MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

School of Industrial Automation and Digitalization

Department of Industrial Engineering

Orysbay S. N.

Computer-integrated preparation of the manufacturing technology of the "shaft" part in the CAD/CAM environment. Annual production program 1000 pieces

DIPLOMA PROJECT

5B071200 – Mechanical Engineering

Almaty 2020

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

School of Industrial Automation and Digitalization

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APPROVED FOR DEFENSE

Head of the Industrial

Engineering Department, PhD

Arymbekov B.S.

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DIPLOMA PROJECT

Topic: “Computer-integrated preparation of the manufacturing technology of the "shaft" part in the CAD/CAM environment. Annual production program 1000 pieces”

5B071200 – Mechanical Engineering

Performed by: Orysbay S.N.

Scientific adviser
PhD, tutor
________ ZhankeldiA.Zh.
“___” ________2020

Almaty 2020

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CONFIRM

Head of the Industrial

Engineering Department, PhD

Arymbekov B.S.

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TASK

for completing the diploma project

For student: Orysbay S.N.

Topic: “Computer-integrated preparation of the manufacturing technology of the "shaft" part in the CAD/CAM environment. Annual production program 1000 pieces”

Approved *by the order of university rector №762-bfrom "27"January 2020*

Deadline for completion the work *"24" May2020*

Initial data for the diploma project: Gear no. 05–1701216 from the transmission of the motor block Belarus-09N/09N-02

Summary of the diploma project:

a) *3D model of the Shaft ;*
b) *Technological analysis of the shaft designing;*
c) *CAD/CAM systems and their application in mechanical engineering.*

List of graphic material: *presented 10 slides of presentation of the diploma project*

Recommended main literature:

1. *Malyuhv.N. Introduction to modern CAD: a Course of lectures. - Moscow: DMK Press, 2010. -192 p. - ISBN 978-5-94074-551-8*
2. Kondakova. I. CAD of technological processes and productions. ACADEMA, 2007

THE SCHEDULE

For the diploma work preparation

Name of sections, list of issues being developed	Submission deadlines to the scientific adviser	Notes
Theoretical part	10.03.2020	Task completed
Technical part	23.03.2020	Task completed
Calculation part	8.04.2020	Task completed
Modeling part	15.04.2020	Task completed

Signatures

Of consultants and standard controller for the completed diploma work, indicating the relevant sections of the work (project).

The section titles	Consultant name (academic degree, title)	Date	Signature
Theoretical part	PhD, ZhankeldiA.Zh.	10.03.2020	
Technical part	PhD, ZhankeldiA.Zh.	23.03.2020	
Calculation part	PhD, ZhankeldiA.Zh.	8.04.2020	
Modeling part	PhD, ZhankeldiA.Zh.	15.04.2020	
Normcontrol	PhD, ZhankeldiA.Zh.	22.05.2020	

Scientific adviser ________________ PhD, ZhankeldiA.Zh.
Signature

The task was completed by student: ___________Orysbay S.N.
Signature

Date: “22” May 2020

АҢДАТПА

Диссертациялық жұмыста жылдық өндірісі 1000 дана болатын «Вал» бөлігін механикалық өңдеудің технологиялық процесі жасалды.

Бөлімнің құрылымдық және технологиялық ерекшеліктеріне сипаттама берілген. Сатып алу әдісін, өңдеуді, технологиялық жабдықты таңдау.

Осының негізінде жәрдемақы есептеледі. Кез-келген машинаның білігі жоғары жүктемелерде және көбінесе жоғары жылдамдықта жұмыс істейді. Инженерлік технологияның маңызды міндеттерінің бірі - дайындаманы өңдеу дәлдігі мен оларды өндірудің экономикалық тиімділігін арттыру арқылы өңдеудің нақты ауырлығын азайту.

Сондықтан білік күшті және жеңіл болуы керек. яғни жұқа қабырғалы. Редукторлардың, турбиналардың, компрессорлардың, сорғылардың және басқа да машина жасау бұйымдарының біліктерінің сыртқы беттері әртүрлі элементтердің тіркесімі болуы қажет, мысалы, олар мойынтіректер, сплиттер, жіптер, фланецтер, редукторлар (редукторлар), радиалды және осьтік тесіктер және т.б.

АННОТАЦИЯ

В дипломной работе разработан технологический процесс на механическую обработку детали «Вал» с годовой программой выпуска 1000 штук.

Дана характеристика конструктивной и технологической особенности детали. Произведен выбор метода заготовки, последовательность обработки, технологическое оборудование.

Исходя из этого, рассчитаны припуски. Вал практически любой машины работает при больших нагрузках, а зачастую и при высоких оборотах. Одной из важнейших задач технологии машиностроения - является сокращение удельного веса механической обработки резанием за счет повышения точности обработки заготовки и экономичности их изготовления.

Следовательно, вал должен быть прочным и легким. т. е. тонкостенным. Внешние поверхности валов редукторов, турбин, компрессоров, насосов и других изделий машиностроения представляют собой комбинацию различных элементов, например они могут содержать гладкие шейки под подшипники, шлицы, резьбы, фланцы, зубья зубчатых колес (валы-шестерни), радиальные и осевые отверстия и т. д.

ANNOTATION

In the thesis, a technological process for the machining of the Shaft” part with an annual production program of 1000 pieces was developed.

The characteristic of the structural and technological features of the part is given. The selection of the procurement method, the sequence of processing, technological equipment.

Based on this, allowances are calculated. The shaft of almost any machine works at high loads, and often at high speeds. One of the most important tasks of engineering technology is to reduce the specific gravity of machining by increasing the accuracy of processing the workpiece and the cost-effectiveness of their manufacture.

Therefore, the shaft must be strong and light. i.e. thin-walled. The outer surfaces of the shafts of gearboxes, turbines, compressors, pumps, and other mechanical engineering products are a combination of various elements, for example, they may contain smooth necks for bearings, splines, threads, flanges, gear teeth (gear shafts), radial and axial holes, etc.

Content

Introduction

The need to save material resources makes high demands for a rational choice of blanks, to the level of their technology, which largely determines the cost of technological preparation of production, cost, reliability and durability of products.

Mechanical engineering has a lot of ways to get the parts needed by the national economy. This diversity, on the one hand, makes digital possible to significantly improve the performance of machines and mechanisms through the use and in some cases of improving the properties of the source material, on the other hand, digital creates great difficulties in choosing a rational, economical way to obtain a particular part.

To make the right decision, a comprehensive analysis of the feasibility of the options under consideration is needed, when comparing them to the national economic aspect, to take into account the self-sustaining interests of enterprises.
But in all cases, the adopted option should help to improve labor efficiency, reduce material intensity, increase productivity and improve the quality of products.

Chapter 1. Production of shaft

1.1 Purpose of a detail and requirements to a detail.

The shaft of almost any machine operates at high loads, and often at high speeds. Therefore, the shaft must be strong and light. i.e. thin-walled. The outer surfaces of the shafts of the reduction gears, turbines, compressors, pumps and other machine building products are a combination of various elements, for example, they may comprise smooth journal bearings for bearings, splines, threads, flanges, gear teeth (gear shafts), radial and axial holes, etc. The shape of the inner surfaces of the shaft ensures its equal strength over all sections. Nominal geometrical dimensions of the shaft and thickness of its wall are calculated from the condition of strength at safety factor depending on the purpose of the machine.

Development of machining process. Initial data for design.

Technical requirements:

Detail – shaft . Preparation – stamping. Material – steel.Weight – 6,0 kg.

Annual Product Release Program $N = 1000\frac{pieces}{in\ year}$

1.2 Method of production preparation. Service purpose of the article and description of its operation.

The formulation of the service purpose of the product includes a list of conditions under which the product must operate and produce products (in a broad sense) of the required quality and quantity. The operating conditions of the article are derived from the manufacturing process of the product for which the article is intended. They consist of a set of parameters with permissible deviations, which characterize the quality of produced products, consumed energy, modes of operation of the article, etc. From the description of the purpose and design of the article it becomes known which parts and their surfaces are the main, decisive importance for carrying out the technological process.

Shaft together with gear transmits torque. All mating surfaces of shaft are made on 7 qualite.

Gear, bushing, ball bearings and flange are pressed on shaft.

Parts with guaranteed interference are assembled until stop against adjacent part. When pressing the flange, the mating surfaces are attached to the abutment by paint.

The assembly drawing is shown in Figure 1.

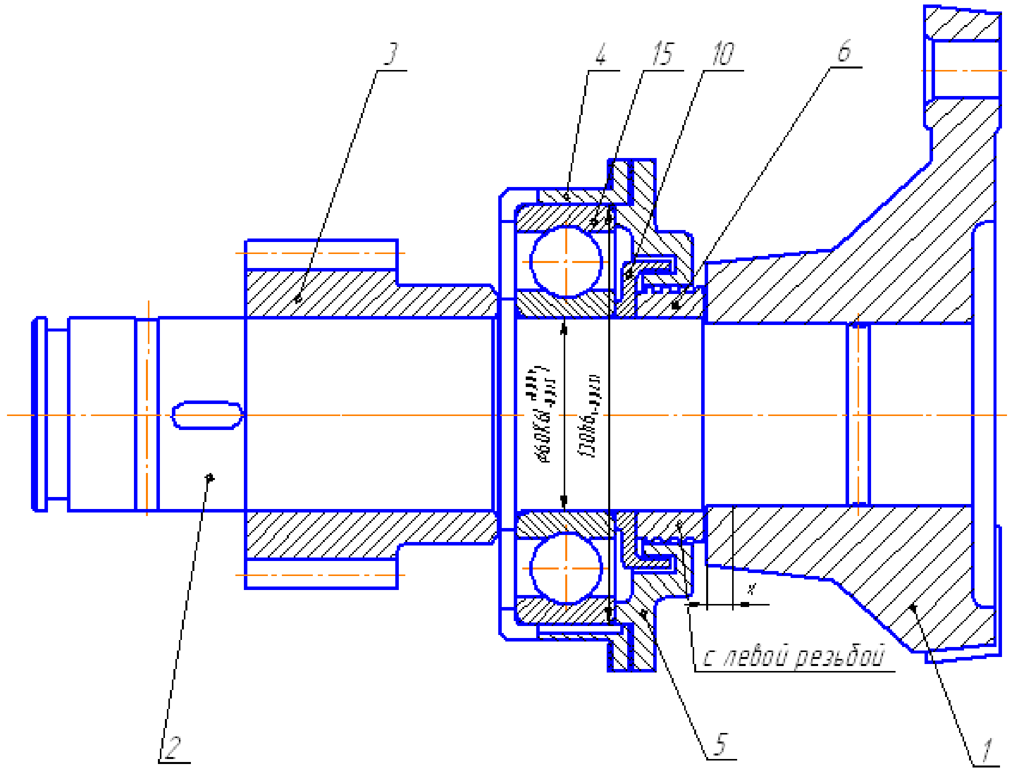

Figure 1 - Drive shaft assembled.

1— flange; 2 — shaft; 3 — gear wheel; 4 — bearing seat; 5 — cover; 6 — plug; 10 – circle; 15 – bearing   .

Technical requirements for part manufacturing:1.

It is allowed to be made of steel 45 also became 38 .

2. HB = 302...255 (d =3,5...3,8 mm)

3. Run-out is permitted during shaft check in centers:

a) surfaces A, B, C and D not more than 0.02 mm

b) surfaces D - not more than 0.05 mm

4. Ovality and taper of surfaces B, B and D not more than 0.01 mm

5. The cone must be checked by the agreed calibre to fit the paint. Fit must be at least 75% of blend surface

6. It is permitted to perform groove for grinding outlet

Of the circle according to variant III

7. Unspecified limit deviations of dimensions H14, h14, IT14/2

8. To brand STK brand

The shafts are subjected to considerable variable bending, torsion, compression and stretching loads during operation, the material from which the shaft is made should be high-strength, low-sensitivity to the stress concentrator, well processed and its use economically feasible. Structural and alloyed became brands 30X, 35X, 40Г, 50Г and others meet these requirements.

The method of producing a blank for a particular shaft is largely determined by its geometric parameters and responsibility. Blanks for most shafts are produced by transverse rolling, stamping on horizontal forging machines and rotary reduction (for hollow shafts). In single production, piece billets are produced by cutting rolled stock. In serial production, hot stamping in open and closed dies has become very common. Note here that die connector is possible both along and across the shaft depending on billet shape. Stamping slopes for shaft holes are taken within 10... 15 *, and for external surfaces - 3... 7 *. Blanks of heavy shafts are obtained by free forging.

If the shaft blanks are accepted by the first control group (for highly important shafts), it should be taken into account that in order to produce samples for mechanical tests, a part of 70... 75 mm length must be cut from each blank, which requires an increase in the length of the blanks. Besides. Blanks of essential shafts are checked on ultrasonic flaw detector.

Workpieces for shafts are supplied to mechanical shop in normalized state (after thermal treatment) with hardness HV 190... 270, without scale and with cleaned external defects. The depth of the internal defect shall not exceed half of the allowance per side.

Mechanical treatment of shafts is divided into black, finish and final. Roughing removes surface defects and ensures uniform distribution of allowance for subsequent treatment. In finishing, the allowances removed are considerably smaller, and less stressed modes are used to avoid damage to the workpiece and surface layer of the finished part. The main purpose of finishing is to eliminate errors in roughing and warping of the workpiece after heat treatment, as well as to obtain a workpiece with the least allowance for final treatment.

At final treatment (grinding, honing, superfinishing, smoothing, polishing, etc.) accuracy and purity of shaft surfaces specified by shaft drawing are obtained.

In designing the production process of the shaft, the choice of the heat treatment site is important. The thermally improved shafts can be tempered and tempered before and after machining

Tapa (or rigging), which is determined by the size of the total treatment allowance. For shafts whose individual surfaces are to be cemented, the place of heat treatment depends on the method of protection of non-cemented surfaces (copper or allowance).

The best method of positioning the shaft blank is to center it using a yoke and supply it with torque from the machine spindle. When processing long blanks, a lonnet is used, which, taking the cutting force, practically prevents their deformation. In this case, separate surface machining operations are required for layout.

The treatment route of a thermally improved shaft, the workpiece of which is formed by bulk forming, generally consists of the following operations.Термическая обработка заготовки (нормализация).

1. end clipping and centering.
2. wrap the outer surface under the cradle (if the shaft is long).
3. a draft processing step comprising:
    - grinding of external surfaces;
    - section of part of blank for mechanical tests (for shafts of the first control group); сверление осевого отверстия;
    - melt the hole and sweep the center chamfers.
4. heat treatment (quenching and tempering).
5. restores the center chamfers and mechanically edits the possible deformation of the workpiece resulting from thermal treatment.
6. grinding of the necks under the cradle (if the shaft is long).
7. a final processing step comprising:
    - grinding of external surfaces;
    - boring of an opening;
    - milling of keyways and other flat areas of surfaces;
      drilling of radial openings;
    - cleaning of hangnails.
8. a final processing step comprising:
    - dusting or grinding the hole sections with high accuracy;
    - • grinding of external surfaces;
    - • cutting of shlits;
    - • cutting of a carving;
    - • polishing of surfaces;
    - • Finishing (spurfinishing, etc.) of working surfaces.
9. control of a ready detail.

1. Strength conditions of designing

After determining the dimensions and structural elements of the shaft, its updated fatigue calculation is performed.

It is known that key slots, threads for mounting nuts, transverse through holes for styphs or screwdrivers for mounting screws, grooves, as well as sharp changes in shaft section cause concentration of stresses that reduce its fatigue strength.

Therefore, if the shaft has a small fatigue strength margin, stress concentration elements should be avoided.

In places of reduced fatigue strength it is undesirable to make grooves for tool exit (grinding stone, dies, etc.). Instead of grooves, the fillet must be as smooth as possible. Where possible, the radius of the pebbles should be increased (Figure 1.). Concentration of pebbles stresses with undercut is reduced markedly. The unloading grooves on the shaft and in the mating part also reduce the stress concentration in this section of the shaft. (fig. 1.)

The key groove produced by the disk milling (Figure 1) causes less stress concentration than the key groove formed by the finger cut-in, but in the latter the key is more securely fixed.

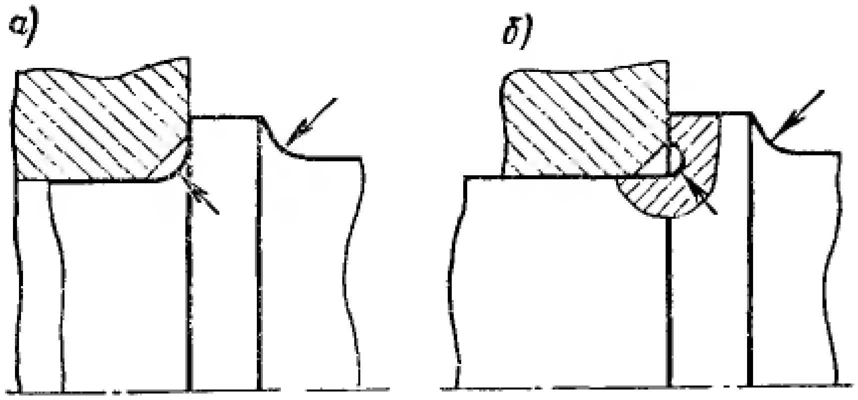

Figure 1 - Disk milling

The evolute splines cause less stress concentration than the straight splines. Instead of axial fastening of the parts sitting on the shaft with a mounting screw, a round nut or a spring ring, which require a transverse hole, thread and groove respectively, axial fixation of the parts with spacer bushings is used to improve the fatigue strength margin. In the extreme case, the hole on the shaft for the setting screw should be countersunk, which also leads to some reduction of stress concentration.

When the fatigue strength of the shaft is low, it is useful to prevent it from spinning. Connect the parts sitting on the shaft with bushing (Fig. 2.). It should be understood, however, that the design of the shaft assembly with the parts becomes more complicated and the production of the shaft increases in cost. Therefore, it may be economically more advantageous to increase the fatigue strength of the shaft in other ways, such as by increasing its diameter.

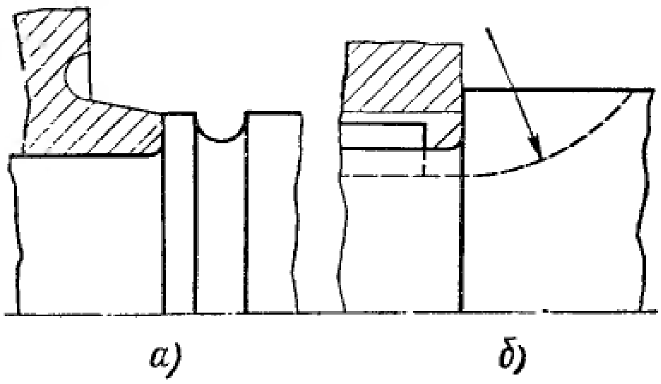

Figure 2 - Connect the parts sitting on the shaft with bushing

Parts that do not transmit torque through the shaft (parasitic gears, etc.) should not be connected to the shaft with keys or splines.

Such parts shall be fitted on a smooth surface of the shaft. Some of the recommendations to make the shaft fatigue margin more complicated. Therefore, it is necessary to find a solution, which to a lesser extent results in complication and increase of cost of assembly manufacturing. In particular, in some cases it may be economically more advantageous to use the simplest measures to increase the fatigue strength of the shaft, such as replacing the grooves with pebbles or enriching the diameter of the shaft.

a)

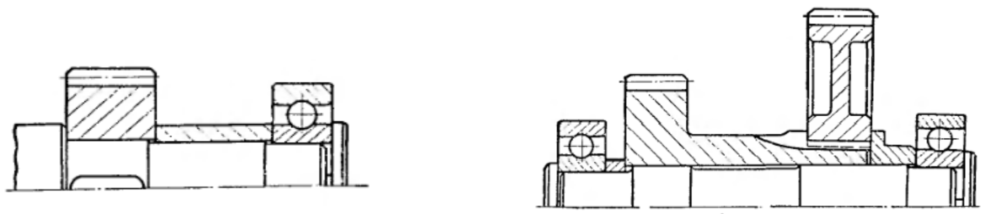

Figure 3.

All considerations given above apply to shafts having little fatigue margin. If the dimensions of the shaft are determined not by the strength, but, for example, by its rigidity or the dimensions of the rolling bearings, then, naturally, it is not necessary to resort to increasing the roll strength by the above-mentioned methods. In these conditions, the main attention should be paid to the improvement of the shaft technology.

Technological conditions of designing

The assembly technology of the assembly has essentially one fundamental requirement for the construction of the shafts: the shaft must be designed so that each part sitting on it passes during assembly to the place of landing without interference. Therefore, if two or more parts are mounted on the shaft on one side, it is not recommended to use the same diameter shaft in the interference fit. Setting and removal of part 1 (Fig. 4, a) in this case becomes more difficult, and fitting of part 2 on shaft after passing of part 1 is weakened. Here, the shaft diameter for part 1 must be larger than the diameter for part 2. However, if one long part is installed on the shaft instead of two, it is undesirable to make different diameters of the shaft (Fig. 4, b): due to inevitable misalignment of both necks of the shaft and both holes of the part, it is very difficult to connect the parts during interference fit and is accompanied by significant elastic and even plastic deformations. In this case, it is necessary to make both shaft journals of the same diameter and to loosen the tension on the first (in the direction of assembly) neck.

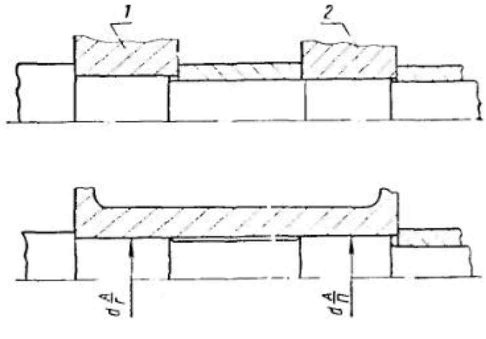

Figure 4 - Setting and removal of part 1

When designing shafts and axles, the technology of their processing should be taken into account: labor intensity should be the least.

In general mechanical engineering, so-called smooth (one diameter along the entire length) and stepped shafts and axles are widely used.

The production of smooth shafts and axles is much simpler than stepped shafts, so wherever possible the shafts and axles should be made smooth.

In addition to the simplicity of construction and the lower cost of manufacture, there are almost no stress concentrators (except keyway slots) in smooth shafts. One drawback of smooth shafts is the need for shaft system fits. Another disadvantage is the inconvenience of fitting the parts with guaranteed interference if the parts are located some distance from the end of the shaft.

Stepped shafts do not have these disadvantages, which are characteristic of smooth shafts, but their manufacture is much more complicated and more expensive.

1.3 Material of details and its properties

Material used for making shafts is divided into thermally improved, cementable and nitrided materials. Shafts made of thermally improved steels (grade 40XHMA, etc.) are subjected to quenching and tempering to obtain hardness of working surfaces HRC 38... 42. Working surfaces of shafts made of cemented steels (grades 18XH3A, 12XH3A, etc.) are cemented (saturated with carbon) to a depth of 0.7... 1.2 mm, and then subjected to quenching and tempering to obtain hardness of treated surfaces not less than HRC 58. Working surfaces of shafts made of nitrided steels (grade 38XMЮA, etc.) are nitrided (saturated with nitrogen) to a depth of 0.6... 0.9 mm to obtain hardness of treated surfaces of HRC 65.

Shaft of domestic cars produce from staly brands 30X, 35X, 40X, 20HGN, etc. Shafts of aircraft steels (grades 18XHBA, 12XH3A, 40XHMA, etc.) and hardness of their working surfaces after quenching and tempering make NV 390.

Single-use shafts, for example in process plants, are made of cheaper steels such as grade or 45 or 38XA.

The requirements for the accuracy of the production of shafts, determined by the heavy conditions of their operation, relate mainly to the working surfaces of the shaft and their operation, relate mainly to the working surfaces of the shaft and their mutual arrangement

The accuracy of most responsible shafts is characterized by the following parameters

- tolerance fields for bearing seats defined by the coupling type are n6... n8, m6... m8, h8... h11, g6... g8, f6... f8 at
- roughnesses of surfaces of necks шеек Ra 1,25…0,63;
- permissible deviations from the roundness of the geometric shape of the mounting necks for bearings – 0,005…0,200 мм;
- accuracy of non-working surfaces - 9th and 10th qualites at roughness Ra 2.5;
- accuracy of mating surfaces - 7... 9th qualites;
- mutual run-out of working surfaces - 0,005... 0.02 mm;
- end run-out of shaft shoulders for installation of rolling bearings - not more than 0.02mm at roughness Ra 1.25;
- tolerance fields for installation of gear and worm gears - s6 and s7;
- roughness of teeth surfaces Ra 0.63;
- center of mass displacement from shaft rotation axis (depending on shaft rotation speed) - 0,0005... 0.001 mm.

1.4 Analysis of the manufacturability of the design details. Analysis of the technological design details

Analysis of workability of the part structure.

Processability is assessed by two levels - qualitative and quantitative.

Quality indicators:

- a possibility of receiving preparation in the most economic way with sizes and forms close to a ready detail.

In our case it is possible to obtain a shaft blank - by stamping.

- simultaneous processing of several preparations is possible;
- on a detail there are convenient basic surface;
- characteristic of material of a detail;
- the set admissions and parameters of roughness of surfaces can be reached;
- processing of a shaft the high-performance tool is possible;

Quantitative indices:

1. Material utilization factor $К_{ИМ}$

$$К_{им} = \frac{M_д}{M_з} = \frac{6,0}{8} = 0,75$$

where $Mд$ – is the mass of the part; $Mз$ – is the mass of the workpiece.

2. Machining accuracy factor – $К_m$

$$К_m = 1 - \frac{1}{A_{cp}} = 1 - \frac{1}{9,28} = 0,89.$$

where A_{cp} – is the average quantum of surface treatment accuracy.

$$A_{cp} = \frac{n_1 + 2*n_2 + 3*n_3 + \cdots + 19*n_{19}}{n_1 + n_2 + \cdots + n_{19}} = \frac{\Sigma A_i * n_i}{\sum_{i=1}^{19} n_i},$$

$$A_{cp} = \frac{6*3+11*1+12*3}{3+1+3} = 9,28$$

Where 1..19 – corresponding surface qualites; $n_1, n_{2\ldots} n_{19}$ - is the number of surfaces of the part of the corresponding qualite; A_i - is a quantum of precision of the *i*-th surface.

Part design is considered technological if $К_m > 0,8$

3. Roughness Coefficient – $К_ш$

$К_m = 1 - \frac{1}{Б_{cp}} = 1 - \frac{1}{7,05} = 0,86$, where $Б_{cp}$ - average value of the numerical roughness value

$$Б_{cp} = \frac{100 n_{100} + 50 n_{50} + \cdots + 0,025 * n_{0,025} + 0,0125 n_{0,0125}}{n_{100} + n_{50} + \cdots + n_{0,0125}} = \frac{\Sigma Б * n_i}{\sum n_i},$$

$$Б_{cp} = \frac{12,5*4+1,6*4}{4+4} = 7,05$$

The detail is technological if value of all indicators are in limits 0.7÷1. Therefore, the detail "shaft" - is technological 0,7÷1. Therefore, the detail ‘shaft’ – is technological.

Analysis of the production program, definition of the type and organizational form of production.

The main form of organization of production in large-scale and mass production is in-line, which is characterized by placement of means of technological equipment in the order of carrying out technological operations, specialization of workplaces and availability of production stroke τ:

$$\tau = \frac{60 * F_{д}}{N_{г}},$$

where $F_{д}$ – valid annual fund of equipment operation time under double-shift operation mode;

$F_{\partial} = F_{н} \cdot \tau = 3984 \cdot 0{,}97 = 3865$ hour

where $F_{н}$ – nominal annual time fund in hours;

$F_{н} = (365 - \lambda - m) \cdot t \cdot z,$

where λ – Number of days off per year;

m – Number of public holidays per year;

t – working shift duration per hour;

z – number of working shifts per day; Z = 2

η– factor taking into account simple equipment in repair according to schedule PPR.

During the two-shift work ι =0,97

$F_{н} = (365 - 106 - 10) \cdot 8 \cdot 2 = 3984$ (hour)

$$\tau = \frac{60 * 3865}{1000} = 231.9$$

2.Processing an Assembly Process Plan

2.1 Determining the time funds of the type of production and organizational form of assembly.

The approximate type of production is determined by the production program. Determining the type of production

Table 1

Production	Annual program of products production, pcs.		
	large	averages	small
Small-scale	3 – 10	5 – 25	10 – 50
Medium batch	10 – 50	25 – 200	51 – 500
Business lot	>50	>200	>500

In this case, the program is produced - 1000 pieces a year. Consequently, the production is large-series. If you have a typical assembly process with a known performance of technological operations, the type of production is determined by the tact of the assembly. Build tact, mine:

$$\tau_{сб} = \frac{60 \cdot F_{д} \cdot m}{N},\text{(min.)}$$

where $F_{д}$ - a valid annual fund of working time – collector, hour, $F_{д}$ =2030 hour; m - number of shifts; N - annual product production program per year,

If the assembly clock is close or shorter than the average duration of operations, the assembly is carried out on the principle of mass production, if significantly exceeds the average duration of operations - on the principle of serial production.

$$\tau = \frac{60 * 3865}{1000} = 231{,}9 \text{ min}$$

Depending on the type of production and the nature of the collected products, the organizational form of the assembly is selected: in-line or not in-line.

During in-line assembly, the process is exploded into separate operations attached to separate work centers. The assembly is carried out on conveyors moving continuously or intermittently (mass and large-scale production), rollgangs, stationary stands or specialized workplaces.

2.2 Dimensional analysis of the process, the calculation of allowances.

The purpose of this analysis is to determine the technological dimensions for each operation and their tolerances, general allowances and workpiece sizes. It is necessary to determine:

a) the ability to perform linear drawing dimensions;

b) operational linear dimensions with tolerances;

c) dimensions of the workpiece with tolerances.

We build a dimensional scheme of the technological process. Choose the root of the dimensional scheme -4. We find allowances according to the table of machining accuracy We accept allowances for roughing equal to 1.5 mm, for finishing - 1 mm, allowance for grinding - 0.5 mm.

2.3 Design of technological operations of machining.

To reduce the processing time, we select transitions so that it is possible to process two surfaces at the same time. The dimensional analysis shows trimming of two ends at the same time, which allows the shaft design. In a separate operation, roughing and finishing of the shaft is introduced. Calculation of cutting conditions Operation 10 - Milling and centering Input data:

Equipment - Semi-automatic milling machine, model MP71. Fixture - special prismatic. The workpiece is a shaft. Material - steel. Weight of the workpiece - 9 kg

Operation structure

I position

1 transition - install and remove the workpiece

2 transition - mill the ends of the shaft at the same time in size $296_{-0,5}$

II position - drill center holes of the form “B” in the ends of the shaft.

Determination of the cutting mode and main time t_0 for the 2nd transition– milling of the shaft ends

Minimum allowance for diameter 56,4 мм и 60 мм $z_в$ = 1,5 мм. Selection of cutting tool - end cutter with insert knives made of hard alloy technical requirements. Mill diameter D =(1,25-1,5)B, where B is milling width. D = (1,25-1,5)· 60 = 75 – 90 (mm) according to a 100 mm diameter cutter, the number of teeth is 10.

Hard alloy material – T15K6

Cutting depth is equal to allowance t = $z_в$ = 1,5 mm

Rough milling feed over 10 кВт S_z = 0,15 mm/tooth

Cutting Speed - Mill Circumferential Speed

V = $\frac{D^q C_v}{T^m\, t^x\, S_z^y\, B^u\, z^p} \cdot K_v$ (m/min),

C_v = 332, q = 0,2, x = 0,1, u = 0,2, p = 0, m = 0,2

T_{mills} = 180 min since multi-tool machining (2 mills at a time) therefore the resistance is increased by the coefficient of change of K_{mu} resistance for two tools $K_{mu} = \frac{1+1,7}{2} = 1,35$

The general correction factor on cutting speed, considering the actual conditions of cutting of $K_v = K_{Mv} \cdot K_{nv} \cdot K_{uv}$, где K_{Mv}- the coefficient considering quality of the processed material

$K_{Mv} = 1\ (750/1000)^1 = 0,75$. K_{nv}= 0,8, K_{uv} = 1,15

K_v =0,75 · 0,8 · 1,15 = 0,69

Having substituted values we will receive $V_р = \frac{100^{0,2} \cdot 332}{180^{0,2}\ 1,5^{0,1}\ 0,15^{0,4} 60^{0,2}\ 10^0} \cdot$ 1,15=155,7 m/min

Calculate spindle speed = 495.8 rpm

Nearest lower value of RPM by machine passport n = 456 .

Actual speed of cutting $V = \frac{\pi\, D\, n}{1000} = \frac{3,14 \cdot 100 \cdot 456}{1000}$ =143,2 m/min

Minute feed $S_{min} = S_z$ ·z ·n = 0,15 ·10 ·456 = 684 mm/min

Working course of a mill of $L_{рх}$ = $D_{фр}$ + $L_{рез}$ + $l_{вр}$ + $l_{пер}$ = 100 + 50 + 10 =160

The main milling time is determined $t_{о\ фр} = \frac{L_{рх}}{S_{мин}} = \frac{160}{684}$ = 0,23 min

Define cutting and t_ modes (o) for 3 center hole drilling transitions. The center hole of shape "B" has dimensions

D = 56,4mm, d = 5 mm, l = 55mm, $l_{1=}$ 0 mm, l_2 = 35mm, d_2 = 27mm

Cutting depth t = 0,5 D = 0.5 ·5 = 2,5 мм

Steel drilling feed S_0 = 0,11 mm/vol.

Speed V = $\frac{D^q C_v}{T^m\ S^y}$ · K_v (m/min) , C_v = 7,0 , q = 0,40, m = 0,2, y = 0,70. . Resistance T = 25 min, since 2 center drill bits operate simultaneously , $K_{mu} = \frac{1+1,7}{2} = 1,35$ is taken into account . General correction factor

$K_v = K_{Mv} \cdot K_{uv} \cdot K_{ev}$ [1, стр. 276], where $K_{Mv} = 1\ (750/1000)^{0,9}$ = 0,77

K_{uv} = 1 , K_{ev} = 1,0

K_v = 0,77 ·1·1 = 0,77 , then V = $\frac{7 \cdot 5^{0,4}}{25^{0,2} \cdot 1,35 \cdot 0,11^{0,7}} \cdot 0,77$ = 18,62m/min.

We Determine the rated frequency of rotation of $n_р = \frac{1000\ V_р}{\pi\ D} = \frac{1000 \cdot 18,62}{3,14 \cdot 5}$ = 1186 rpm. We accept the next smaller value by the passport of machine n = 958 rpm , the actual speed of cutting of $V = \frac{\pi\ D\ n}{1000} = \frac{3,14 \cdot 5 \cdot 456}{1000}$ = 7,16 m/min.

Minute feed *a* $S_{мин} = S_0$ ·n = 0,11 ·958 = 105,38 mm/min.

Main drill time $t_{о\ св} = \frac{L_{рх}}{S_{мин}} = \frac{2 \cdot 20,15}{105,38}$ = 0,3 мин

Cutting depth 2, 5 мм.

Steel drilling feed S_0 = 0,11 mm/vol.

Speed V = $\frac{D^q C_v}{T^m\ S^y}$ · K_v (м/мин), из , C_v = 7,0 , q = 0,40, m = 0,2, y = 0,70. Resistance T = 25 мин , since 2 center drill bits operate simultaneously , is taken into account. $K_{mu} = \frac{1+1,7}{2} = 1,35$ [1, стр. 247, табл. 7]. General correction factor

K_v = K_{Mv} · K_{uv} · K_{ev} [1, стр. 276], где K_{Mv} = 1 $(750/1000)^{0,9}$ = 0,77

K_{uv} = 1 , K_{ev} = 1,0

K_v = 0,77 ·1·1 = 0,77 , тогда V = $\frac{7 \cdot 5^{0,4}}{25^{0,2} \cdot 1,35 \cdot 0,11^{0,7}}$ · 0,77 = 26,48 m/min.

We determine the rated frequency of rotation of $n_{\text{р}}$ = $\frac{1000\, V_{\text{р}}}{\pi\, D}$ = $\frac{1000 \cdot 26,48}{3,14 \cdot 5}$ = 1352 об/мин. We accept the next smaller value by the passport of machine n = 1300 об/мин , the actual speed of cutting of $V = \frac{\pi\, D\, n}{1000}$ = $\frac{3,14 \cdot 5 \cdot 1300}{1000}$ = 27 m/min.

We coredrill an opening. Cutting depth 0,75 мм. Steel drilling feed S_0 = 1 мм/об.

Speed V = $\frac{D^q C_v}{T^m\, t^x\, S^y}$ · K_v (м/мин), из , C_v = 16,2 , q = 0,4, m = 0,2, , x =0,2 ,y = 0,5. Resistance T = 25 мин , since 2 center drill bits operate simultaneously, K_{mu} = $\frac{1+1,7}{2} = 1,35$ is taken into account. General correction factor.

K_v = K_{Mv} · K_{uv} · K_{ev} [1, стр. 276], где K_{Mv} = 1 $(750/1000)^{0,9}$ = 0,77

K_{uv} = 1 , K_{ev} = 1,0

K_v = 0,77 ·1·1 = 0,77 , V = $\frac{7 \cdot 5^{0,4}}{25^{0,2} \cdot 0,75^{0,2} \cdot 0,11^{0,7}}$ · 0,77 = 14.25 m/min.

We determine the rated frequency of rotation of $n_{\text{р}} = \frac{1000\, V_{\text{р}}}{\pi\, D} = \frac{1000 \cdot 14.25}{3,14 \cdot 5}$ = 62.75 rpm. We accept the next smaller value by the passport of machine n = 60.5 rpm , the actual speed of cutting of $V = \frac{\pi\, D\, n}{1000} = \frac{3,14 \cdot 5 \cdot 60.5}{1000}$ = 15 m/min.

We cut a carving. Cutting depth 1.5 mm

We define norm on the 05th time operation: : $t_{\text{шт}} = t_0 + t_{\text{всп}} + t_{\text{обсл}} + t_{\text{отд}}$

$t_0 = t_{о\ фр} + t_{о\ св}$ = 0,23 + 0,3 = 0,53 min

$t_{всп} = t_{всп\ уст} + t_{всп\ оп}$ = 0,1 +0,7 = 0,8 min , т.к. $t_{всп\ уст}$ = 0,7 [5, стр. 77, part 1,

$t_в + t_0 = t_{0п}$ = 0,53 + 0,8 = 1,33 min.

$t_{обсл} + t_{отд} = t_{доп}$ = 8% $t_{0п}$ = 8/100 ·1,33 = 0,1 min

$t_{шт}$ = 1,33 + 0,1 = 1,43 min

Operation 55 Circular grinding

Basic data:

Equipment - Circular grinding machine model 3У142. Accessory - center, link cartridge. Workpiece - Drawing Shaft. Material - steel 40. Weight of blank - 9 kg

Structure of operation

1 transition - install and remove workpiece

2 transition - to grind diameter $60^{+0,023}_{+0,003}$

Selection of tool - grinding wheel of straight profile 600 × 50 × 205, ceramic bundle, diameter of wheel 600 mm , non-sealed steel - white electric corundum,

Grain size -32 , C2 hardness, ceramic-based 6K structure.

Cutting Speed

Wheel speed $V_к$ = 35 м/сек, $V_з$ = 30 м/мин , $S_{прод}$ = 0,003.

Grinding wheel spindle speed

$n_{кр} = \frac{1000\, V_к\, 60}{\pi\, d} = \frac{1000 \cdot 35 \cdot 60}{3.14 \cdot 600}$ = 1004 rpm, accept by passport

$n_{кр}$ =1270 rpm, when $V_к = \frac{\pi\, D\, n_k}{1000 * 60} = \frac{3,14 \cdot 600 \cdot 1270}{1000 \cdot 60}$ = 39,8 m/sec

Workpiece Spindle Speed

$n_з = \frac{1000\, V_з}{\pi\, d_з} = \frac{1000 \cdot 30}{3,14 \cdot 60}$ = 159,2 rpm we accept by the passport of $n_з$ = 150 rpm, then $V_з = \frac{\pi\, D\, n_з}{1000} = \frac{3,14 \cdot 60 \cdot 150}{1000}$=28,26 m/min

Grinding allowance 0.3 mm/diam. At cut-in grinding of $z_в = {}^{0,3}/_{2}$ = 0,15 mm on the party. Main time 2 transition: $\square_0 = \left(\frac{\square_в}{\square_{прод} \cdot \square_з}\right) \cdot К = \frac{0,15}{0,03 \cdot 159,2} \cdot 1,7$ = 0,1 min

Where K = 1.7 - depends on grinding accuracy.

Determination of the time limit for operation 55

$\square_{шт} = \square_{0} + \square_{всп} + \square_{обсл} + \square_{отд}$, min

$\square_{в} + \square_{0} = \square_{0п}$, $\square_{0} = 0,4$ min

$\square_{в} = \square_{в\,уст} + \square_{в\,0п} = 1,6 + 0,1 = 1,7$ min

$\square_{0п} = 0,4 + 0,4 = 0,8$ min, $\square_{доп} = 8\%\ \square_{0п} = 8/100 \cdot 0,4 = 0,03$ min, then

$\square_{шт} = 0,8 + 0,03 = 0,83$ min

3.1 In a CAD/CAM environment . Preparing 3D model details in CAD

The latest automated design technology in the NX system provides high speed editing of the model of parts created in any CAD. By using synchronous technology, you can directly edit parts models and prepare them for CNC loom programs, including processing deaf holes, gaps, and shifting surface, and resize parts. The NX system also provides a number of specialized CAD functions that allow CNC machine programmers to perform rapid anaoize parts before creating operations corresponding to the control program.

The NX system uses the master model concept to provide end-to-end design and software development for CNC by linking all CAM and CMM functions to a single model that determines the geometry of the part. As a result, the programmer can start developing a program for the machine with cNC, without waiting for the end of the work of the designer. Full association ensures that the management program for the CNC machine is then updated when the model geometry changes.

The production chain OF SAD-CAM-CNC

To get the most out of the machine, you need to optimize the process of using it. A consistent holistic approach allows for the rapid installation of new machines and improved production efficiency. The manufacturing process begins with the input of design data, usually a 3D model of CAD, but in some cases 2D drawings are also used. 3D-CAD software is often needed to prepare or refine the design model and programming of CNC machines. 3D-CAD software is often necessary to prepare or refine the design model and programming of CNC machines. CAD apps can also be used to design and install fixtures. NX CAM applications include fully integrated CAD SAM features.

The NX CAM system provides CNC machine programming, post-processing and machine simulation. In an optimized production chain, each of the CAM elements is customized to match the specifics of the machines.

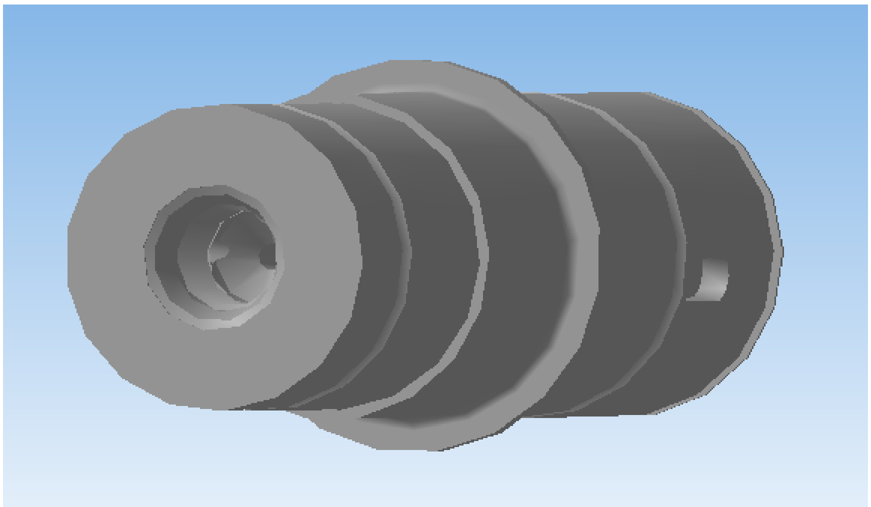

Figure 5 – Shaft's 3D model

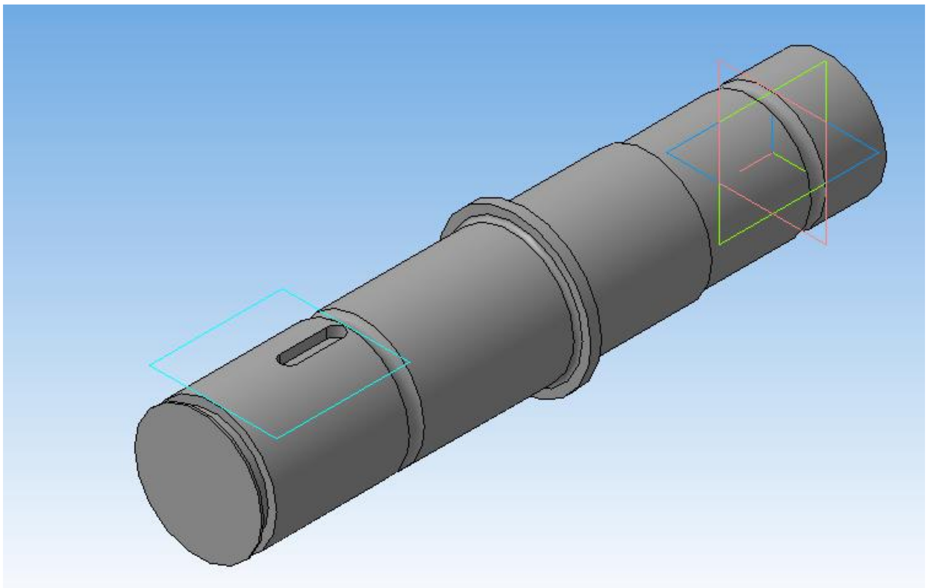

Figure 6 – Shaft's 3D model.

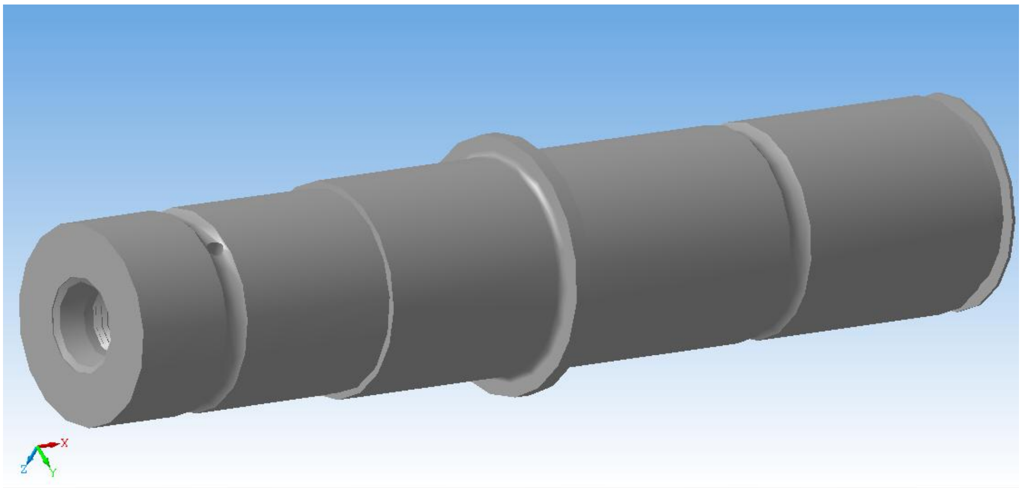

Figure 7 – Shaft’s 3D model.

CONCLUSION

The work has developed technological processes for assembling the drive shaft and machining the shaft. The service purpose of the shaft assembly is considered. The workpiece - stamping for the shaft was selected and its dimensions were calculated. Selected equipment, tooling, tools for machining the shaft. Billet - stamping has minimal machining allowances, which leads to metal savings.

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