shown that he provides increased productivity by 3-4 times compared to turning on CNC machines and 30 times compared with slizyvanie. The roughness of the processed spherical surface is 1.6 µm and the geometric tolerance does not exceed ±0.01 mm.

REFERENCES

1. Способ изготовления сферической заготовки пробки шарового крана : пат. RU 2393047 / В.П. Анисимов, А.А. Цыбулаев. – Опубл. 10.03.2010.
2. Охрименко, Я.М. Технология кузнечно-штампового производства / Я.М. Охрименко. – М. : Машиностроение, 1966. – 602 с.
3. Андрианов, В.Н. Неразъемный штампосварной шаровой кран из коррозионностойких материалов / В.Н. Андрианов, М.М. Тверской, В.А. Маркин // Арматуростроение. – 2006. – № 5 (44). – Режим доступа: http://www.valve-industry.ru/pdf_site/44/44_nauka_sharovoi_kran_andrianov.pdf – 2 с.
4. Штамповка пробок шаровых кранов из трубчатых заготовок / Н.Н. Кузьмин [и др.] // Кузнечно-штамповочное пр-во. – 1985. – № 10. – С 19–20.
5. Агеев, Н.П. Разработки и исследование технологических возможностей изготовления двухслойных сферических пробок шаровых кранов из трубных заготовок способами обжима / Н.П. Агеев, Ф.М. Малых, К.О. Дубицкий // Изв. МГТУ «МАМИ». Сер. 2, Технология машиностроения и материалы. – 2013. – № 2 (16). – С. 23–27.
6. Аналитическое решение задачи о формообразовании шаровых пробок путем обжима трубных заготовок в полусферических матрицах / М.М. Тверской, С.П. Самойлов, В.Н. Андрианов, В.А. Иванов, Ю.М. Хищенко // Вестник ЮУрГУ. Сер. Машиностроение. – 2014. – Т. 14, № 2 : Технология – С. 39–49.
7. Кожевникова, Г.В. Теория и практика поперечно-клиновой прокатки / Г.В. Кожевникова. – Минск : Беларус. навука, 2010. – 291 с.
8. Анализ способов обработки сферических поверхностей деталей / Н.Н. Попок [и др.] // Вестник Полоцкого государственного университета. Сер. Прикладные науки. – 2006. – № 12. – С. 42–45.
9. Способы обработки сферических поверхностей деталей и технологическое оснащение для их реализации / Н.Н. Попок [и др.] // Материалы, технологии и оборудование в производстве, эксплуатации, ремонте и модернизации машин : сб. науч. Трудов VII междунар. науч.-техн. конф. : 3 т. / под общ. ред. И.А. Витязя, С.А. Астапчика. – Новополоцк: ПГУ, 2009. Т. II. – С. 315–319.
10. Хмельницкий, Р.С. Анализ конструкций технологического оснащения для точения выпуклых сферических поверхностей на универсальных токарных станках / Р.С. Хмельницкий, А.С. Максимчук // Труды молодых специалистов Полоцкого государственного университета. Промышленность, 2013. – Вып. 68. – С. 89–91
11. Хмельницкий, Р.С. Анализ способов обработки сферических поверхностей деталей / Р.С. Хмельницкий, А.С. Максимчук // Труды молодых специалистов Полоцкого государственного университета. Промышленность, 2013. – Вып. 68. – С. 92–94.