MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Institute of Industrial Automation and Digitalization

Department of Industrial Engineering

Bekbulatova A.B.

Computer-integrated preparation of the manufacturing technology of the "gear" part in the CAD/CAM environment. Annual production program 8000 pieces

DIPLOMA PROJECT

5B071200 – Mechanical Engineering

Almaty 2020

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Institute 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 "gear" part in the CAD/CAM environment. Annual production program 8000 pieces”

5B071200 – Mechanical Engineering

Performed by: Bekbulatova A.B.

Scientific adviser
PhD, tutor
_____ Zhankeldi A.Zh.
“___” _____2020

Almaty 2020

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

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5B071200 – Mechanical Engineering

CONFIRM

Head of the Industrial

Engineering Department, PhD

Arymbekov B.S.

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TASK

for completing the diploma project

For student: Bekbulatova A.B.

Topic: “Computer-integrated preparation of the manufacturing technology of the "gear" part in the CAD/CAM environment. Annual production program 8000 pieces”

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

Deadline for completion the work *"20" April 2020*

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 Gear no. 05–170126 ;*
b) *Technological analysis of the gear designing;*
c) *CAD/CAM systems and their application in mechanical engineering.*

List of graphic material: *presented 20 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, Zhankeldi A.Zh.	10.03.2020	
Technical part	PhD, Zhankeldi A.Zh.	23.03.2020	
Calculation part	PhD, Zhankeldi A.Zh.	8.04.2020	
Modeling part	PhD, Zhankeldi A.Zh.	15.04.2020	
Normcontrol	PhD, Zhankeldi A.Zh.	22.05.2020	

Scientific adviser _____ PhD, Zhankeldi A.Zh.
Signature

The task was completed by student: _____ Bekbulatova A.B.
Signature

Date: “22” May 2020

ANNOTATION

In the provided diploma project were performed computer modeling and study of technological processes for the production of the part "Gear no.05-1701216".

This gear was modeled using the "Kompas-3D" program. After manufacturing the gear in the CAD/CAM environment, I analyzed the factory process and chose the method of extracting the workpiece of the part "Gear no.05-1701216".

The analysis and verification of technical requirements for processing and assembling were performed by using available data.

АҢДАТПА

Берілген дипломдық жұмыста "Тісті доңғалақ 05-1701216" бөлшектерінің өндіріс кезіндегі технологиялық процестеріне зерттеу жүргізілді және компьютерлік моделдеу өткізілді.

Бұл тісті доңғалақ "Компас-3D" бағдарламасында жасалынған. CAD/CAM жүйесінде дайындағаннан кейін, мен зауыттық технологиялық процесті талдаған соң, " Тісті доңғалақ 05-1701216" бөлшектерін дайындау тәсілін таңдадым.

Қолда бар деректер негізінде құрастыру және өңдеуге арналған техникалық талаптарға талдау жүргізілді. Берілген шығарылым бағдарламасын есепке ала отырып, өндіріс түрі анықталды, дайындау әдісін таңдау және негіздеу жүргізілді.

АННОТАЦИЯ

В предоставленной дипломной работе было произведено компьютерное моделирование и изучение технологических процессов производства детали- «Зубчатое колесо 05-1701216».

Через программу «Компас-3D» было смоделировано данное зубчатое колесо. После изготовления зубчатого колеса в среде CAD/CAM, я проанализировала заводской технологический процесс и выбрала метод добывания заготовки детали «Зубчатое колесо 05-1701216».

Анализ и проверка технических требований на обработку и сборку был произведен на основе имеющихся данных. С учетом заданной программы выпуска был определен тип производства, а так же осуществлялся выбор и обоснование типа выпуска заготовки.

CONTENT

INTRODUCTION

Keywords: Gear transmission, gear no.05-1701216, design and modeling, CAD/CAM systems, Kompas 3D.

The aim is to build 3D models of gear and draw operation processes of the gear production. Also, explore the preparation of the manufacturing technology of the gear in the CAD/CAM environment.

The relevance of the topic is to build the computer model and checking the technical requirements for processing the desired part using reliable technologies.

Nowadays, to realize success within the market, an mechanical business has to work to decrease the manufacturing period, decrease its cost and progress quality. The fast improvement of computer and data innovations has led to the rise of CAD/CAM systems, which are the most beneficial instruments for resolutioning these issues.

The object of research is the gear no. 05-1701216.

The method of research is the usage of "Kompas 3D" program to build the model based on design principles.

Mechanical engineering is part of scientific and technical progress and is the most important component of the industry. Machines for complex automation of production and modern efficient systems have been created and mastered in mechanical engineering.

Nowadays, the main goal is to improve the living conditions of citizens of our Republic, accelerate scientific and technical development and put the economy on the path of intensive development. To achieve this goal, it is important to design and produce high-performance machines and equipment, and introduce advanced technologies into production. Due to this, uncommon consideration ought to be paid to the plan, improvement and execution of unused compelling innovative forms, lessening the metal substance of items, mechanization and computerization of generation. Within the conditions of developing request for machines and gear in different areas of activity, it is critical to supply high-quality support and repair, since most organizations buy unique save parts created by the gear factory. Diploma project gives the opportunity to grow and solidify college information approximately the organization distinctive sorts of businesses, calculations, plan, and strategies of executing different sorts of gear, gadgets and apparatuses. The reason of the thesis is additionally to think about a particular mechanical prepare and discover ways to move forward it in terms of saving time, vitality, hardware and materials with financial defense. This makes it conceivable to extend the proficiency of generation and decides its specialized advance

1. The basis of the mechanism.
1.1 Gear and classification of its transmission

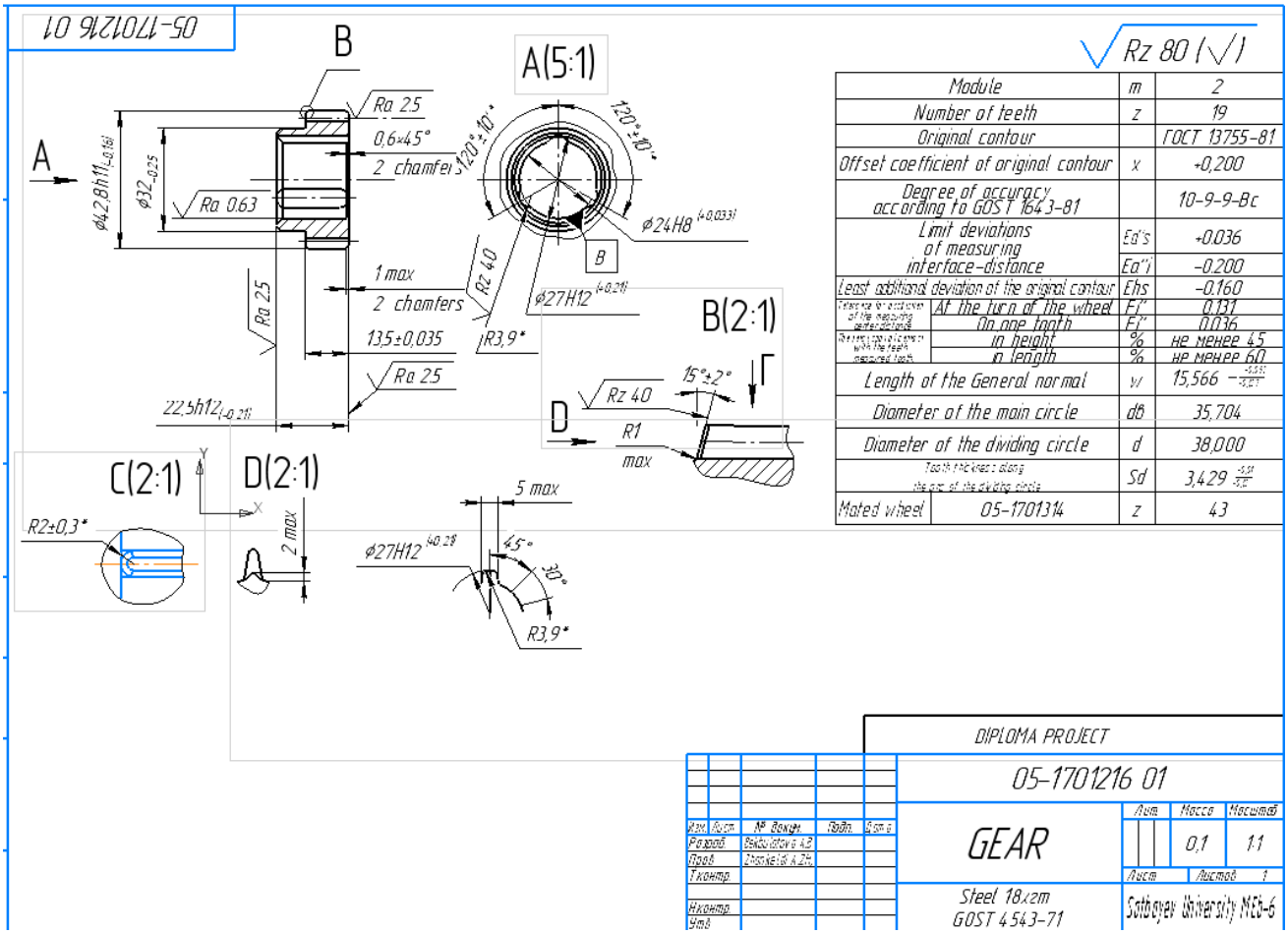


Figure 1– Gear no.05-1701216

The basis of the plan of any mechanism are components that planned to exchange mechanical drive from the motor to the other parts of the machine. Depending on their working rule, there are four sorts of transmissions: V-belt, gear, worm (friction). In any case, among them, gears are the foremost common within the world. They utilized to transmit power from divisions to tens of thousands of kilowatts at peripheral speeds of up to 150 m/s and gear proportions of up to a few hundred or indeed thousands, with a wheel distance across from divisions of a millimeter to 6m. or more. The wheel diameters of marine establishments, for illustration, in propeller gears reach 6m.

A gear wheel is the main part of a gear train, which is similar to a disk with teeth and transmits rotational motion between the shafts. They can be on a conical, spur or rack-and-pinion surface and engage with the teeth of neighboring gears as shown in Figure 2.

To begin with, in numerous machines, the specified development of the mechanism is associated with the have to be exchange turn from one shaft to another,

given that the axes of these shafts cross. In such cases, a cone shaped adapt is utilized. There are sorts of conical wheels that differ within the shape of the teeth lines: with straight, tangential, circular and curved teeth. Bevel wheels with a circular tooth, for example, are used in automotive main gears of the transmission.
The profile of the teeth of spur gears, as a rule, has an involute side shape. This implies that there is a gear engagement, in which the profiles of the teeth are laid out along the direction of any point of a straight line, rolled around the circle without sliding.

Rack and pinion is a mechanical adapt that changes over the rotational movement of a adapt wheel to the translational movement of a rack or vice versa

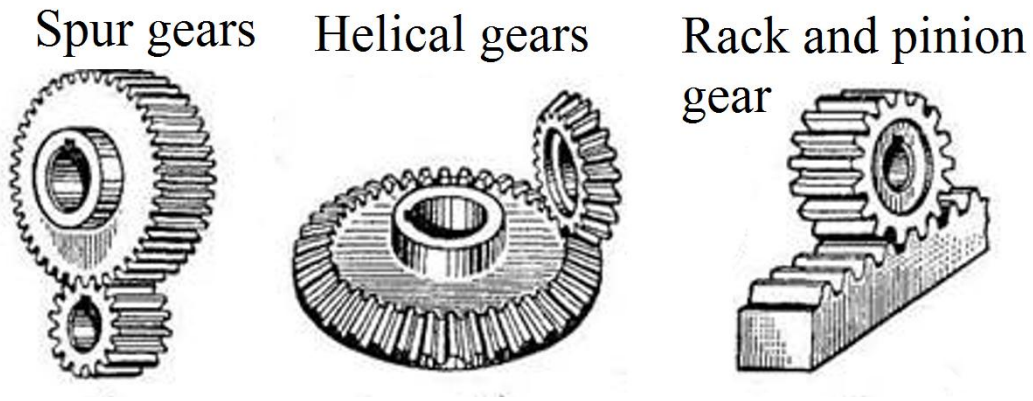


Figure 2 – Types of gears

Also, according to the shape of the longitudinal line of the tooth, cylindrical gears are divided into: Skew wheels, Straight wheels, Chevron wheels, Wheels with circular teeth (Fig. 3).

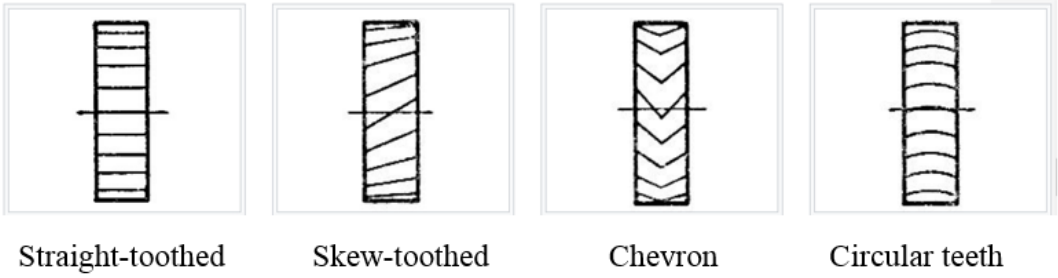


Figure 3– Types of cylindrical gears

In addition, it can be classify by its area. Depending on its work, the engagement components can be found on the inside or outside of the wheel. (Fig.4).

Figure.4– Types of gears by its location

1.2 Advantages and disadvantages of gear transmission

The main advantages of gears:

- Manufacturability, constant gear ratio;

- High quality in operation and simple support;

- High load capacity (up to N=50000 kW);

- Moderately little loads on the shafts and supports;

- High efficiency (up to 0.970-0.990 for one pair of wheels);

The disadvantages of gears include:

- High necessities for accuracy fabricating and establishment;

- Noise at high speeds; poor damping properties;

- Bulkiness at huge separations between the axes of the drive and driven shafts;

- High inflexibility, which does not permit compensating for dynamic loads;

- Require for uncommon equipment and instruments for cutting teeth.;

- Unreasonable utilize of teeth – the transmission more often than not includes no more than two teeth of each of the locked in wheels at the same time;

- The gear prepare does not ensure the machine from conceivable dangerous over-burdens.

1.3 The purpose of the part and operation at the node

The gear no.05-1701216 is included in the transmission of the Belarus-09N/09N-02 motor unit (Fig. 5). The walking tractor is a mobile power unit, which is prepared with extra connections for performing a wide run of rural exercises. The

walking tractor can essentially spare time and exertion for summer inhabitants and proprietors of little farms. It permits you to plow arrive rapidly and proficiently sufficient.

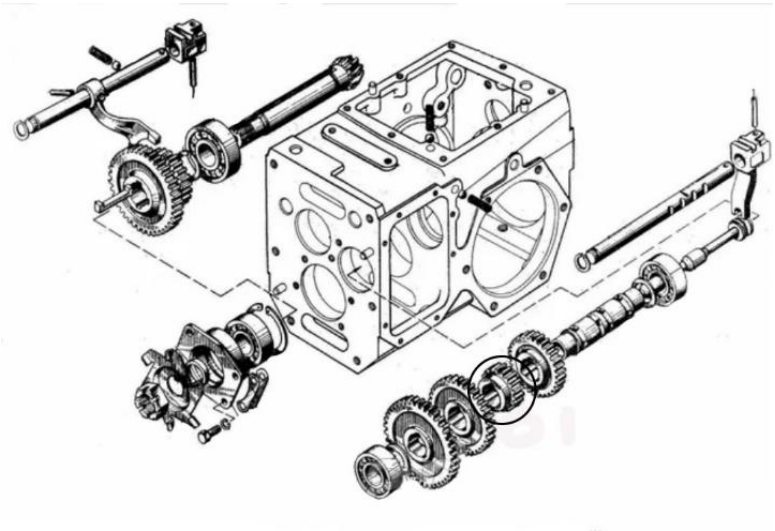


Figure 5– Belarus-09N/09N-02 motor unit

Oil-operated and physically worked clutch. The clutch is a multidisc.

Differential gear cone shaped with constrained locking.

Control of the power takeoff shaft lever on the transmission lodging.

Gearbox speed is manual with steady engagement of gears. The main gear is bevel gears with a winding tooth.

Final drives are single-stage with cylindrical gears.

Brake system-the unit consists of a motor block and a trailer (the brakes installed on the trailer) equipped with brakes that can break the unit in motion and in parking.

Fuel supply control-lever with cable drive.

Control of the differential lock-lever via the traction system.

The trailer gadget may be a bracket with a stick, a hitch of a tubular form.

Steering – rod, movable in stature and within the flat plane with the possibility of changeover to turn around, left or right position at an angle of 150.

1.4 Chemical composition of "gear no.05-1701216"

The "gear no.05-1701216" is made of steel grade 18HGT GOST4543-71. This is structural alloy steel. It utilized in progressed or cemented parts of a capable reason, which require expanded quality and consistency of the core, as well as high surface hardness, working beneath the impact of shock loads. In addition, 18HGT steel can be replaced with 25HGT steel due to similar properties. Also, you can see real photo of the "gear no.05-1701216" below (Fig. 6, 7).


Figure 6, 7–Real photo of the "gear no.05-1701216"

Table 1– Chemical composition of 18HGT steel

Chemical element	%
Silicon (Si)	0.17 -0.37
Copper (Cu), not more than	0.30
Manganese (Mn)	0.8 -1.10
Nickel (Ni), no more than	0.30
Titanium (Ti)	0.03 -0.09
Phosphorus (P), no more than	0.035
Chrome (Cr)	1.00-1.30
Sulfur (S), no more than	0.035

Table 2– mechanical properties of 18HGT steel at T=200C

Assortment	Size	S_{st}	S_{ys}	d_5	y	KCU	Heat treatment
-	mm	MPa	MPa	%	%	[kJ/m2]	-
Rod GOST 4543-71	-	980	885	9	50	780	Quenching and tempering
Steel	5	1520	1320	12	50	720	Tempering850^{0}C, oil, 200^{0}C release, air
Steel	20	980	730	15	55	1130	Tempering 850^{0}C, oil, 200^{0}C release, air

Hardness of 18HGT after annealing, GOST4543–71HB 10^{-1}= 220MPa;
Hardness of 18HGT of carbonized, GOST4543–71HB 10^{-1}= 230MPa;
S_{ys} – The limit of proportionality, [MPa];
HB – Brinell Hardness, [MPa];
d_5 – elongation at break, [%];
y – The relative narrowing, [%];
S_{st} – Short-term strength limit, [MPa];
KCU – Impact strength, [kJ/m^2];
Technological properties of 18HGT steel:
- Weld capacity: without confinements, it implies welding is perform without warming and without consequent warm treatment;
- The inclination to temper brittleness: less tended.

1.5 Choosing the type and form of production organization

Production type – a classification category of production, which is recognize by the breadth of extend, normality, solidness and volume of yield of items. In mechanical engineering, there are five types of production: mass, large-scale, medium-scale, small-scale and single.

Table 3– Type of production

№	Type of production	Value $k_{S.}$
1	Mass	up to 1.0(inclusive)
2	Large-scale series	1 to 10
3	Average series	10 to 20
4	Small-scale series	20 to 40
5	Single	40 and more

Table 4– Type of production

Type of production	The number of workpieces of the same name and size		
	High labor intensity, large, heavy, weighing more than 30 kg	Medium size and labor input, weighing 9-30 kg	Small, light, low- labor input, weighing up to 9 kg
Single	<5	<10	<100
Small-scale series	5-100	10-200	100-500
Average series	100-300	200-500	500-5000
Large-scale series	300-1000	500-5000	5000-50000
Mass	>1000	>5000	>50000

Based on Table 4, the gear no.05-1701216 refers to large-scale production. You can also check this using the calculation below:

Annual product program N= 8000 pcs.

The actual annual operating time of the equipment: T_o=3950 hours.

Defining the release time of parts:

$$t_r = \frac{T_o \times 60}{N} = \frac{3950 \times 60}{8000} = 29{,}625 \left(\frac{\text{min}}{\text{piece}}\right)$$

Table 5– Summary table of technical time standards for operations, min.

№ Operation	**Name of operation**	**n**	**T_p**
005	Lathe	8000	3,43
010	Lathe		3,43
015	Lathe		3,43
020	Vertically-extended		3,53
060	Gear hobbing		4,06
065	Teeth rounding		4,06
070	Gear cutting		4,06
105	Gear-rolling		4,06
115	Internal grinding		4,43
120	Grinding		2,84

Number of operations n=10.

Total unit time for all operations:

$\sum T_{piece} = 37{,}23$ min.

The average unit time is determined by the formula:

Average $T_{piece} = \sum T_{piece}/n = 37{,}23/10 = 3{,}723$ min.

The coefficient of seriality is determined by the formula:

$k_S = t_r$/Average T_{piece}= 29,625/ 3,723 = 7,957

T.к. $1 \leq k_S \leq 10$, then the type of production is large-scale.

Large-scale production is a transitional form to mass production.
In large-scale production, items are create in huge bunches over a long period. As a rule, this sort of undertaking specializes within the production of individualized items or sets of subject-specific sorts.

2. Analysis of the manufacturability of the part design

2.1 Methods of strengthening technology

The surface of the gear no.05-1701216 improved by chemical and heat treatment.

Chemical-heat treatment (CHT) of steel may be a set of heat treatment operations with immersion of the item surface with different components (chromium, carbon, nitrogen, aluminum, silicon, etc.) at high temperatures.

Surface saturation of steel with metals (silicon, chromium, aluminum, etc.) that form strong substitution arrangements with iron is more energy-intensive and longer than immersion with nitrogen and carbon that shape strong arrangements with press. In this case, the dissemination of components is simpler within the alpha-iron lattice than within the more thickly stuffed gamma-iron lattice.

Chemical-heat treatment increments hardness, wear resistance, cavitation, and erosion resistance. Chemical and heat treatment, making favorable leftover compression stresses on the surface of items, increments unwavering quality and solidness.

Cementation of steel - chemical and heat treatment by surface immersion of low-carbon (C less than 0.20 %) or alloy steels at temperatures of 910...960°C-solid (cementation with a solid carburetor), and at 860...910°C - gaseous (gas cementation) carbon with subsequent quenching and tempering. The reason of cementation and consequent heat treatment is to extend the hardness, wear resistance, as well as expanding the limits of contact continuance of the surface of the item with a thick center, which guarantees the perseverance of the item as an entirety amid twisting and torsion. First cleaned parts planning for cementation. Surfaces that are not subject to carburization are cover with extraordinary defensive cement coatings.

To begin with composition of the easiest coating: fire-resistant clay with the expansion of 10% asbestos powder, water. The blend is weaken to the consistency of thick sour cream and connected to the specified ranges of the surface of the item. After the coating dries, assist cementation of the item can be perform.

Second composition of the applied coating: kaolin-25 %, talc-50 %: water-25 %. Weaken this blend with fluid glass or silicate glue. Cementation is done after the coating is totally dry.

Name of the substances, which enter into the composition of the coating, is called carburization. They can be solid, liquid, or gaseous. In a little domestic workshop, it is more helpful to carry out cementation with glue. Usually cementation in a strong carburetor. The paste consists of soda ash-30%, soot-55% sodium oxalate-15%, water for the formation of a creamy mass. Glue connected to the required zones of the item and permitted to dry. Then the item is put within the broiler, kept at a

temperature of 910-930°C for 2- 2,5 hours. When utilizing this glue, cementation gives a thickness of the carburized layer of 0.7- 0.8mm.

Fluid cementation is additionally conceivable in a small workshop in case there is a furnace-bath, in which the carburization of apparatuses and other items takes put. The composition of the liquid includes: soda 75-85%, 10-15% sodium chloride, 6-10% silicon carbide. The oven-bath is filled with this composition and the item or instrument is submerged. The process takes place at a temperature of 850-860°C for 1.5- 2 hours; the thickness of the carbonized layer reaches 0.3-0.4 mm.

Gas cementation performed in a blend of glowing gasses containing methane and carbon monoxide in extraordinary chambers at a temperature of 910-960°C and as it were in production conditions. After cementation, the parts cooled beside the heater and after that tempered at 770-790°C last cooling in oil.

Nitrating of steel - chemical and heat treatment by surface immersion of steel with nitrogen by long-term holding it when warmed to B00 ... 650°C in a climate of smelling salts NH3. Nitrating steels have a really high hardness (nitrogen shapes different compounds with iron, aluminum, chromium, and other components that have a better hardness than carbides). Nitrating steels are exceedingly safe to erosion in situations such as environment, water, and steam.

Nitrating steels hold tall hardness, in differentiate to cemented ones, up to moderately tall temperatures (500...520°C). Nitrating items don't twist amid cooling, since the temperature of nitrating is lower than that of cementation. Nitrating of steels is broadly utilized in mechanical designing to extend the hardness, wear resistance, continuance constrain and erosion resistance of basic parts, such as gears, shafts, barrel liners.

Nitro cementation of steel - chemical and heat treatment with concurrent surface immersion of items with nitrogen and carbon at raised temperatures, taken after by extinguishing and hardening to extend wear and erosion resistance, as well as weakness quality. Nitro cementation can be carried out in a gas environment at a temperature of 840..860°C – nitro cyanation, in a liquid environment - at a temperature of 820...950°C - liquid cyanidation in molten salts containing the NaCN group.

Nitro cementation is compelling for instrument (especially high-speed) steels; it utilized for parts of complex arrangement that are inclined to distorting. In any case, since this prepare includes utilize of toxic cyanide salts, it has not found broad utilize.

Boration of steel - chemical and heat treatment by immersion of the surface layers of steel items with boron at temperatures of 900... 950°C. The reason of boring is to extend the hardness, wear resistance and a few other properties of steel items.

The dissemination layer with a thickness of 0.05... 0.15 mm, comprising of borides FeB and Fe2B, encompasses an exceptionally tall hardness, resistance to grating wear and erosion resistance. Boring is especially successful for expanding the solidness (by 2...10 times) of boring and pass on instruments.

2.2 Technological analysis of the design

Technological analysis of the design gives advancement of specialized and financial pointers of the created innovative prepare. Hence, mechanical analysis is one of the foremost imperative stages of innovative processing. The most assignments that unraveled when analyzing the manufacturability of the plan of the prepared part are diminish to the conceivable advancement of labor intensity and metal concentrated, the capacity to prepare the part utilizing high-performance strategies. In this way, progressing the manufacturability of the plan permits you to diminish the cost of fabricate, increment labor efficiency and decrease the time to make the item whereas guaranteeing the fundamental quality.

There are two types of assessment of the design's manufacturability:

1) Quality;
2) Quantitative;

Qualitative assessment characterizes the manufacturability of the design generically based on the involvement of the entertainer and is permitted at all stages of design as preliminary.

Quantitative assessment of the manufacturability of the item communicated by numerical indicators and defended in the event that they essentially influence the manufacturability of the plan in question. Qualitative assessment of manufacturability 18hgt steel features a great cutting machinability and includes a small cost.

The part has surfaces that can be prepared with a standard instrument, but there are surfaces that are not prepared by cutting. The surfaces to be handle are of a basic shape. By the by, there are surfaces that require utilize of a complex and special instrument.

When analyzing the dimensioning of the drawing, it ought to be note that the estimate limits that decide non-working surfaces have more extensive resilience areas and more prominent unpleasantness than the measurements of the working surfaces, which does not require an increment in labor concentrated within the fabricate of this portion. The positive angles incorporate the nearness of untreated surfaces, moo unpleasantness pointers, low fabric taken a toll and straightforwardness of the frame of most components of the portion. This encompasses a great impact on the method of getting the portion.

Quantitative assessment of manufacturability. It can be actualized as it were when utilizing the suitable essential indicators of manufacturability. Subsequently, it is fundamental to decide the most and extra indicators. The following indicators used to assess the method ability:

Key indicators: 1) the Technological cost of the part, 2) the Complexity of manufacturing the part: T_c

Additional indicators:

1) Coefficient of unification of basic elements:

$K_{u.e} = Q_{u.e} / Q_e$;

where $Q_{u.e.}$ and Q_e - accordingly, the number of unified structural elements of the part and the total, PCs;

2) The coefficient of applicability of standardized treated surfaces:

$K_{s.st.} = D_{p.st} / D_{м.р}$;

where $D_{p.st}$, $D_{м.р}$ - accordingly, the number of surfaces of the portion handled with a standard instrument, and all surfaces to be machined.

3) The Ratio of the surface treatment: $K_{s.st} = 1 - D_{м.р} / D_e$;

where D_e – the total number of surfaces of the part, PCs.

4) The utilization of the material: $K_{u.м} = q / Q$;

where q , Q – the mass of the part and the work piece, respectively, kg.

5) Coefficient of application of typical technological processes in the manufacture of this part: $K_{т.р.}=Q_{т.р.}/Q_р$;

where $Q_{т.р.}$ и $Q_р$ - respectively, the amount of standard technical processes for the manufacture of parts;

6) The maximum value of the processing quality is IT - 9;

7) Maximum value of the surface roughness parameter;

8) The level of manufacturability of the design at the technological cost:

$K_{MC} = C_C/C_{B.C;}$

where $C_{C.}$, $C_{B.C.}$ – respectively, the achieved and basic cost of the product.

After analyzing the quantitative indicators of manufacturability for this part, we must recognize negative and positive indicators, and decide the manufacturability of the part.

2.3 Analysis of the factory process, preparation of the processing route

The method analysis performed from the point of view of guaranteeing the desired item quality and preparing execution. The content and depth of the analysis depends on different components: the plan of the item, the strategies utilized for processing it, and the real generation conditions. In common, the method analysis must include the taking after main questions:

1) Rationality of the strategy of getting a billet for a given production scale;
2) The strategy of hardening the part and their compliance with its useful reason and working conditions of machines;
3) Machine instruments and their rational use;
4) Concentration and separation of preparing as a means of expanding productivity;
5) Process automation;
6) Basing of workpieces amid processing and assurance of mistakes of basing;
7) Preparing Defects and their causes;
8) The degree of equipment of operations, etc.

The technological process of the gear no.05-1701216 consists of the following operations:
005 lathe model 16K20 Figure 12;
010 CNC turning machine model 16A20F3 shown in Figure 14;
015 CNC turning machine model 16A20F3 shown in Figure 13;
020 vertical stretching machine model MP141N15;
060 Gear milling machine model BO07 shown in Figure 15;
065 Tool presetting on the machine model 5H580;
070 Gear cutting machine model 5525;
080 Gear shaving on the machine model 5702B;
115 internal grinding machine model 3K228 shown in Figure 11;
120 Sanding machine model 3B1531 shown in Figure 11;

Annual production program of Gears no.05-1701216 8000 PCs per year. Production type is large-scale. The subject of the analysis is the technological process of manufacturing is the gear no.05-1701216.

Table 6 -Technological capabilities of the equipment used.

№ operation	Machine model	Maximum dimensions of the workpiece, mm			Technological capabilities of the processing method	
		Diameter d, мм	Lenght l, мм	Height H, мм	Accuracy quality	Surface roughness
1	2	3	4	5	6	7
005	16К20	400	1500	-	12	2.5
010	16А20Ф3	500	1000	-	12	2.5
015	16А20Ф3	500	1000	-	12	2.5
020	МП141Н15	400	1000	-	10	1.6
060	ВО-07	300	1500	-	9..7	0.8
065	5Н580	320	1000	-	9..7	0.8
070	5525	300	700	-	8..6	0.6
080	5702В	125	250	-	8..6	0.6
115	3К228	300	320	-	8..6	0.6
120	3Б1531	220	700	-	8..6	0.6

Operations 005-015 will be replaced with a multi-operation machine 16A90MФ4 (Fig.8).

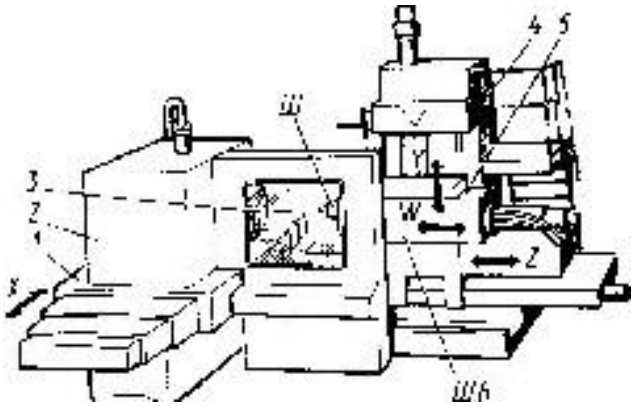


Figure 8– Multi-operation machine 16A90MF4.

On the machine, you will perform turning work pieces of the shaft sort, introduced within the chuck with back on the rear center 5 or within the centers. In this case, by utilizing apparatuses settled within the spindle 4, it is conceivable to prepare keyways, grooves, gaps and other components found along the shaft.

Moreover, a scraper conveyor and a trolley used to remove the chips. Blanks of the sort of revolution bodies with a distance across of up to 250 mm and a length of up to 100 mm, weighing up to 200 kg. Set in four-cam chuck 3, which gets turn from the axle mounted within the headstock 2. The headstock mounted on the sled 1. In expansion to nonstop turn, the work piece spindle can perform a moderate circular feed, which is vital for preparing, for case, curved grooves.

Table 7– Cutting tools

№ operation	The name of the tool	Type of the tool	The material of the cutting part	Resistance, min	Cutting fluid	Cutting modes			Size adjustment method
						V, m/min	S, mm/turnover	t, mm	
1	2	3	4	5	6	7	8	9	10
005	Pass-through cutter	special	Plate MKTC-sandvik		emulsion	70	0,2	2,2	Static
010	Pass-through cutter Boring tool	special	Plate MKTC-sandvik		emulsion	50 15	0,15 0,15	2 2	Static Static
015	Pass-through cutter	special	Plate MKTC-sandvik		emulsion	70	0,2	2	Static
020	Broach	special	P6M5		Oil U-20A	15	0,2	1,5	Dynamic
060	worm milling cutter	special	P6M5K5	240	Oil U-20A	31,6	1,5	1	Dynamic
065	finger mill	special	H6M5		Oil U-20A		0,08	1	Static.
070	cutting wheel	special	24A 25ПСТ 7B	30	emulsion	50		1	Dynamic
080	shaver	special	P6M5		emulsion	48	0,04	0,2	Dynamic
120	grinding wheel	special	24A40 МПГСМ1	30	emulsion	35	1,5	0,2	Dynamic

Table 8– Characteristics of mechanization and automation of the technological process

№ operation	Type of the tool	Managing the processing cycle	Method for loading workpieces	Type of interoperable transport	$d=T_0/T_p$	Qualitative assessment		
						Degree	View	Category
005	16К20	Automatic	Manual	Mobile conveyor	0,63	1	Complex incomplete	Average
010	16А20Ф3	Automatic	Manual	Mobile conveyor	0,83	1		Elevated
015	16А20Ф3	Automatic	Manual	Mobile conveyor	0,79	1		Elevated
020	МП141Н15	Automatic	Manual	Mobile conveyor	0,56	1		Small
060	ВО-07	Automatic	Manual	Mobile conveyor	0,83	1		Average
065	5Н580	Automatic	Manual	Mobile conveyor	0,67	1		Small
070	5525	Automatic	Manual	Mobile conveyor	0,66	1		Lowest
080	5702В	Automatic	Manual	Mobile conveyor	0,81	1		Lowest
115	3К228	Automatic	Manual	Mobile conveyor	0,79	1		Average
120	3Б1531	Automatic	Manual	Mobile conveyor	0,53	1		Average

3. Computer integration

3.1 Basic design principles

The method of designing is the starting stage of developing mechanisms that do not yet exist or updating modern ones. The design process is the arrangement and translation of the starting item portrayal into the ultimate description based on the implementation of the vital remedial complex of works. Computer-aided design is the method of getting plan solutions utilizing the interaction of people, computers, and computerization instruments. This framework called computer-aided design (CAD). The system approach could be a set of concepts for designing complex structure. This approach considered the foremost common among a large number of options and so utilized most frequently. One of the most Common standards of the system approach is to consider the interaction of different complex systems and parts of specific effects.

System engineering just investigates such complex specialized structures, different ways to design them. System engineering considers the totality of the organization of the method of designing, using and creating mechanical systems and strategies and standards of their plan and research exercises. In system engineering, it is vital to set the objective of the frameworks and the capacity to organize the thought of the strategy through the crystal of determined objectives. This helps the designer discard insignificant data in the design and modeling of a particular model and not mediocre move to the formulation of optimized tasks. Computer-aided design systems are one of the foremost complex modern artificial structures that creates their design incomprehensible without an efficient approach or other options. Hence, system designing is an imperative portion of consider of present day computerized frameworks and advances for their application, since without it; A clear example of the need for a systematic approach to modeling is the ability to implement design continuity through this system and the ability to reuse information and developments during the design of complex engineering structures.

Then, we are going consider different approaches and assortments of a systematic approach to tackling these complex systems. Within the basic approach, as a kind of framework approach, it is essential to combine different structures from components (blocks) and allow assessment criteria to these alternatives when making and repeating over their fractional synthesis with preparatory estimates of the characteristics of these components. The object-oriented approach to design (OOD) intended primarily for the consideration and development of information systems and, above all, their software. The reason for this specialization could be a number of preferences that this approach gives in solving issues with complex data frameworks and coordination computer program into them:

- Permits a high level of model organizing, conveying existing information and demonstrate strategies between classes of objects;
- Reduces the volume of determinations by presenting protest hierarchy descriptions and investigate connections between question properties at diverse levels of the chain of command;
- Decreases the probability of information twisting due to incorrect activities by limiting get to certain categories of information in objects. The description in each question course of worthy gets to them and acknowledged message groups makes it simpler to arrange and coordinated the program. The taking after highlights moreover characterize all approaches to the design of complex systems;
- Organizing of the design mechanism, communicated by the deterioration of project tasks and documentation, the assignment of stages, stages, and design strategies. This organizing is the substance of the progressive approach to design;
- Iterative nature of design;
- Typification and unification of design arrangements and design devices.

3.2 Modern CAD/CAM systems and their application in mechanical engineering

CAD (computer-aided design), CAM (computer-aided manufacturing) systems allow you to avoid traditional design methods by opening the possibility to do it on personal computers. These programs work with illustrations, as well as resistance investigation, calculation of mass inactivity properties, FEM modeling, and visualization of analysis comes about.

The most work of CAD systems is to characterize the geometry of the model structure as a characteristic from which all-further calculations and estimations based as a case of deciding the life cycle. The preferences of this plan strategy are the capacity to design parts that are more complex and disentangle preparatory calculations of item characteristics. Therefore, these systems usually considered computer-aided design systems. The geometric information that was added to the CAD System can be further added and used in CAM and CAM systems, which makes CAD systems an very important part of modern design, which spares time and diminishes the number of blunders related with the ought to show and decide the fundamental geometry of the demonstrate. For modern CAD systems, the modular construction principle is used.

The essential modules of the designed model utilized for solid-state and surface modeling, making structures from fundamental shape components, and making drawings with measurements and resistances. Design continuity ensured by the user's capacity to include unique models to the library. Get together carried out employing a function call or a reference to the components and models in library chronicles, their

adjustment, advancement of unused parts and their combination. You can change the spatial position of Assembly parts, fix their position relative to other Assembly elements, and set the position of these elements. There are extra design building modules that can be used for a more particular but contract specialization. These modules used, for case, when it is vital to plan boards made of composite materials, create passes on and casting molds, pipeline systems, welded structures, wiring electrical cables and harnesses. The presence of such modules for CAD systems increments their value in computer-aided design.

CAM innovation employments computer systems to analyze the geometry of a CAD model, recreate and study the behavior of an object, progress and optimize its design by robotizing engineering calculations, analyzing and simulating physical forms, and perform energetic modeling. The CAM system can perform: Using CAM systems permits you to design manufacturing process, rapidly synthesize programs for CNC machines, recreate machine handling procedure, and more. Checking in case the sample piece has any geometry mistakes that will affect the fabricating prepare. Designing settling where the CAM system will choose the excellent attitude for a portion to maximize machining effectiveness. For illustration, when making a component base for control systems, etc. - modeling of elastic-stressed, deformed, heat state, vibrations of the structure and assurance of basic loads. Most regularly performed in agreement with the limited component strategy (FEM); - calculation of States and homeless people at the large-scale level; -reenactment of complex generation frameworks based on queuing models.

Now there are a large number of companies developers offer and a number of universal software systems that implement CAD/CAM technology, based on methods that provide the process of computer-aided design in the field of mechanical engineering. CAM systems include such programs as PowerMill, MasterCam, ESPRIT**,** CAMWorks, Nisa, Moldflow, ABAQUS, LS-DYNA, ADEM, MSC, T-FLEX Analysis. CAD systems include CATIA (Dassault systems), UNIGRAPHICS NX (Siemens PLM Software), Pro/ENGINEER (PTC), AutoCAD Inventor Professional, Kompas 3D, and SOLIDWORKS. The basic advantage of strategies for analyzing and optimizing structures is that the production of test models and their testing is an costly prepare that can take a long time but utilizing these systems it is conceivable to expect conceivable issues and impediments of the model some time recently its creation which incredibly decreases the design procedure.

3.3 CAD Selection

The 3D model will be execute in the Kompas 3D program. Kompas 3D provides huge opportunities for modeling various mechanisms, machines, parts, etc. Programs

in this system consequently create acquainted sees of three-dimensional models (counting segments, areas, local segments, neighborhood sees, arrow sees, and split sees). All of them related with the model: changes within the model cause the picture within the drawing to alter.

3.4 Creating a part drawing using the Kompas 18.1 V program

1) Create a Drawing document, set the format A3, orientation-horizontal.
2) Name the shafts and mechanical transmissions of 2d library by clicking the "library manager" button on the standard panel. Select the "calculation" and construction tab. double-click it on the desired library.
3) Double-click the "build model" command.
4) In the shown window, click "create a new model", that we will build in the section.
5) Settle the primary point of the picture and start building a model of the gear wheel.
5.1) To begin with of all, let construct the protruding part of the center. Within the external form, select a cylindrical organize. Setting its size.
5.2) Since we are going to draw a straight-toothed gear wheel, within the elements of mechanical gears tab, select a cylindrical gear.
5.3) Set the chamfers to the right and left. Run the calculation for the center separate.
5.4) Enter the values of the transmission parameters. Within the window and calculate the center separate. Go to the moment page.
5.5) Tap on the Calculation button, hold up for comes about of checking the entered information by the system to seem and in case everything is ordinary, tap Finish calculations.
5.6) Choose a gear or wheel (in this case, no difference). Click OK.
5.7) Screwing part of the hub.
5.8) Making out the internal contour of the wheel. Select the inner cylindrical arrange and make chamfer.
5.9) Select extra developments and construct a keyway, its measurements are decided automatically.
5.10) Go back to the outer form and make ring grooves and gaps (additional constructions).
5.11) Tap on the button for additional developments within the outside form and select the development of the parameters table. Making a simplified table.
5.12) Create a solid-state model of the wheel.
We save our model of the gear wheel (Figure 9,10)

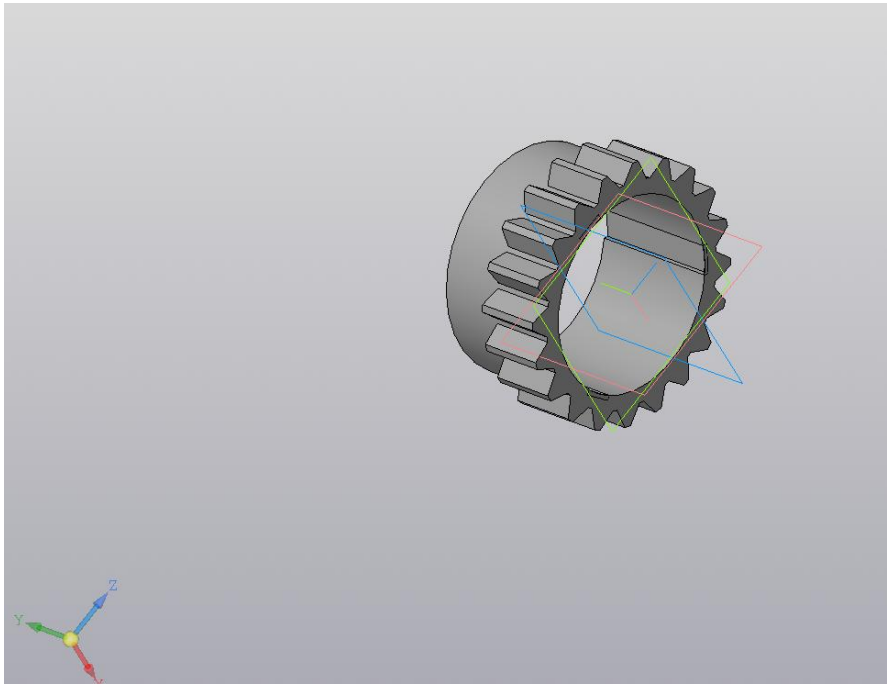


Figure 9– 3D model of gear in Kompas 3D

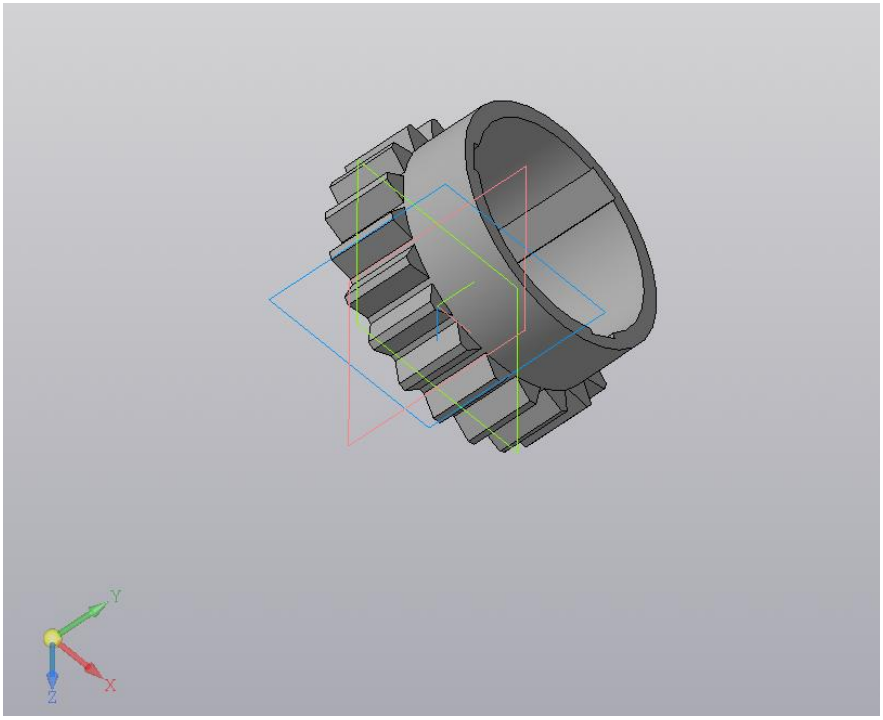


Figure 10– 3D model of gear in Kompas 3D

I also built operational drawings that used in the manufacture of the gear wheel (Figure 11, 12, 13, 14, 15).

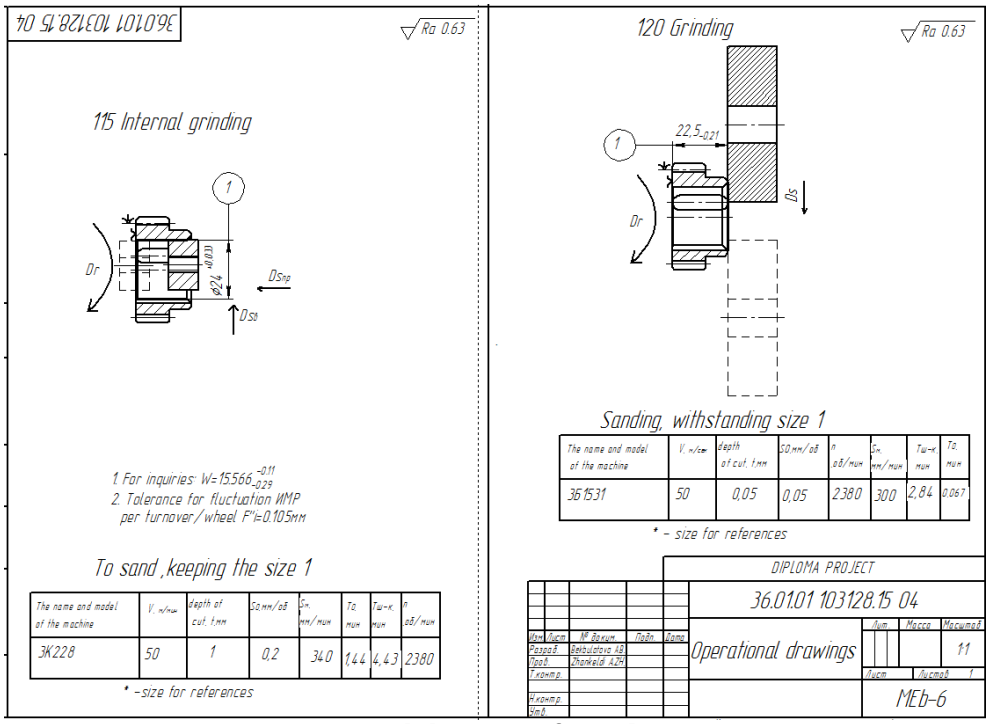
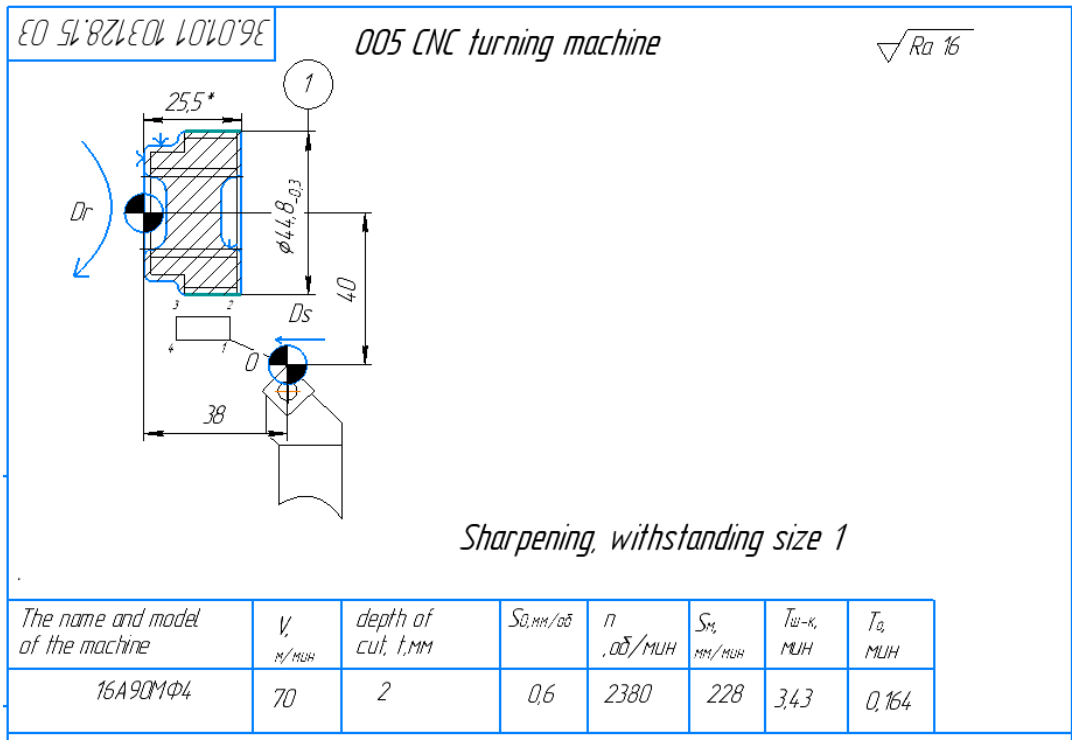
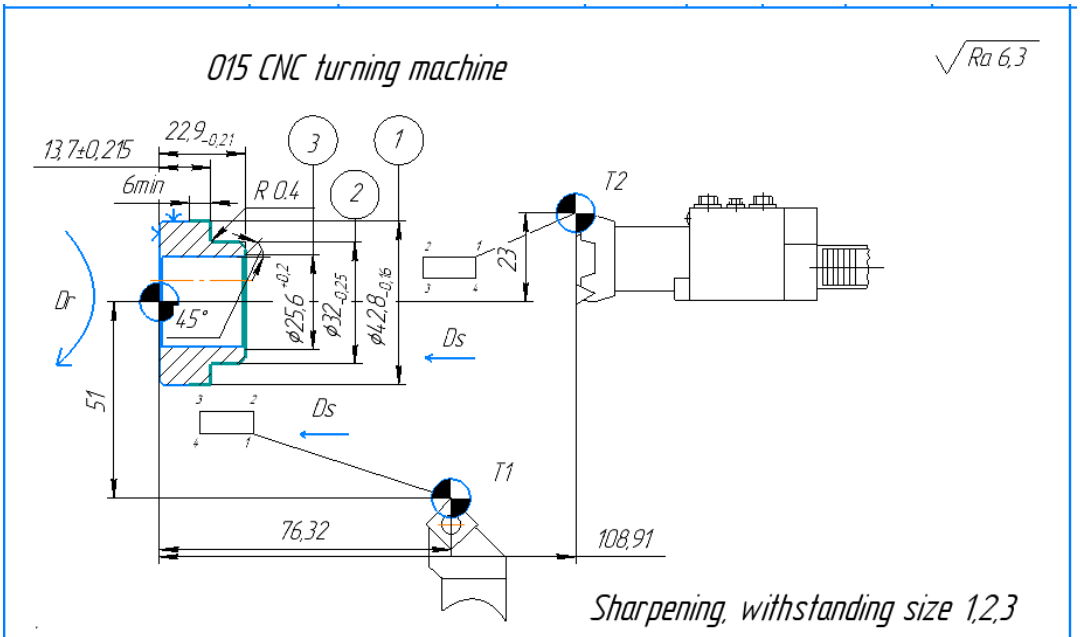


Figure 11– Operational drawing of grinding in Kompas 3D



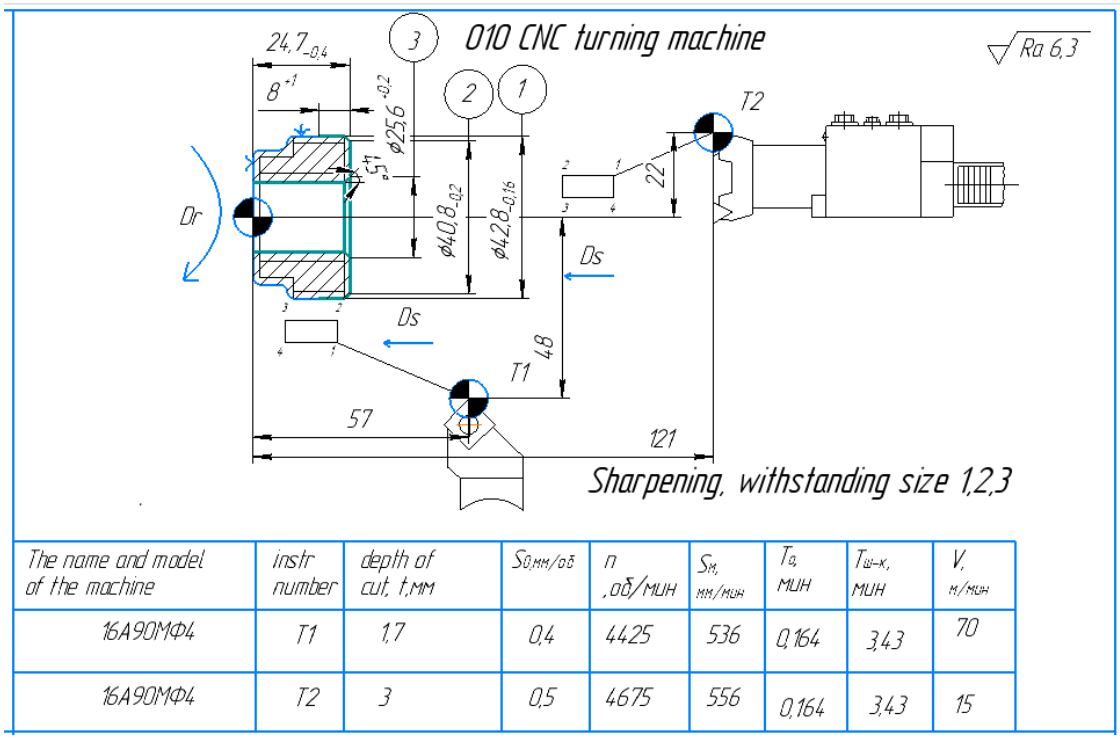
The name and model of the machine	V, м/мин	depth of cut, t,мм	So,мм/об	n ,об/мин	Sм, мм/мин	Тш-к, мин	То, мин
16А90МФ4	70	2	0,6	2380	228	3,43	0,164

Figure 12– Operational drawing of CNC turning machine in Kompas 3D



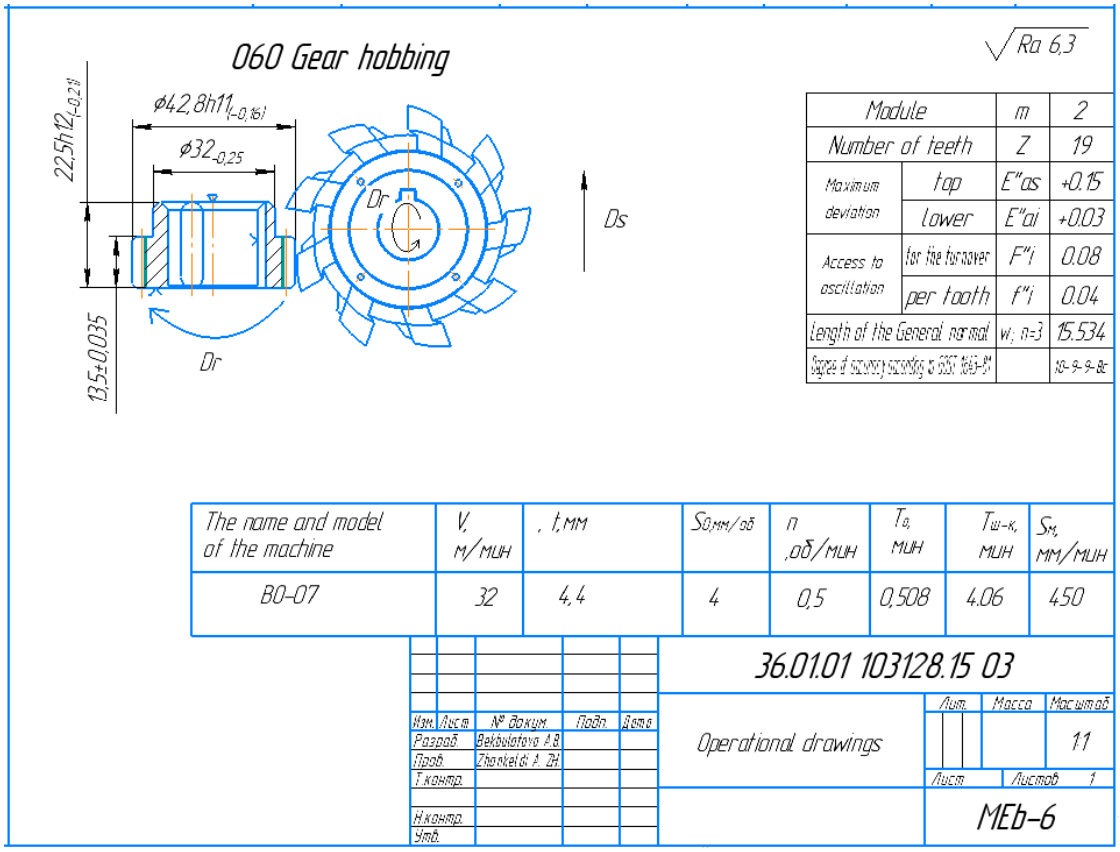
The name and model of the machine	instr number.	depth of cut, t,мм	So,мм/об	n ,об/мин	То, мин	Тш-к, мин	Sм, мм/мин	V, м/мин
16А90МФ4	T1	1,7	0,4	4425	0,164	3,43	536	70
16А90МФ4	T2	3	0,5	4675	0,164	3,43	556	15

Figure 13– Operational drawing of CNC turning machine in Kompas 3D



The name and model of the machine	instr number	depth of cut, t,мм	S0,мм/об	n ,об/мин	Sм, мм/мин	To, мин	Tш-к, мин	V, м/мин
16А90МФ4	Т1	1,7	0,4	4425	536	0,164	3,43	70
16А90МФ4	Т2	3	0,5	4675	556	0,164	3,43	15

Figure 14– Operational drawing of CNC turning machine in Kompas 3D



The name and model of the machine	V, м/мин	, t,мм	S0,мм/об	n ,об/мин	To, мин	Tш-к, мин	Sм, мм/мин
ВО-07	32	4,4	4	0,5	0,508	4.06	450

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Operational drawings

Лит. Масса Масштаб 1:1

Лист Листов 1

МЕЬ-6

Figure 15– Operational drawing of gear hobbing in Kompas 3D

CONCLUSION

To complete this work, we should remember the main subjects that studied at university and perform the calculation like real engineers. In this diploma project, I wrote down the technology for the complete manufacture of a gear.

I done my thesis to identify the relevance of using CAD/CAE systems for the technology of designing gear parts and its construction operations. Work it carried out on the design of the gear wheel part and a 3D model of this detail created in the Kompas-3D program.

In addition, I developed the technological process of manufacturing the part "Gear no.05-1701216". We analyzed the factory technological process and selected a method for obtaining the work piece "Gear no.05-1701216". We determined the required number of machines and made a schedule for their loading.

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