MINISTRY OF EDUCATION AND SCIENCE OF
UKRAINE NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
"IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE"
INSTITUTE OF MECHANICAL ENGINEERING
Department of Manufacturing Engineering

The defense allowed:
Acting head of the department
Oleksandr Okhrimenko
_____

Diploma project
Level of higher education – first (bachelor)
Program subject area – 131 "Applied Mechanics"
Educational Program "Manufacturing Engineering"

Topic: «Manufacturing Process Planning for the Part " Bracket "»

Developed by:
Student of the IV year of study, group MT-03
Salih Sezer Fucucuoglu _____

Supervisor:
Ph.D, associate professor Volodymyr Korenkov _____

Reviewer:
Ph.D, associate professor Kholavik Olga _____

I certify that in this diploma project there are no borrowings from the works of other authors without proper references.

Kyiv-2024

National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"
Educational and Research
Institute of Mechanical Engineering
Department of Manufacturing Engineering

Level of higher education – first (bachelor)
Specialty – 131 "Applied Mechanics"
Educational and Professional Program "Manufacturing Engineering"

APPROVED
Head of the department
_____ Oleksandr OKHRIMENKO
«___»_____2024

ASSIGNMENT
for the diploma project to the student

_____ Salih Sezer Fucucuoglu _____

1. Topic of the diploma project: Manufacturing process planning for part "Bracket" project supervisor: Volodymyr Korenkov, PhD, associate professor

approved by the University Order dated «___» _____2024 No_____

2. The deadline for the student to submit a diploma project «**10**» **June** 2024

3. Initial data for the project:
Drawings of the product "Bearing Housing";
Material: ISO 185 JL 200 Gray Cast Iron;
Production Volume: 3000 units per year

4. The content of the explanatory note, a list of tasks to be developed:
Chapter 1. Manufacturing Process Planning
Chapter 2. Calculation of Workpiece Deformations
Chapter 3. Fixture design
Chapter 4. Economic calculations

5. A list of graphic and illustrative material
- Presentation of the Chapter 1 results: 1 sheet A1
- Drawing of a part and a blank – 1 sheet A1

- Manufacturing operation presentation – 2 sheets A1
- Results of NC-program development – 1 sheet A1
- Drawing of the workpiece clamping device – 1 sheet A1
- Presentation of the project – 5-10 PowerPoint slides

6. Consultants for chapters of the project

Chapter	Surname, initials, and position of consultant	Signature, date	
		Issued the task	Accepted the task
1	Volodymyr Korenkov, PhD, associate professor		
2	Volodymyr Korenkov, PhD, associate professor		
3	Volodymyr Korenkov, PhD, associate professor		
4	Volodymyr Korenkov, PhD, associate professor		

7. Issue date of the assignment: 20 May 2024

CALENDAR PLAN

No	Stages of the diploma project implementation	The deadline for the stages of the diploma project	Notes
1	Chapter 1. Manufacturing Process Planning	25 May 2024	
2	*Presentation of the Chapter 1 results: 1 sheet A1*	25 May 2024	
3	*Drawing of a part and a blank – 1 sheet A1*	25 May 2024	
4	Chapter 2. Calculation of Workpiece Deformations	31 May 2024	
5	*Manufacturing Operations Presentation - 2 sheets of A1 Format*	31 May 2024	
6	*Results of NC-program development – 1 sheet A1*	31 May 2024	
7	Chapter 3. Fixture design	7 June 2024	
8	*Drawing of the workpiece clamping device – 1 sheet A1*	7 June 2024	
9	Chapter 4. Economic calculations	10 June 2024	
10	Presentation	10 June 2024	

Student Salih Sezer Fucucuoglu

Supervisor Volodymyr Korenkov

ABSTRACT

This project details the comprehensive manufacturing process plan for producing a bracket part. The project begins with a thorough analysis of the part's purpose and operating conditions within its assembly unit, highlighting critical design features and working conditions. Then determines the appropriate production type based on the part's weight and production volume, categorizing it under medium group production, which influences subsequent decisions on manufacturing methods.

The plan outlines the selection and design of the blank, considering material properties and manufacturing tolerances, and the creation of a machining sequence for the bracket. Key manufacturing steps include rough and contour milling, drilling, and centering, ensuring the precision and quality of the final product. The project also addresses the design of locating schemes to maintain spatial positioning accuracy during processing.

Critical considerations such as the choice of manufacturing equipment, cutting tools, and machining conditions are discussed to optimize the manufacturing process. Additionally, the plan includes time and cost calculations, ensuring the feasibility and efficiency of the manufacturing operations. The ultimate goal is to achieve a balance between precision, complexity, and cost-effectiveness in the manufacturing of the bracket.

By integrating theoretical analysis with practical considerations, this project provides a detailed roadmap for manufacturing the bracket, adhering to industry standards and best practices to ensure high-quality output.

Contents

INTRODUCTION

In the domain of manufacturing engineering, the development of a process plan for the production of mechanical parts is pivotal to ensuring high-quality output, cost efficiency, and adherence to production timelines. This project focuses on the manufacturing process plan for a part referred to as the "Bracket." The bracket is an essential component in various mechanical assemblies, requiring precise design and manufacturing considerations to fulfill its functional requirements.

This work entails a comprehensive analysis and detailed planning of the manufacturing process for the bracket. The process begins with understanding the part's design features and its role within the assembly unit, followed by determining the appropriate type of production based on factors such as part weight and production volume. Subsequently, the design of the blank, selection of manufacturing datums, and the development of typical surface processing routes are addressed to ensure the part meets the required specifications.

The introduction provides an overview of the critical steps and considerations in the manufacturing process plan for the bracket, highlighting the importance of each phase in achieving the desired product quality and efficiency. This structured approach ensures that the manufacturing process is optimized for performance, cost-effectiveness, and reliability, which are essential in today's competitive manufacturing landscape.

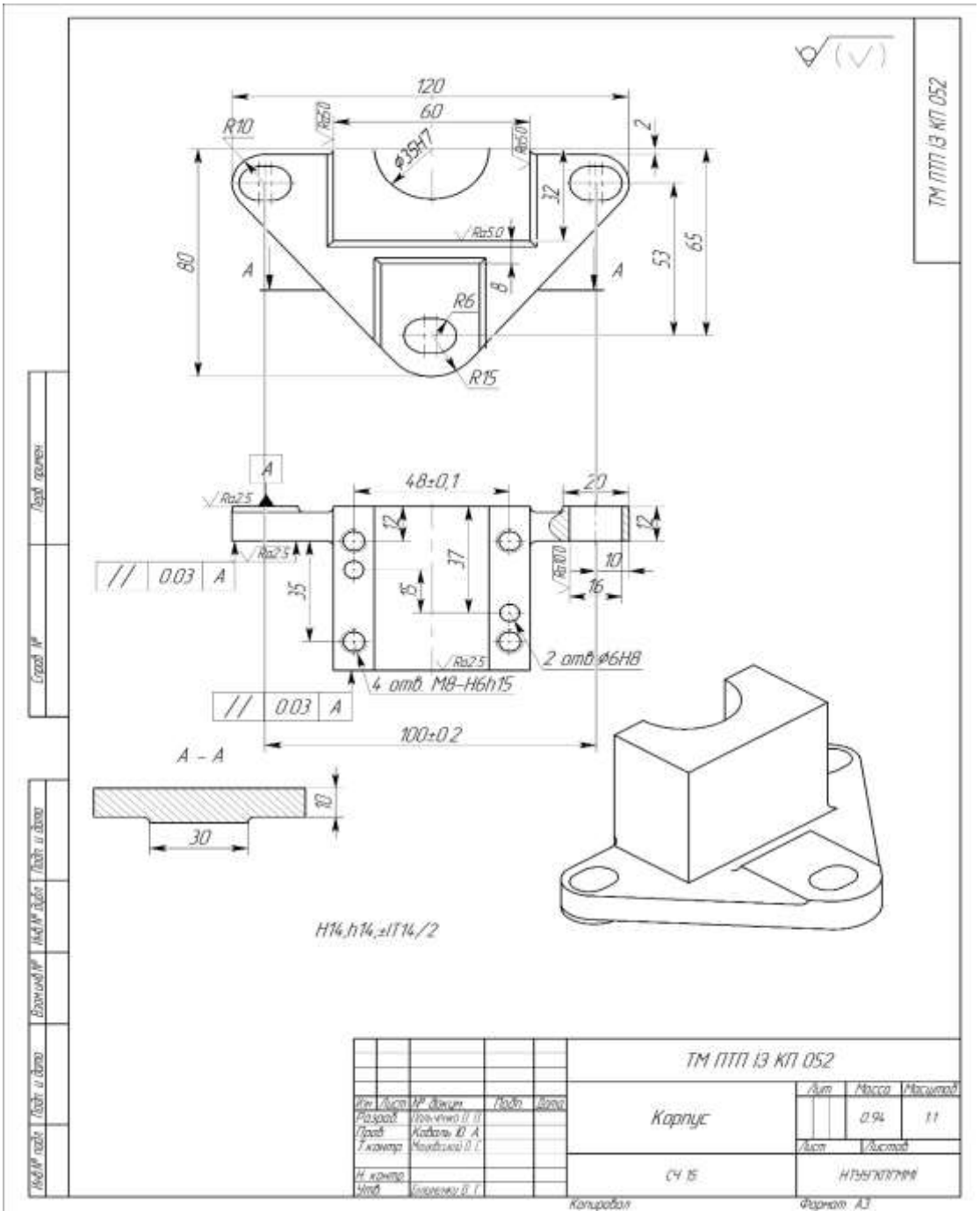
This project not only demonstrates the practical application of manufacturing theories and methodologies but also serves as an educational tool, bridging the gap between theoretical knowledge and real-world manufacturing practices. Through detailed process planning and execution, this work aims to illustrate the complexities and intricacies involved in the production of mechanical components, providing valuable insights for both academic and professional pursuits in the field of manufacturing engineering.

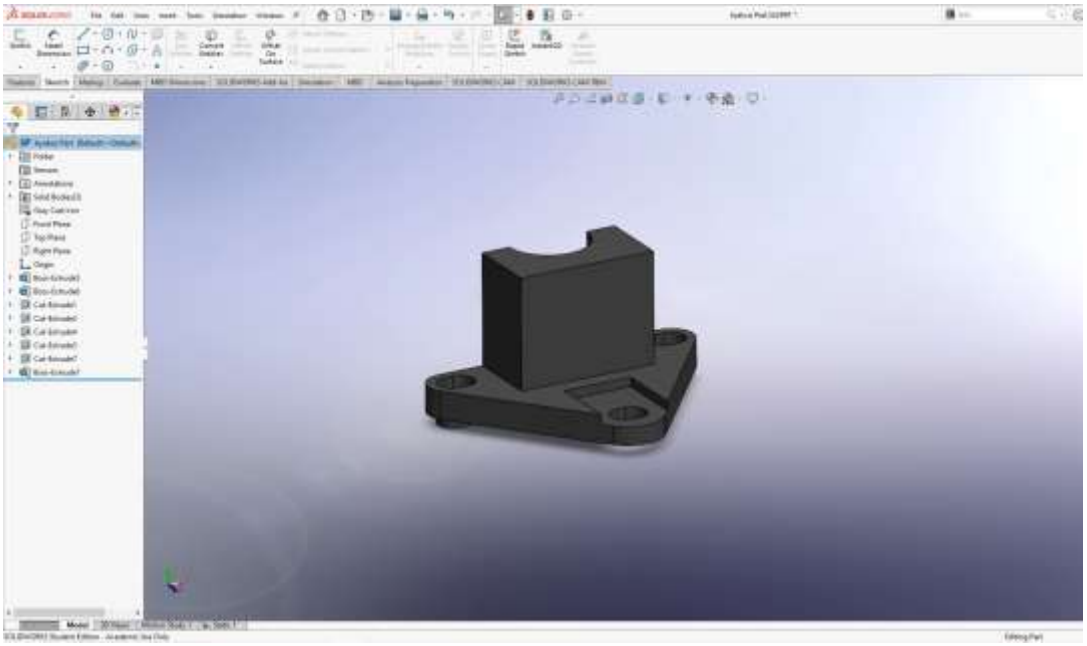
CHAPTER 1. Manufacturing process planning

1.1 Analysis of the purpose and operating conditions of the part in the assembly

1.1.1 Analysis of design features of the part and its classification

Considering the configuration of the part “Bracket” we defined that it belongs to the class “Body.”





In general, the requirements for the accuracy and quality of the surfaces of the part are not very high, but there are a few surfaces that are subject to increased requirements.

During manufacturing a special attention must be paid to the machining of holes ∅48H7, ensuring their perpendicularity to the ends, and alignment.

1.1.2 Analysis of the part's working conditions in the assembly unit

The "housing" is designed to install and hold the gears, shafts, and bearings in the appropriate position, as well as to retain the oil and prevent it from leaking.

There are bearings inside the holes ∅48H7. Holes M8-6H15 are intended for fastening the bearing caps. The cover is connected using 6 threaded holes M8-6H15

The gearbox is securely attached to the frame using the holes ∅8H7 hole. During operation, the part is exposed to significant, long-term alternating loads and vibrations

1.1.3 Analysis of the material

Material of the part is Matte chrome (ISO 185 - Class 150).

Tensile strength $\sigma_в$= 110 MPa; hardness HB=70…185; density ρ= 124.69 g/cm3.

Considering the provided information, it can be deduced that the component functions under cyclic loading and is not subjected to harsh environmental conditions. The material suggested by the designer guarantees the functionality of the part in these circumstances. The part's drawing encompasses an ample variety of views and sections, facilitating a comprehensive comprehension of its design characteristics.

1.2 Determining the type of production and analysis of its impact on the manufacturing process plan

Educational purposes we will use analog methods of designation of production type based on weight of a part and production volume.

Part weight m= 0. 0.91308 kg (Fig. 1.2)

Production volume Np =126816.

Decide the sort of generation agreeing to the taking after table (table. 1.1)

Table 1.1 – Estimation of the production type

Weight of a part, kg	Type of production				
	Single	Small batch	Medium batch	High volume batch	Mass
<1	< 10	10 .. 2000	2000 .. 75000	75000 .. 200000	> 200000
>1 .. 2.5	< 10	10 .. 1000	1000 .. 50000	50000 .. 100000	>100000
> 2.5 .. 5.0	< 10	10 .. 500	500 .. 35000	35000 .. 75000	>75000
> 5.0 .. 10.0	< 10	10 .. 300	300 .. 25000	25000 .. 50000	>50000
> 10.0	< 10	10 .. 200	200 .. 10000	10000 .. 25000	>25000

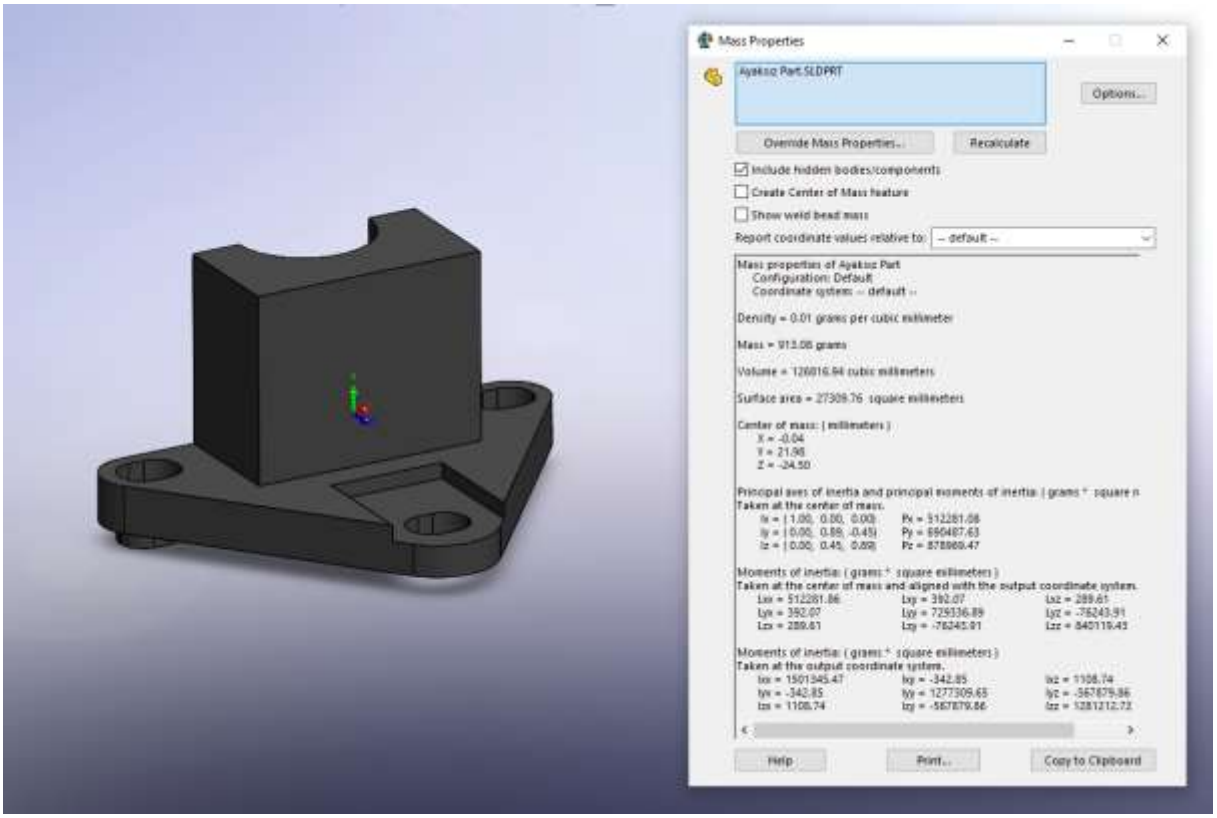


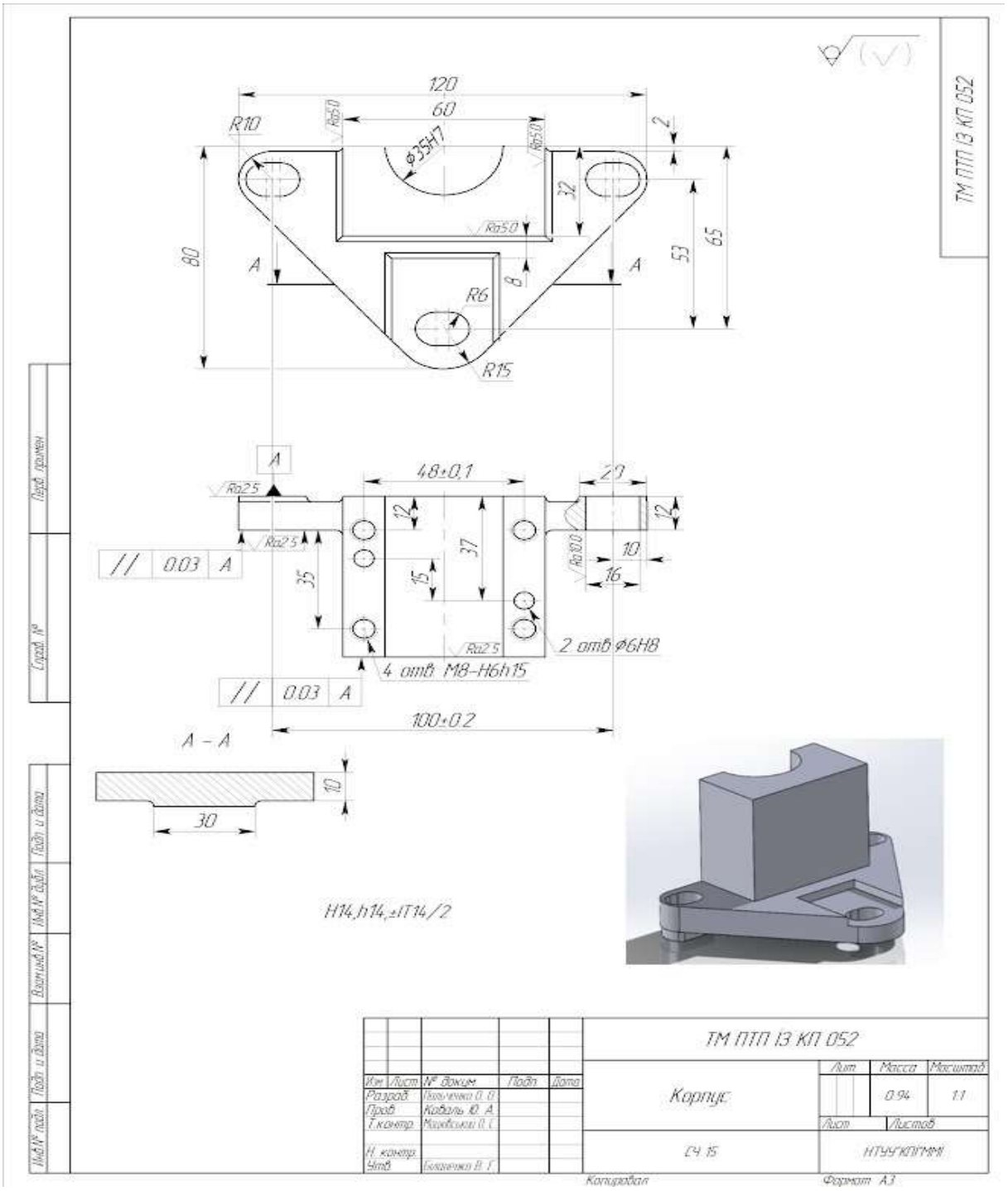
Fig. 1.2 – Characteristics of the part Bracket and its 3-D model

Conclusion: The generation sort – medium group, subsequently, we will perform all advance calculations and make mechanical choices for the medium-volume sort of generation Starting information for the handle choice (agreeing to the variation)

1.3 Selection of the base process and design of the blank

Initial data for the process selection (according to the variant):

- drawing of a part;
- material of a part – Grey Iron;
- Annual output – 3000 pcs.



Given the material and shape of the part, the sand-casting process appears suitable for the manufacturing base.

To ascertain the necessary machining allowance (RMA) grade, we'll consult Table B.1 [2]. For Grey Iron in sand casting, grade F is recommended. According to

this grade and considering the part's largest dimension of 120mm (as depicted in the drawing), a machining allowance of 1.5 mm is required as indicated in Table 2 [2].

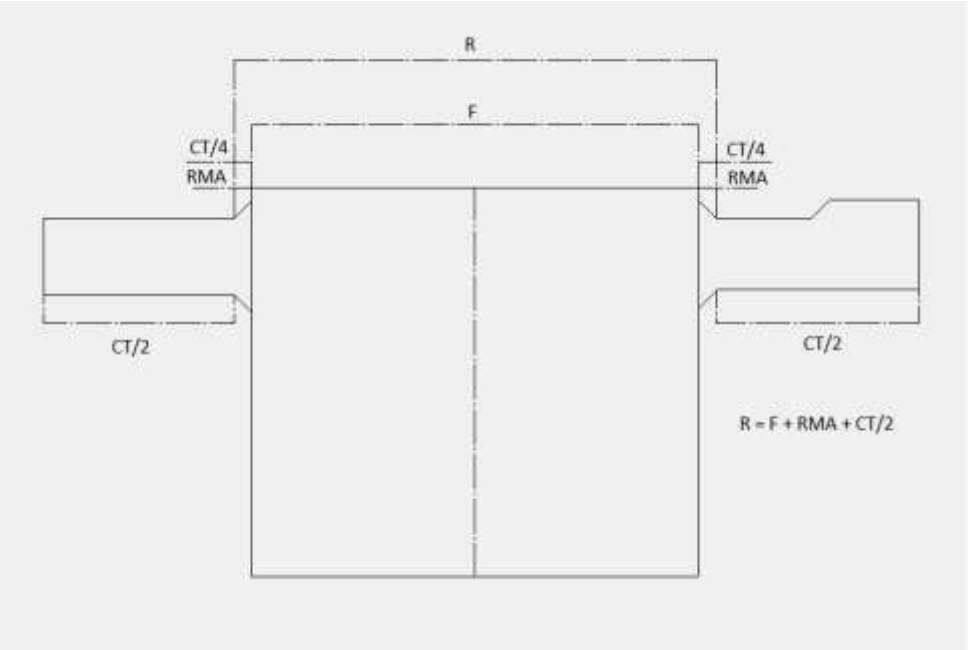
To determine the casting tolerance (CT) grade, Table A1 (for long series) [2] will be utilized. For sand casting with Grey Iron, CT10 seems appropriate. Sketches of the locations of RMA and CT are provided in Fig. 1.

R= Raw casting basic dimension

F= Dimension after final machining

RMA = Required machining allowance

CT = Casting tolerance



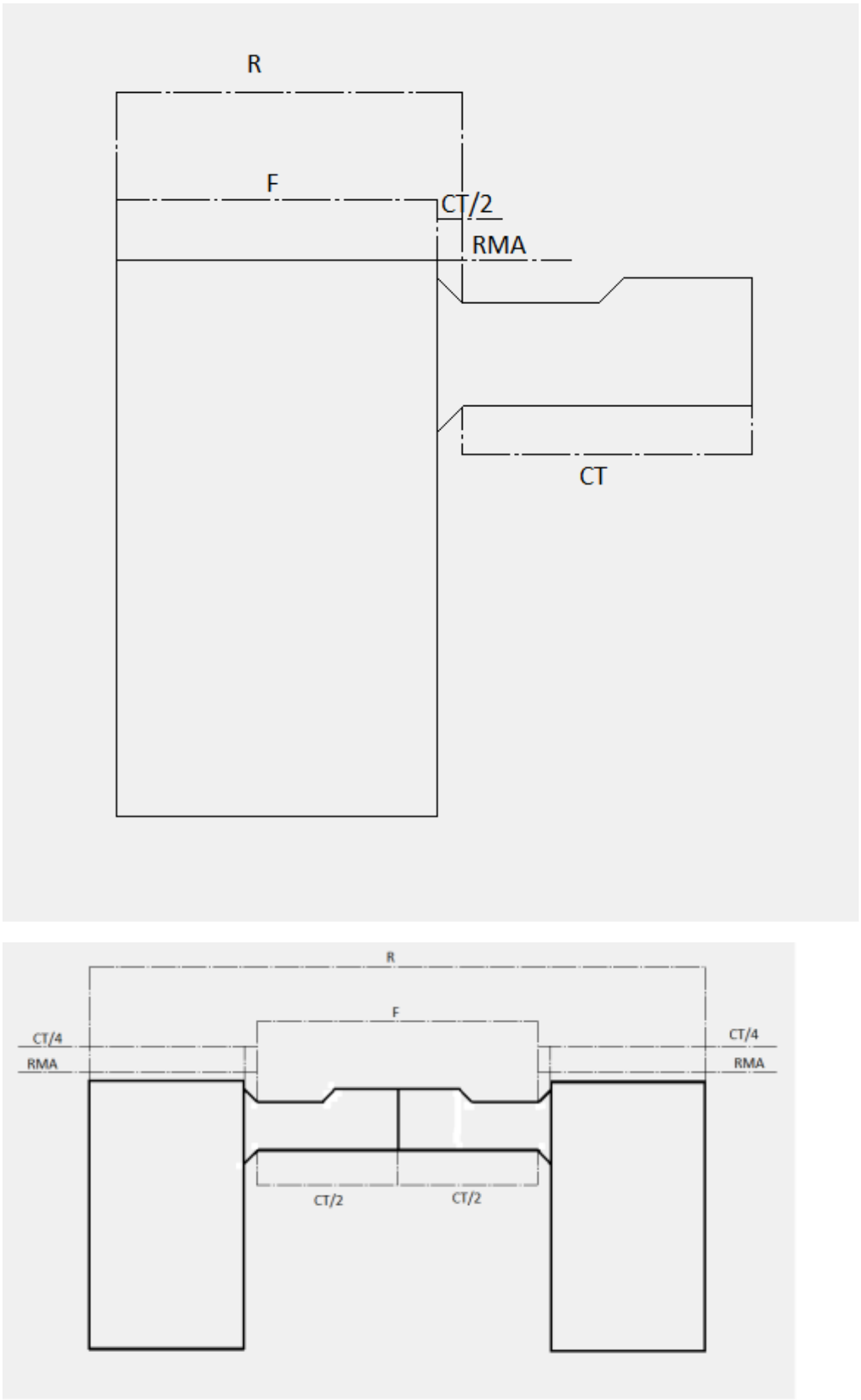


Fig. 1 Sketches for determining Raw casting basic dimension

Table 1 Casting tolerances

Dimension of a part	RMA	Min limit of size for external features (or max for internal features)	Casting tolerance, mm	Raw casting basic dimension
120	1.5	122	3.6	123.8±1.8
100	1.5	104	3.6	105.8±1.8
48	1.5	52	2.8	53.4±1.4
35	1.5	39	2.6	40.3±1.3
20	1.5	24	2.4	25.2±1.2
16	1.5	20	2.2	21.1±1.1
10	1.5	14	2	15 ± 1

When designing the casting we considered the following:

• a workpiece is placed in the way that corresponds to the lowest possible height in the mold;

• the parting line lies within the plane of symmetry;

• the casting do not contain sharp corners, radii of 2-5 mm were applied;

• a draft angle of 2° was applied to all walls perpendicular to parting plane to facilitate removing the part from the mold;

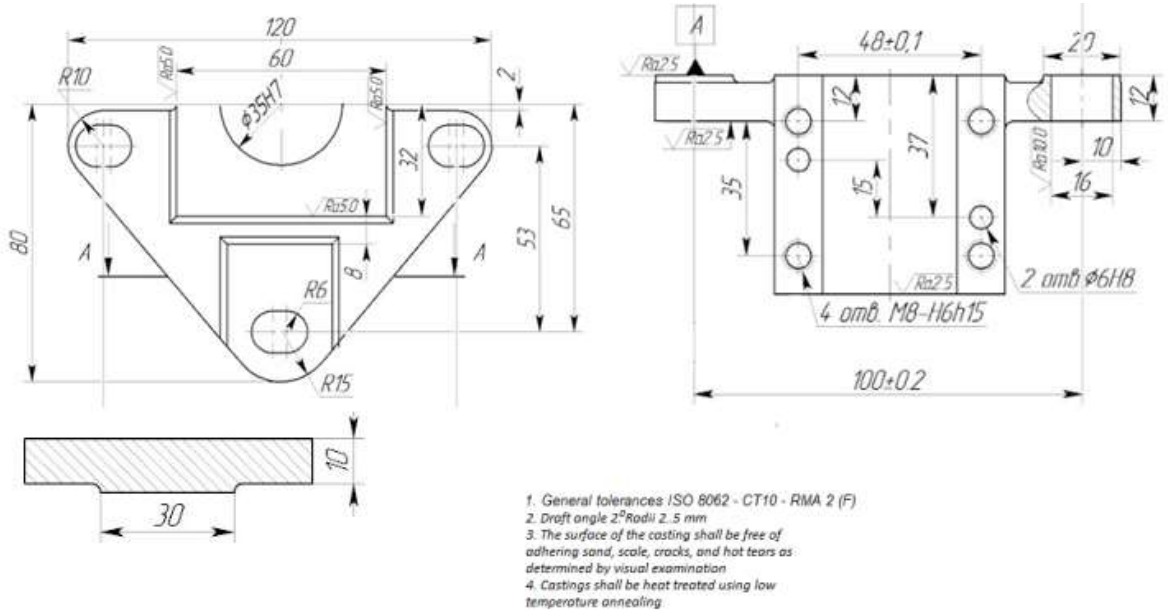
• the RMA should be added only to the surfaces, for which the secondary process (machining) will be applied;

• the 2 center holes and a main pocket of the part will be obtained using cores;

• small features of the part (e.g. small holes) will be obtained by a secondary process.

The results of the workpiece design are presented in Fig. 2.

Fig. 2.



1.4 Locating scheme selection

The method for justifying the selection of manufacturing datum (MD) involves a two-phase approach:

First, establishing the rationale behind selecting a general manufacturing datum (GMD).

Then, determining the specific manufacturing datum for initial production operations.

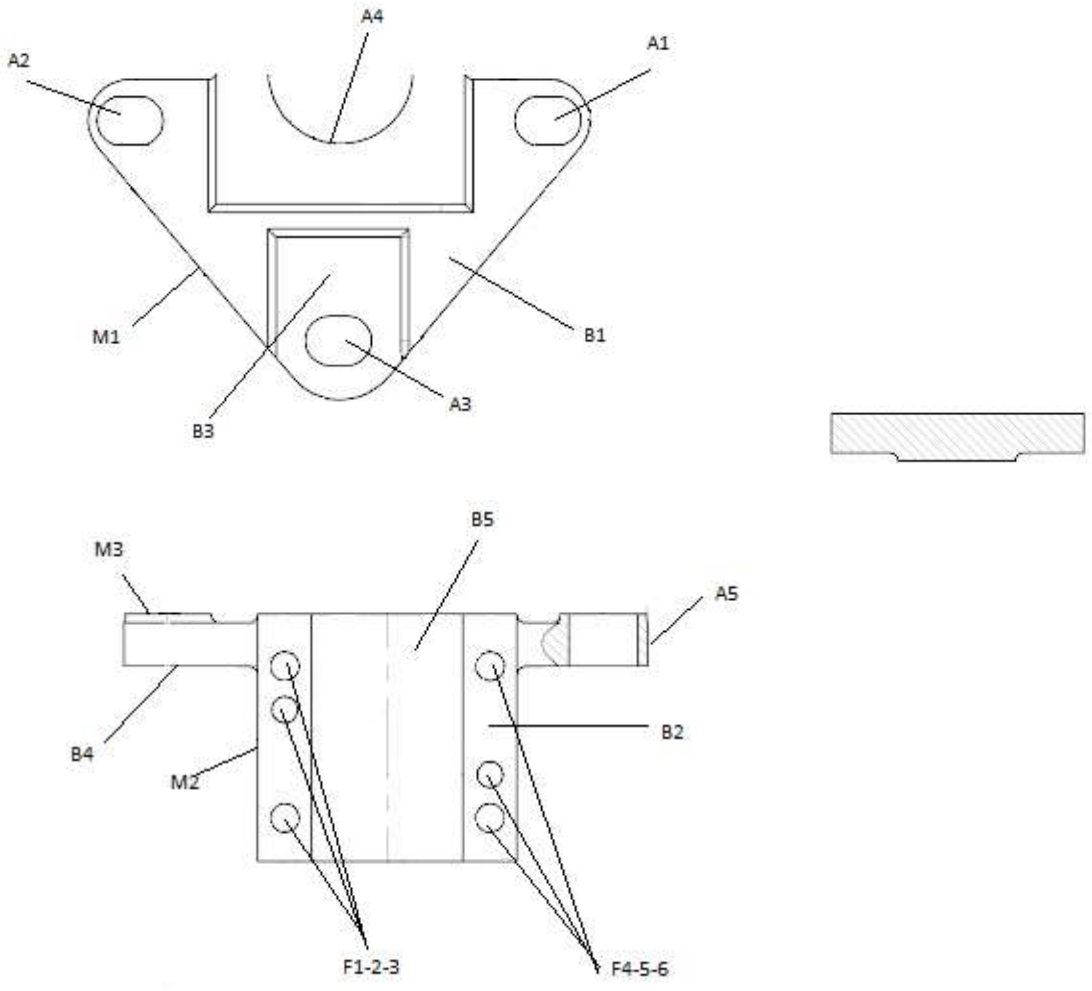
1.4.1 Rationale for the choice of general manufacturing datum

The general manufacturing datum (GMD) encompasses a group of datum surfaces that are applicable across the majority, if not all, of the

manufacturing process stages. The foundational element for deciding on a GMD is the working drawing of the part. To address the requirements of this initial phase, it's essential to categorize the part's surfaces based on their functional roles.

In essence, the structure of any part can be broken down into four distinct types of surfaces, each serving a unique purpose in the overall design:

1. Main functional (design) datum
2. Auxiliary functional (design) datum
3. Fastening surfaces
4. Free surfaces



M – Main design datum
A – Auxiliary design datum
F - fastening surface
B – free surface

We'll assess the possibility of transforming the Main Design Datum into a General Manufacturing Datum (GMD). Two suggested locating schemes demonstrating this transformation are displayed in Figures 1.9 and 1.10.

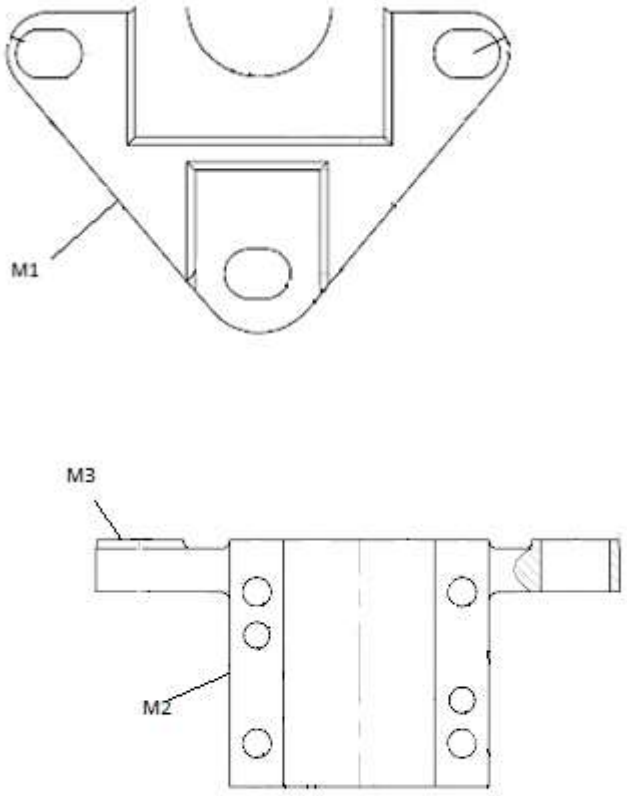


Fig 1.9 Locating scheme for GMD

The configuration of the locating scheme depicted in Fig 1.9 is represented by the formula:

LSGMD =>S(3)+DS(2)+ O(1), (1.1)

wherein S(3) symbolizes the setting datum which restricts the workpiece’s movement by 3 degrees, DS(2) is the double support datum eliminating 2 degrees of freedom, and O(1) is the support datum, reducing the workpiece's freedom by one degree.

For practical implementation, this scheme employs a combination of plane, round head, and diamond head locating pins. In this arrangement, the "Housing" achieves adequate orientation, facilitating the processing of its surfaces while meeting spatial positioning requirements. In this scenario, the GMD remains constant: GMD => Const.

1.4.2 Rationale for the selection of manufacturing datum for the first manufacturing operations

In selecting datum surfaces for the initial stages of manufacturing, it's critical to allow accessibility for processing all GMD surfaces and to opt for machinery capable of sequentially processing GMD surfaces to achieve the desired quality characteristics. It's important to consider that the full range of the GMD should be processed in the subsequent initial technological steps.

The assessment of potential locating schemes for initial manufacturing operations, including their pros and cons, will adhere to these guidelines:

Select as MD surfaces that aren’t required for processing as per the drawing.

If all workpiece surfaces require processing, the MD should be surfaces with the least allowance to avoid defects in further processing. If allowances are equal, choose surfaces where defects are unacceptable.

Opt for MD surfaces that require consistent allowance in later processing stages.

If multiple basing options exist, the MD should be the one with the shortest dimensional chain.

The first option is outlined in Fig. 1.11.

Benefits include:

*Straightforward implementation.

*Accurate positioning of unprocessed surfaces relative to processed ones.

However, drawbacks comprise:

*Limited access for processing the workpiece from three sides.

*Uneven allowance distribution for main housing holes in subsequent processing stages.

*Lack of assurance for perpendicularity of side planes adjacent to main holes relative to the datum plane.

1.5 Design of the operational manufacturing process plan

The design of a part often breaks down into various typical geometric forms, each linked by the shared functional purpose of the component. Standard structural features include external and internal surfaces that are cylindrical or conical, sets of planes, and complex shapes like screw or involute profiles. Different machining tools are required for each type of surface to achieve the desired level of accuracy, which leads to varied treatment sequences.

Crafting machining strategies for each specific surface is the first of seven key steps in the process plan design. This approach addresses the precision, form, and surface quality of individual elements but initially doesn't consider the relative positional accuracy. This aspect is later addressed through the allocation of specific locating schemes and by categorizing the machining process into different phases, like rough, finish, and final.

In the development of a manufacturing process, it's crucial to choose from various machining alternatives the one that offers the most cost-effective outcome. Therefore, utilizing standardized, industry-tested methods for fabricating parts and machining their primary surfaces is recommended for efficiency.

For the component illustrated in Fig. 1.15, selected typical machining sequences along with the attained accuracy and surface roughness are listed in Table 1.3. The classification of the surfaces is displayed in Fig. 1.16.

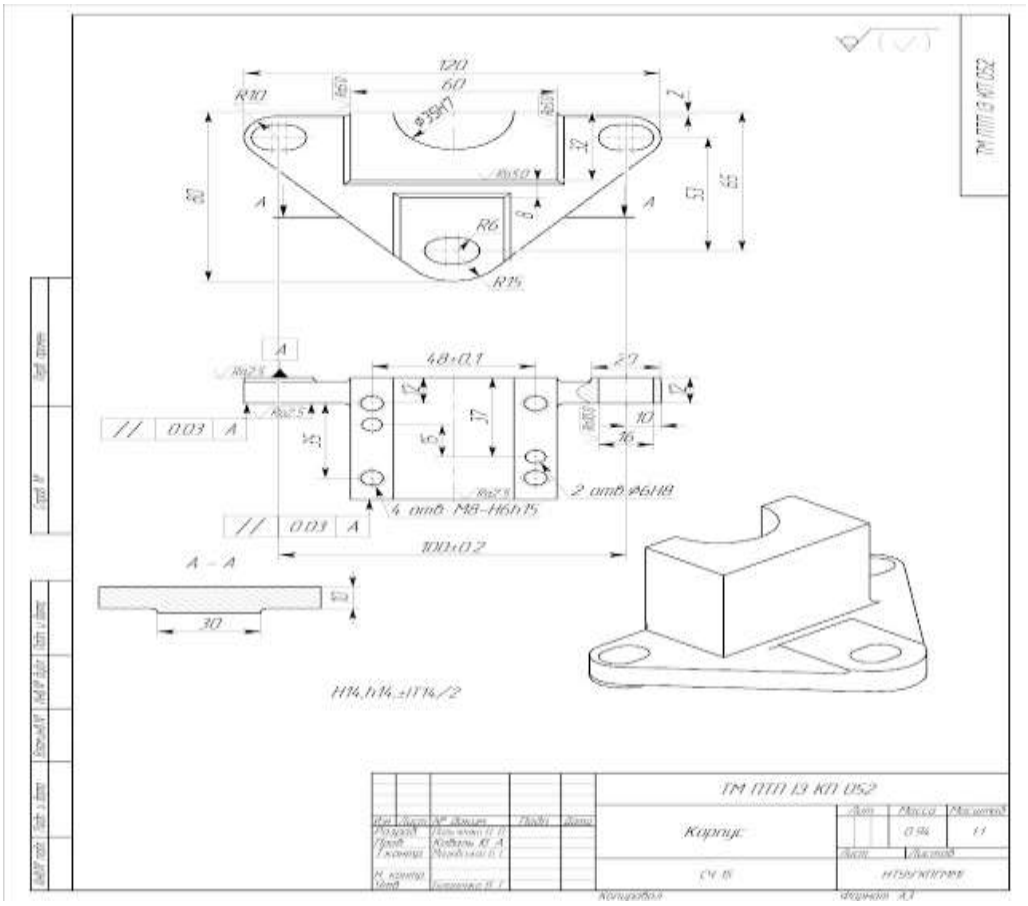
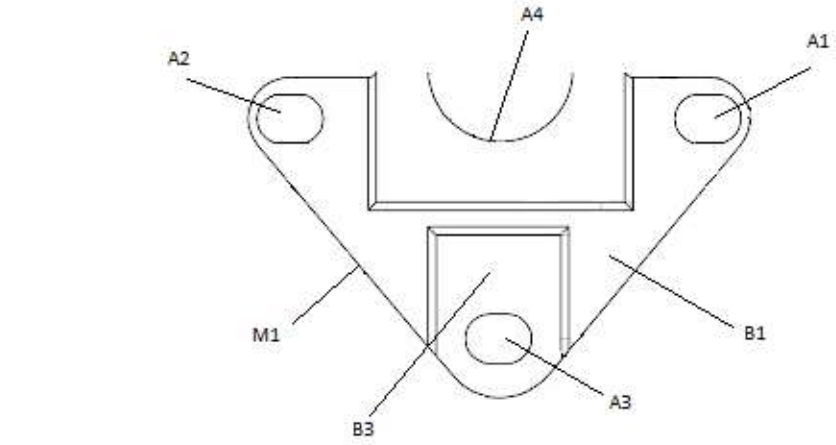
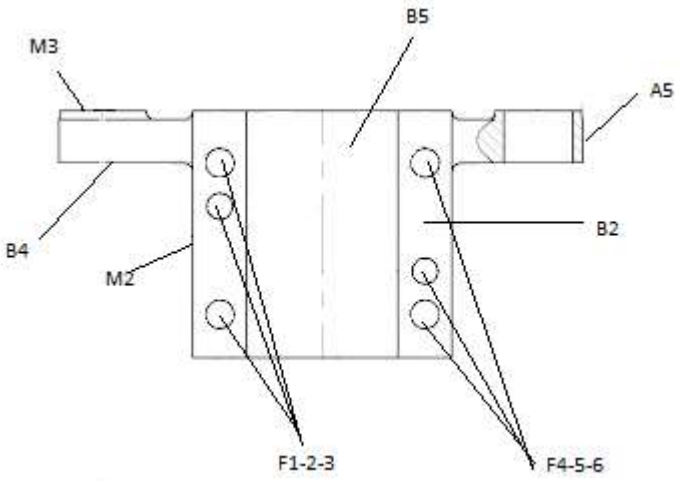


Fig. 1.15 Drawing of a part





M – Main design datum
A – Auxiliary design datum
F - fastening surface
B – free surface

Fig 1.16 Classification of the part according to their intended purpose

Table 1.3 Processing routes for surfaces of a part "Bracket"

Surface	IT	Ra	Machining sequence	IT	RA
	According to the drawing			After machining	
1	2	3	4	5	6
M1	14	2.5	Rough milling Contour milling	14	6,3 2,5
M2, M3	14	2.5	Rough milling Contour milling	14	6,3 2,5
A1	7	0,63	Rough milling Contour milling	9 7	2,5 1,5
A2	14	2,5	Rough milling Contour milling	12 10	6,3 2,5
F1, F2,F3	14	10	Centering Drilling	14	10
B4	14	2,5	Rough milling Contour milling	14	6,3 2,5

F4, F5,F6	14 (7)	2,5 (1,25)	Centering Drilling	12 10	6,3 2,5
B5	14	2,5	Rough milling Contour milling	14	6,3 2,5

1.6 Design of the typical surfaces processing routes

This section elaborates on the formulation of the manufacturing process plan, integrating insights gained from previous chapters.

Aim: The goal is to craft a manufacturing process plan that aligns with the criteria of manufacturing precision, complexity, and cost-effectiveness.

Guiding Principles:

Priority in processing should be given to surfaces that serve as reference points in later stages.

Each succeeding step in the manufacturing process should enhance the quality of the surfaces being worked on. If a step like heat treatment doesn't meet this criterion, it necessitates a return to machining the datum surfaces for the next stages.

A gap or aging operations should separate the initial roughing stage from subsequent stages, particularly for parts that are critical, large, or valuable.

Surfaces where defects are unacceptable should be machined early in the process for early detection of any issues.

During the roughing phase, begin with surfaces that have the greatest allowance and are most critical.

The final finishing of crucial surfaces should occur in the last stages of manufacturing.

Begin with surfaces whose processing least impacts the overall rigidity of the workpiece.

Surfaces requiring precise relative spatial positioning should be machined in a single setup.

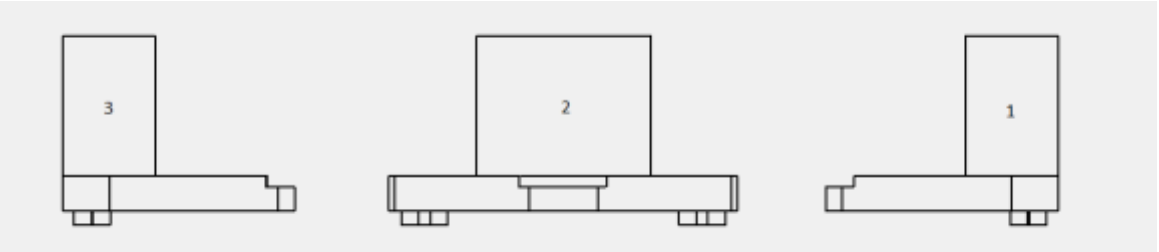
Avoid tool changes while finishing surfaces that are precise and critical.

Fastening surfaces should be machined in the third stage, subsequent to the finishing of related surfaces.

The proposed manufacturing process plan will be derived based on: the analysis of the part's working conditions and technical requirements as outlined in chapter 1.1; the production type determined in chapter 1.2; the workpiece geometry from chapter 1.3; and the processing routes for surfaces established in chapter 1.6.

Machine: HAAS VF-3

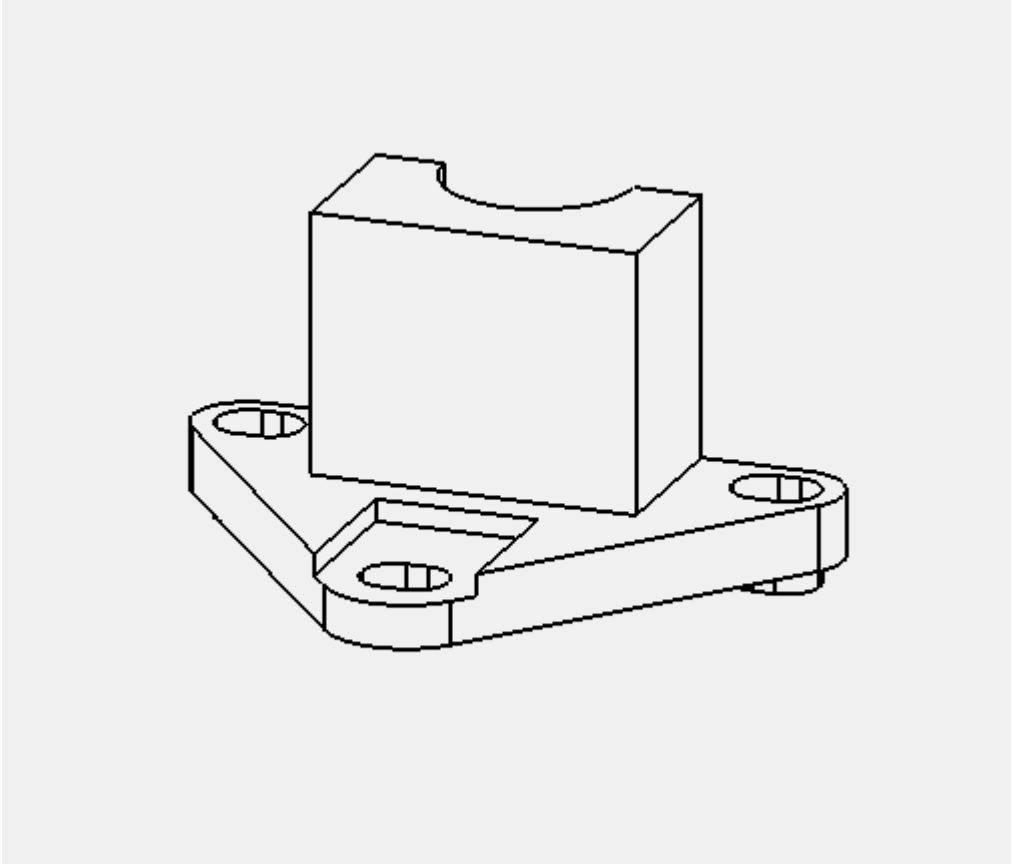
A. Install, secure, remove



Operation Table:

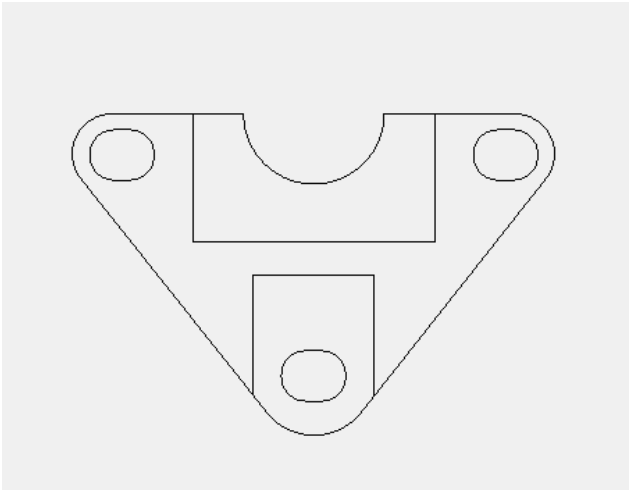
Rough milling the surface from 1 to 3.

Contour milling the surface from 1 to 3.



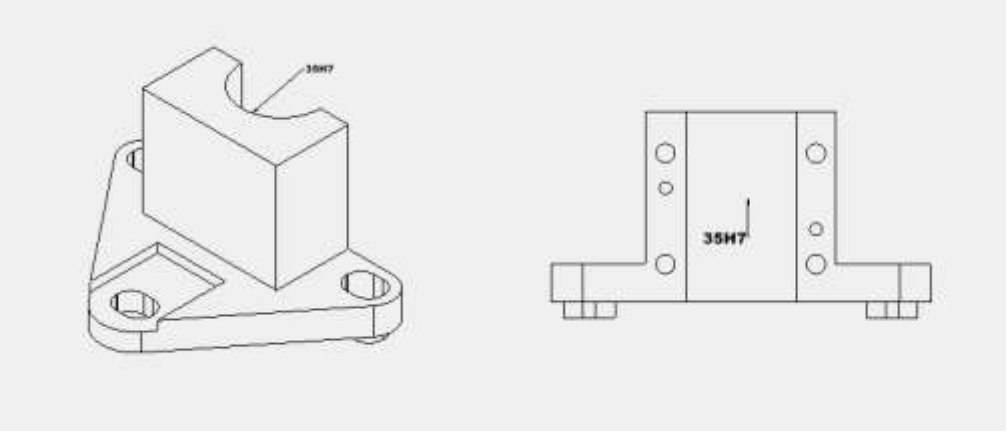
Rough milling the surface along the mark with proper tool (all tools listed in 1.8)

Contour milling the surface to make sure there is no unwanted part left.



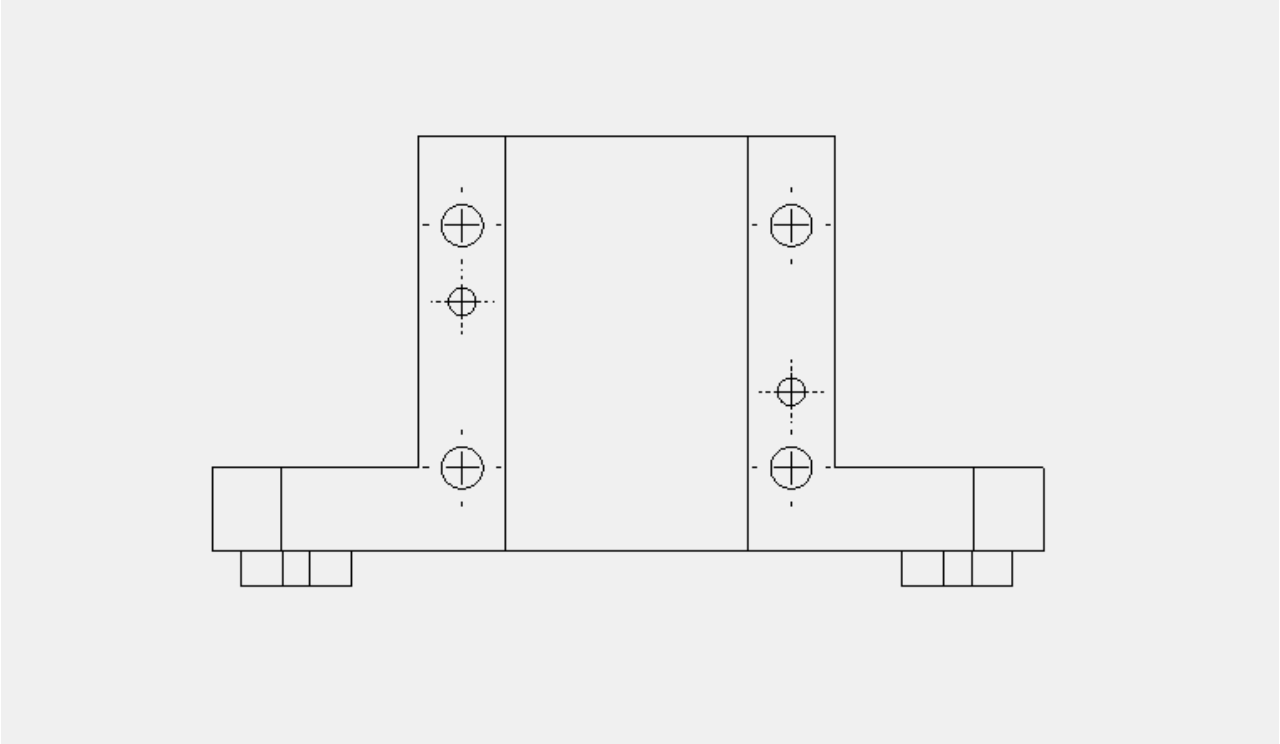
Rough milling the features to obtain the shape in drawings.

Contour milling all three of them to get rid of leftover minimalist deformity.

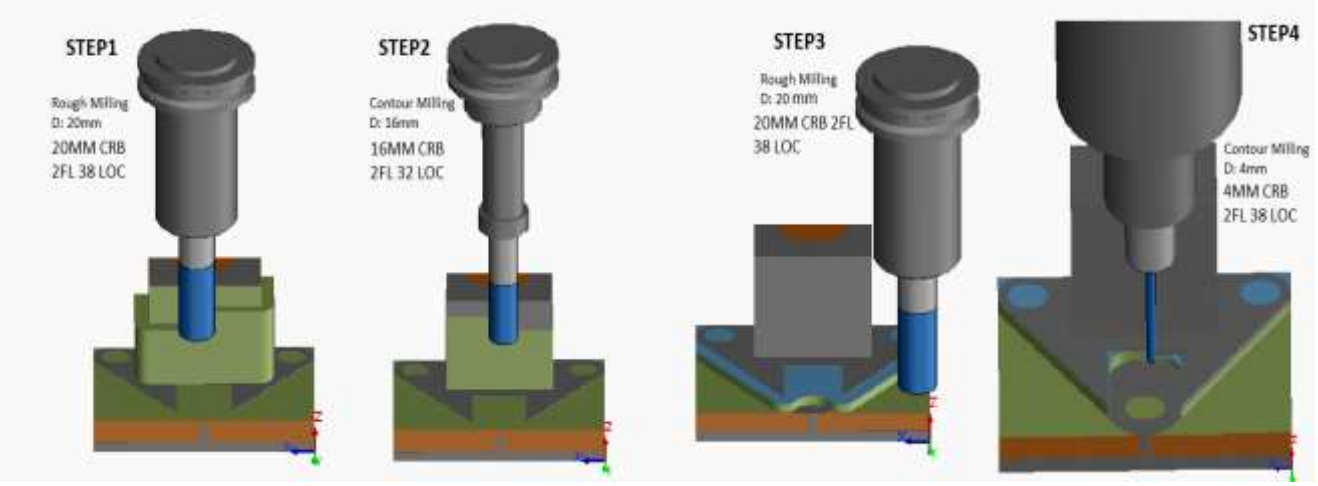


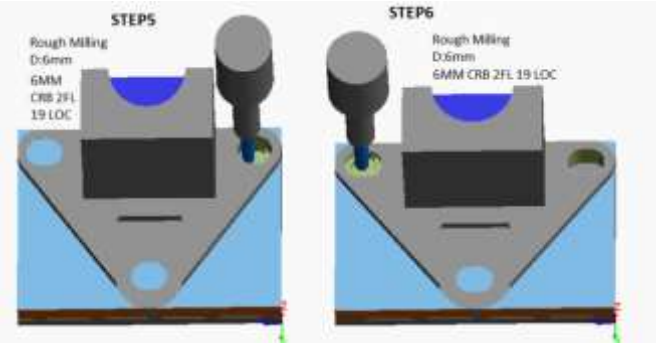
Rough milling the surface from top to bottom to obtain Ø35H7

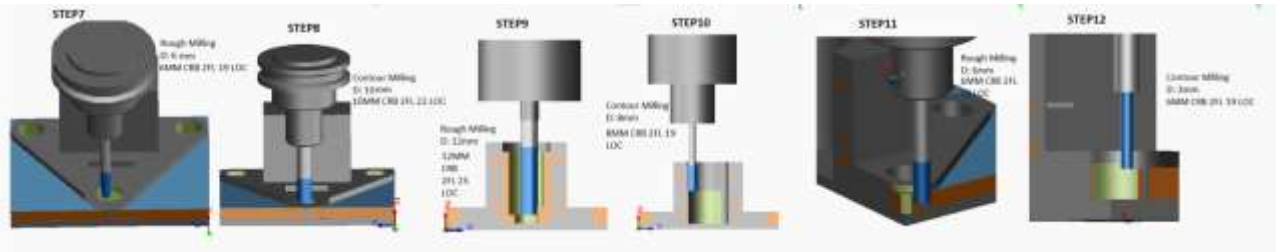
Contour milling after rough milling.

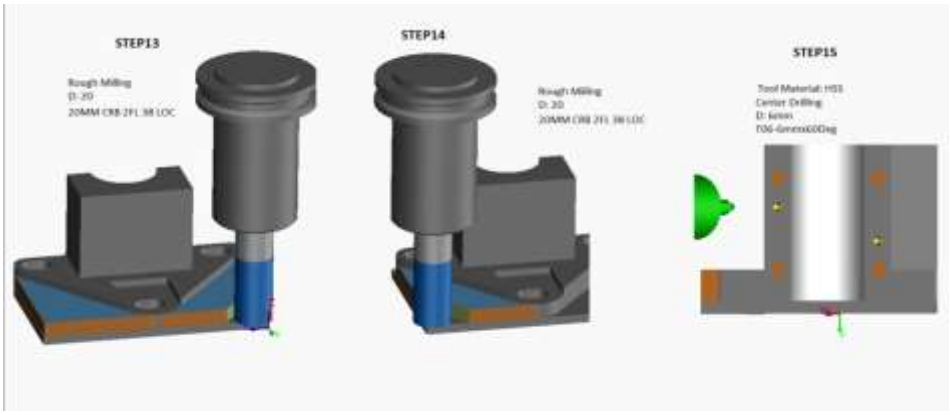


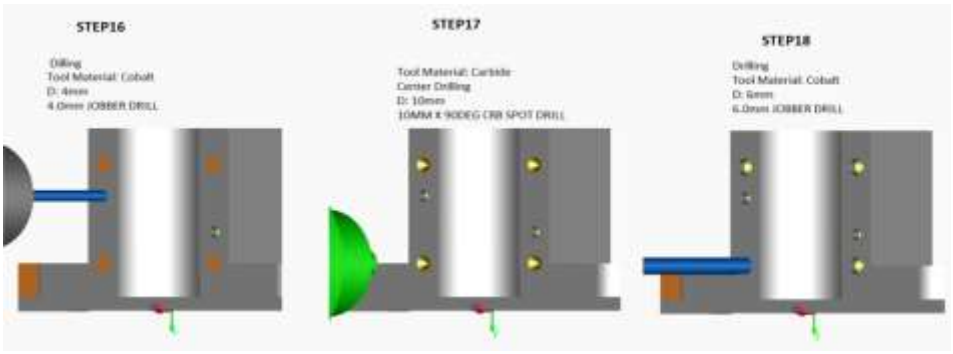
Center drilling for marked holes and drilling to get planned sections.

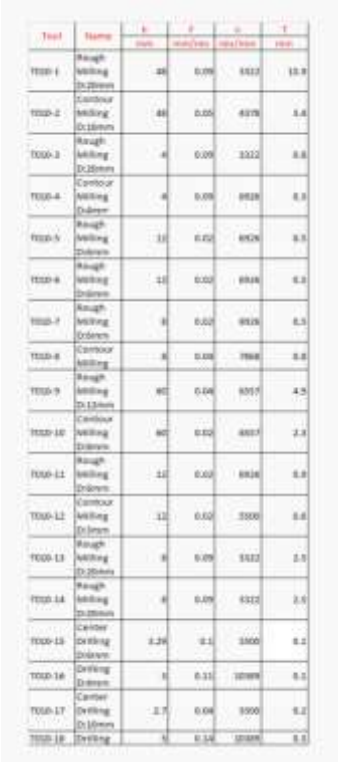

STEP1
Rough Milling
D: 20mm
20MM CRB
2FL 38 LOC
STEP2
Contour Milling
D: 16mm
16MM CRB
2FL 32 LOC
STEP3
Rough Milling
D: 20 mm
20MM CRB 2FL
38 LOC
STEP4
Contour Milling
D: 4mm
4MM CRB
2FL 38 LOC


STEP5
Rough Milling
D:6mm
6MM
CRB 2FL
19 LOC
STEP6
Rough Milling
D:6mm
6MM CRB 2FL 19 LOC


STEP7
STEP8
STEP9
STEP10
STEP11
STEP12


STEP13
Rough Milling
D: 20
20MM CRB 2FL 38 LOC
STEP14
STEP15





1.7 Short Description of a manufacturing equipment

The vertical processing highlight in the CNC machine Haas VF-3 offers accuracy and flexibility in machining operations. Here are a few key points of interest approximately this feature:

Vertical Machining Center (VMC): The Haas VF-3 is a vertical machining center, meaning that the axle hub is vertically arranged. This setup permits for proficient expulsion of fabric from the workpiece set on the table below.

Three-Axis Machining: The VF-3 is prepared with three tomahawks of movement: X-axis, Y-axis, and Z-axis. This permits for development along the X and Y tomahawks on the table surface and development along the Z-axis, which controls the vertical development of the shaft and cutting tool.

High Accuracy: Haas machines are known for their exactness and exactness. The VF-3 is no exemption, advertising tight resiliences and repeatability, guaranteeing reliable and high-quality machined parts.

Rigid Development: The VF-3 is built with a inflexible and vigorous outline to minimize vibrations and guarantee steadiness amid machining operations. This inflexibility upgrades cutting execution and surface wrap up quality.

Spindle Speed and Control: The axle of the VF-3 is competent of coming to tall speeds and conveying adequate control for different cutting assignments. This permits for productive fabric expulsion and the capacity to work with a wide extend of materials, from metals to plastics.

Tool Changer: The VF-3 is frequently prepared with an programmed instrument changer (ATC) that can hold numerous cutting devices. This empowers robotized instrument changes amid machining operations, diminishing downtime and expanding productivity.

Advanced CNC Control: Haas machines are prepared with progressed CNC controls that offer user-friendly interfacing and programming capabilities.

Administrators can effectively program complex machining operations and screen the prepare in real-time.

Versatility: The VF-3 is flexible and can be utilized for a assortment of machining applications, counting processing, penetrating, tapping, and forming. Its vertical introduction permits for simple get to to distinctive sides of the workpiece, making it appropriate for complex portion geometries.

Overall, the vertical processing highlight in the Haas VF-3 CNC machine combines exactness, unwavering quality, and flexibility, making it a well known choice for a wide extend of fabricating applications.

Fig. 8.1 Technical data of the selected machine

RA

VE

LS

Axis 1016 mm

Y Axis 508 mm

Z Axis 635 mm

Spindle Nose to Table (~ max) 742 mm

Spindle Nose to Table (~ min) 107 mm

SPINDLE METRIC

Max Rating 22.4 kW

Max Speed 8100 rpm

Max Torque 122.0 Nm @ 2000 rpm

Max Torque w/opt Gearbox	339 Nm @ 450 rpm
Drive System	Inline Direct-Drive
Taper	CT40 | BT40 | HSK-A63
Bearing Lubrication	Air / Oil Injection
Cooling	Liquid Cooled
TABLE	METRIC
Length	1219 mm
Width	457 mm
T-Slot Width	15.90 mm to 16.00 mm
T-Slot Center Distance	80 mm
Number of Std T-Slots	5
Max Weight on Table	1588 kg

1.8. Cutting tools and cutting conditions selection

Evaluation of process and machine selections – Provided the selection of processes and machines is satisfactory, the range of tools that can be used shouldbe limited to those suitable for the processes and machines selected. Therefore this limits the initial list of possible suitable tooling.

Analysis of machining operations – A specific machine will carry out every operation required. Each machine tool to be used will have specific tool types to carry our certain operations. This analysis should enable the identification of specific tool types for specific operations.

Analysis of workpiece characteristics – At this step the following should be considered: workpiece material and geometry, dimensional and geometric accuracy, and surface finish. This enables to identify suitable tool materials and geometry.

Tooling analysis – Using the tooling data available, the general tooling specifications generated ant the 3rd stage can be translated into a statement of tooling requirements for the job, that is, a tooling list. This will obviously reflect

whatever tooling is actually available for the operations required.

Selection of tooling – If single-piece tooling is being used, then a suitable toolholder should be selected before fully defining the tool geometry and material. If insert-type tooling is being used then the following steps should be followed:

- Select clamping system;
- Select toolholder type and size;
- Select insert shape;
- Select insert size;
- Determine tool edge radius;
- Select insert type;
- Select tool material.

Tool selection for the manufacturing step

“005.09 Mill surface *A3* to dimension *9*”

Allowance = 2.8mm

Radial cutting width = 10mm

To select the appropriate cutting tool and cutting conditions we will use CoroPlus® ToolGuide [1] Firstly, enter the initial data, incl. type of surface, depth of cut, radial cutting width and workpiece material (fig. 8.2).

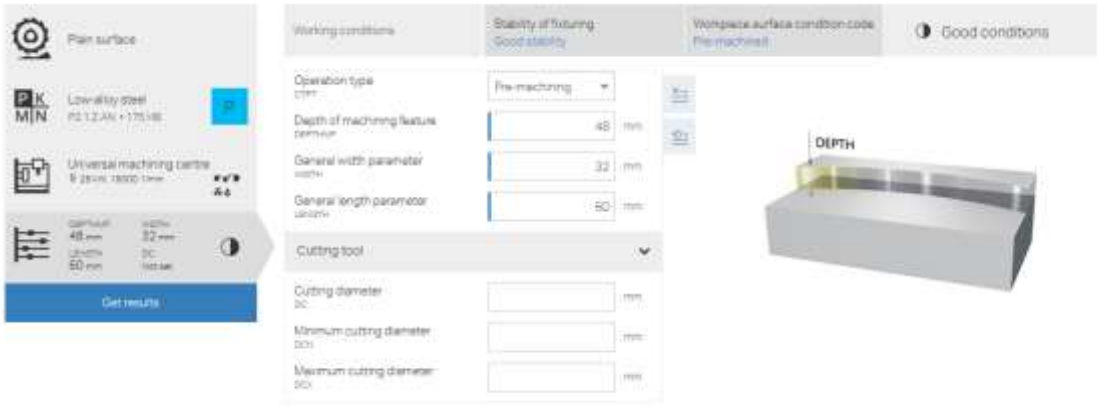


Fig. 8.2 Initial Data for tooling selection (screenshot)

After applying the initial data, consider the results of analysis: recommended cutting tool and cutting conditions (fig. 8.3).

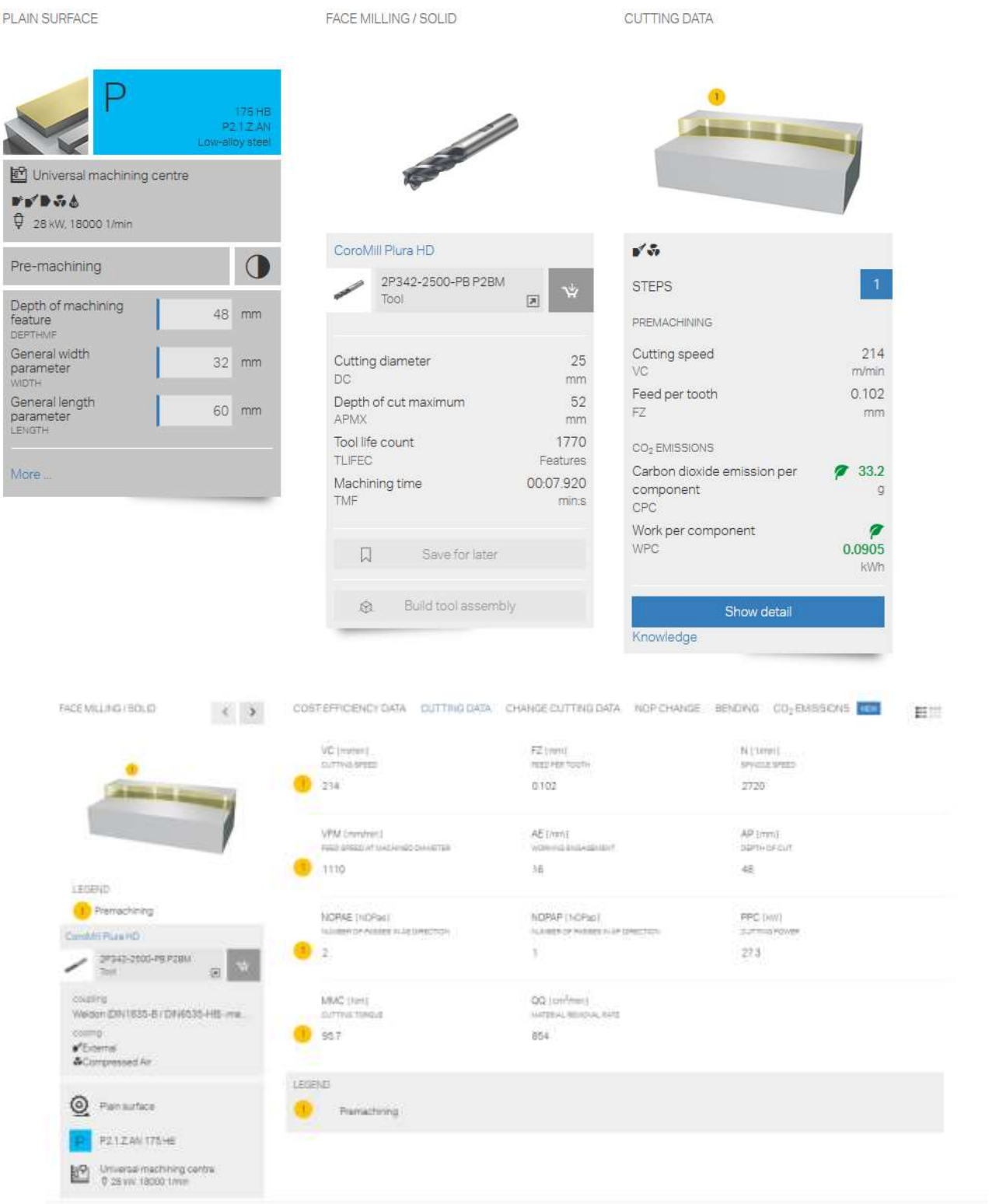
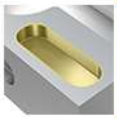


Fig. 8.3 Recommended cutting tool and cutting data

STRAIGHT SLOT WITHOUT OPEN ENDS



P

175 HB
P2.1.Z.AN
Low-alloy steel

Universal machining centre

28 kW, 18000 1/min

Pre-machining

Depth of machining feature DEPTHMF	5	mm
General width parameter WIDTH	12	mm
General length parameter LENGTH	16	mm
General radius parameter RADIUS	6	mm
Corner radius maximum REX		mm

More ...

POCKET MILLING / SOLID

CoroMill Dura

1K324-1200-XB 1730
Tool

Cutting diameter DC	12 mm
Depth of cut maximum APMX	18 mm
Tool life count TLIFEC	1290 Features
Machining time TMF	00:01.368 min:s

Save for later

Build tool assembly

CUTTING DATA

STEPS 1

RAMPING

Cutting speed VC	188 m/min
Feed per tooth FZ	0.0443 mm

CO_2 EMISSIONS

Carbon dioxide emission per component CPC	1.4 g
Work per component WPC	0.00382 kWh

Show detail

Knowledge

CYLINDRICAL HOLE IN SOLID MATERIAL

P

175 HB
P2.1.Z.AN
Low-alloy steel

Universal high-performance machine

200 kW, 10000 1/min

200 kW, 500000 1/min

Good conditions

Machined diameter DM	6	mm
Depth of machining feature DEPTHMF	4	mm

More ...

DRILLING WITH SYMMETRICAL POINT / SOLID

CoroDrill 860

860.1-0600-019A1-PM
P1BM
Tool

Tool life count TLIFEC	37100 Holes
Machining time TMF	00:00.149 min:s

Save for later

Build tool assembly

CUTTING DATA

STEPS 1

DRILLING WITH A SYMMETRICAL POINT

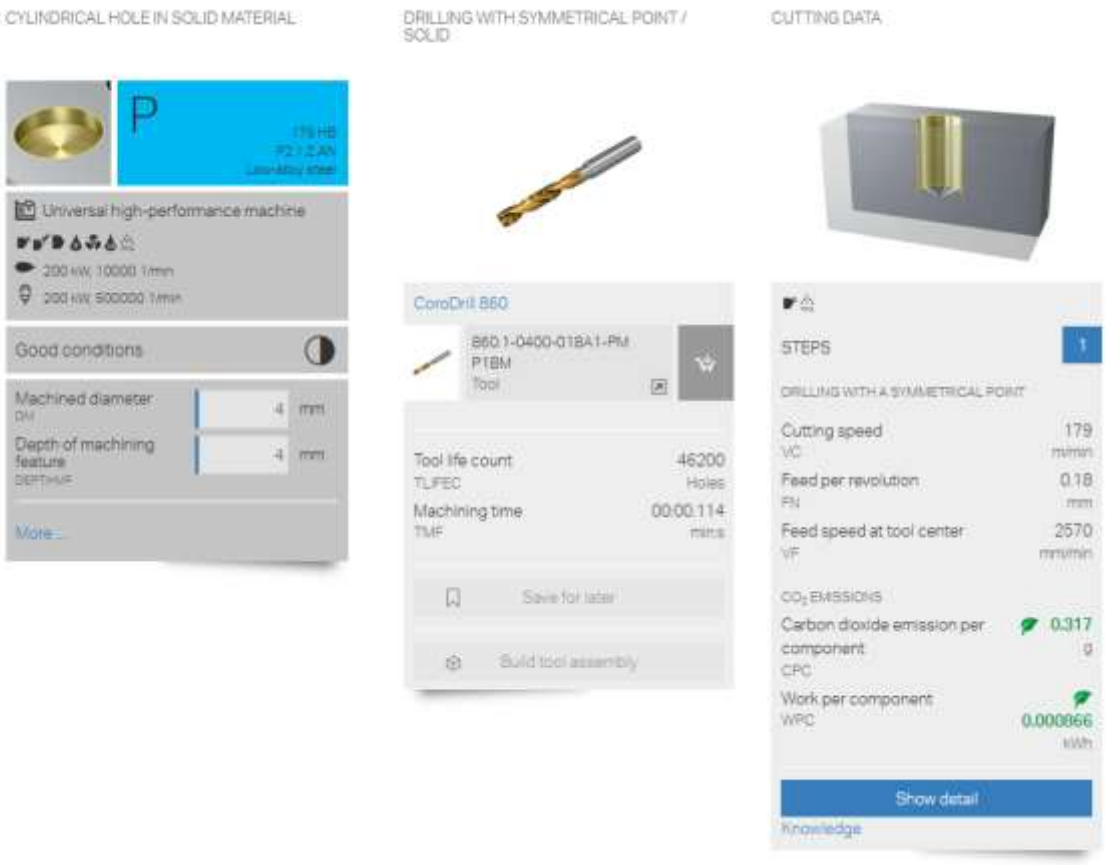
Cutting speed VC	177 m/min
Feed per revolution FN	0.22 mm
Feed speed at tool center VF	2060 mm/min

CO_2 EMISSIONS

Carbon dioxide emission per component CPC	0.44 g
Work per component WPC	0.0012 kWh

Show detail

Knowledge



1.9 Time Calculations

Mahine:	HAAS VF-3				
Cutting parameters					

surface	machine operation	total time [min]	speed [m/min]	Feed per tooth/Feed per,revolution [mm]	depth/allowance [mm]]
1	Rough Milling	7.9	214	0.102	52
1’	Rough	7.9	214	0.102	52

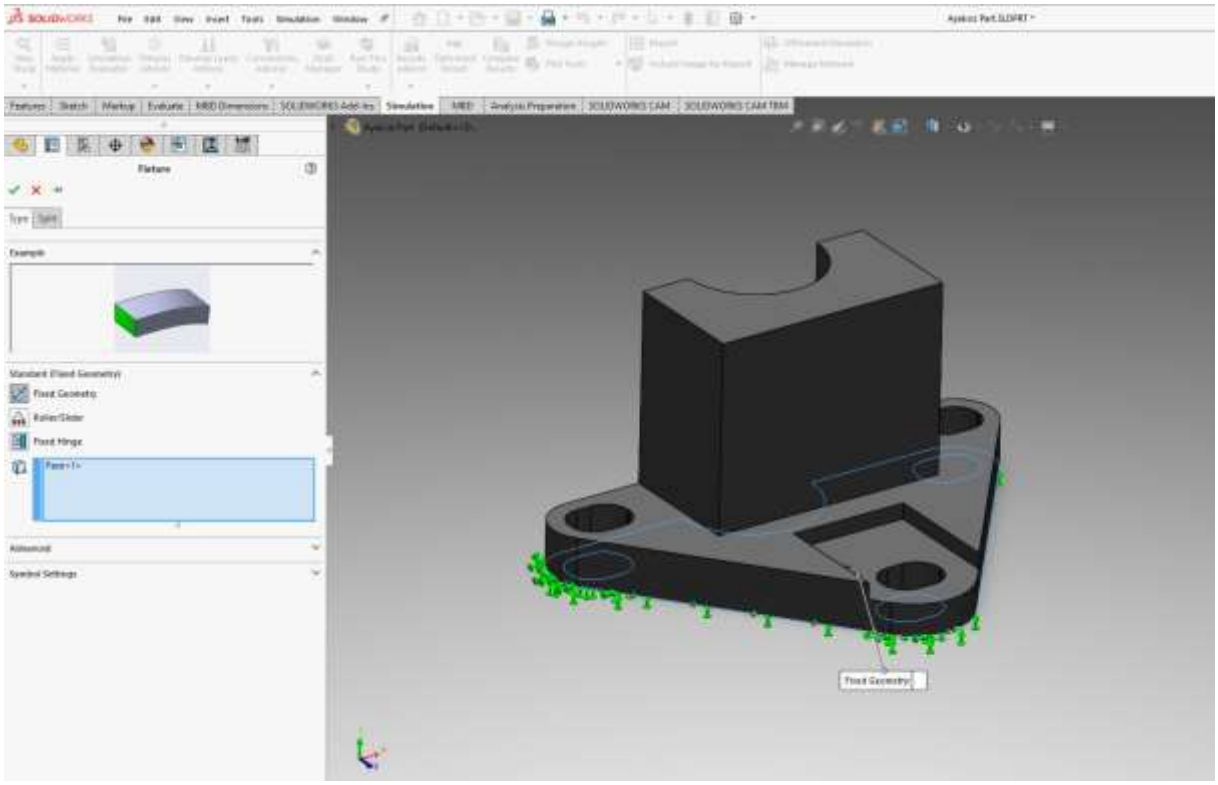
	Milling				
2	Pocket Milling	1.3	188	0.0443	18
2’	Pocket Milling	1.3	188	0.0443	18
2’’	Pocket Milling	1.3	188	0.0443	18
3	Drilling	0.14	177	0.22	
3’	Drilling	0.14	177	0.22	
3’’’	Drilling	0.11	179	0.18	

CHAPTER 2. Calculation of Workpiece Deformations

By using the simulation feature of the Solidworks program, we will observe under what conditions and forces the bracket, which is my part, will react and what deformations may occur.

2.1 Force Simulation

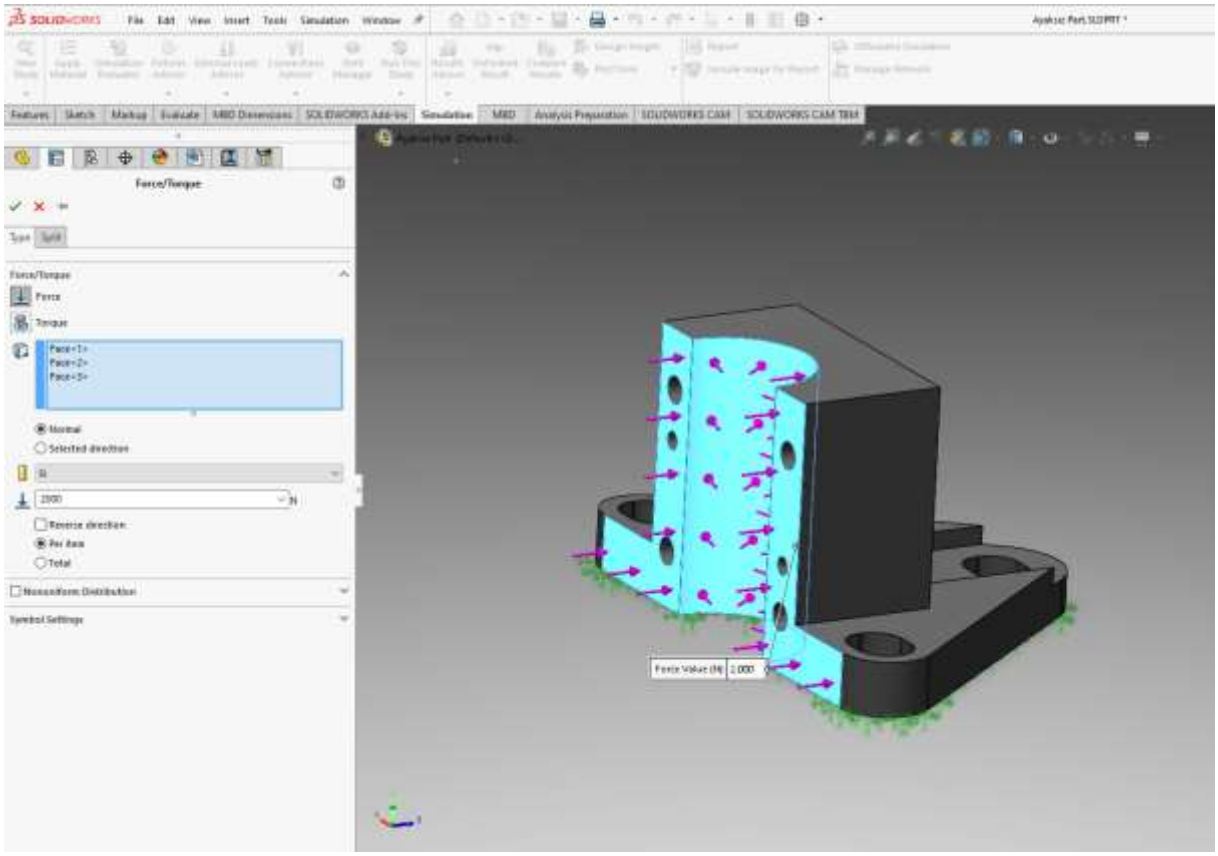
Using the fixed geometry feature, I mark which face of my part will remain fixed.



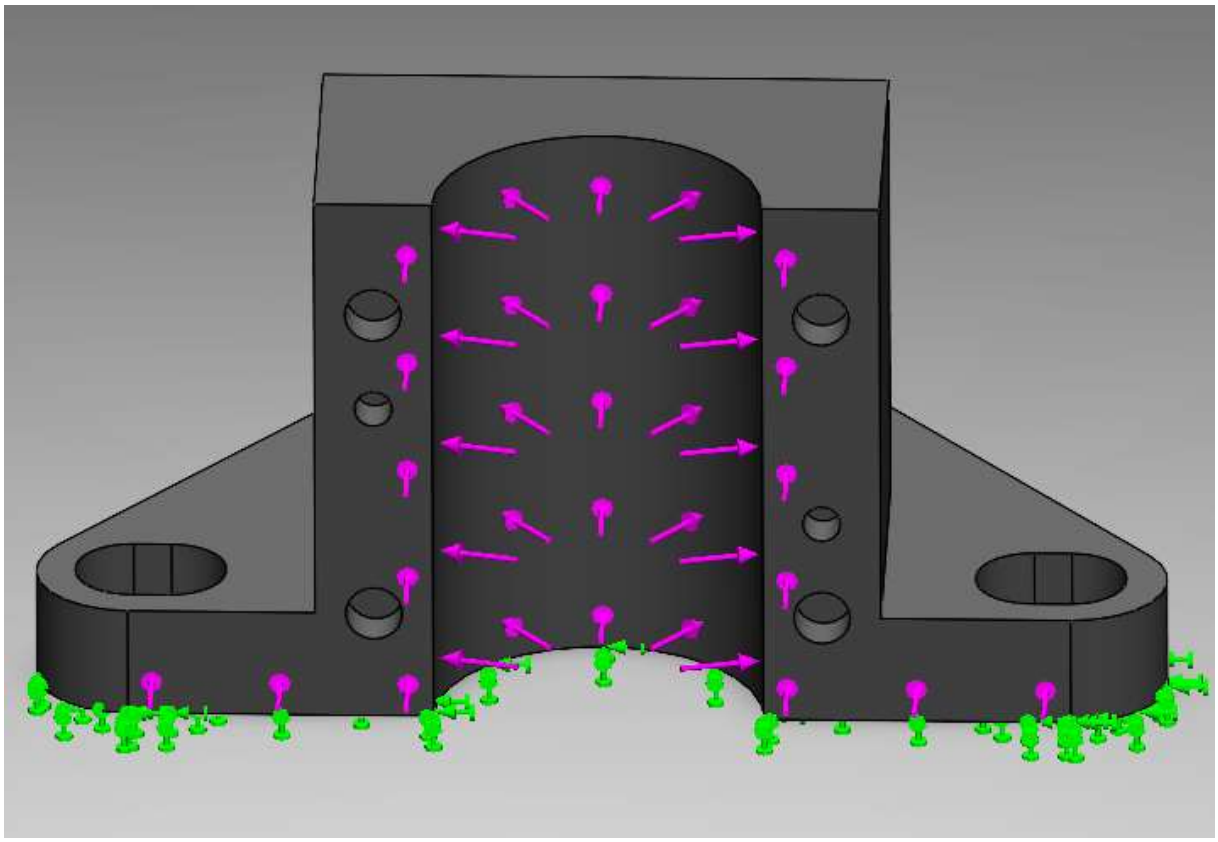
Then we have to apply some force to get result with this feature.
In this work, we applied 2000N of force.

Green Arrows: Fixed fixture.

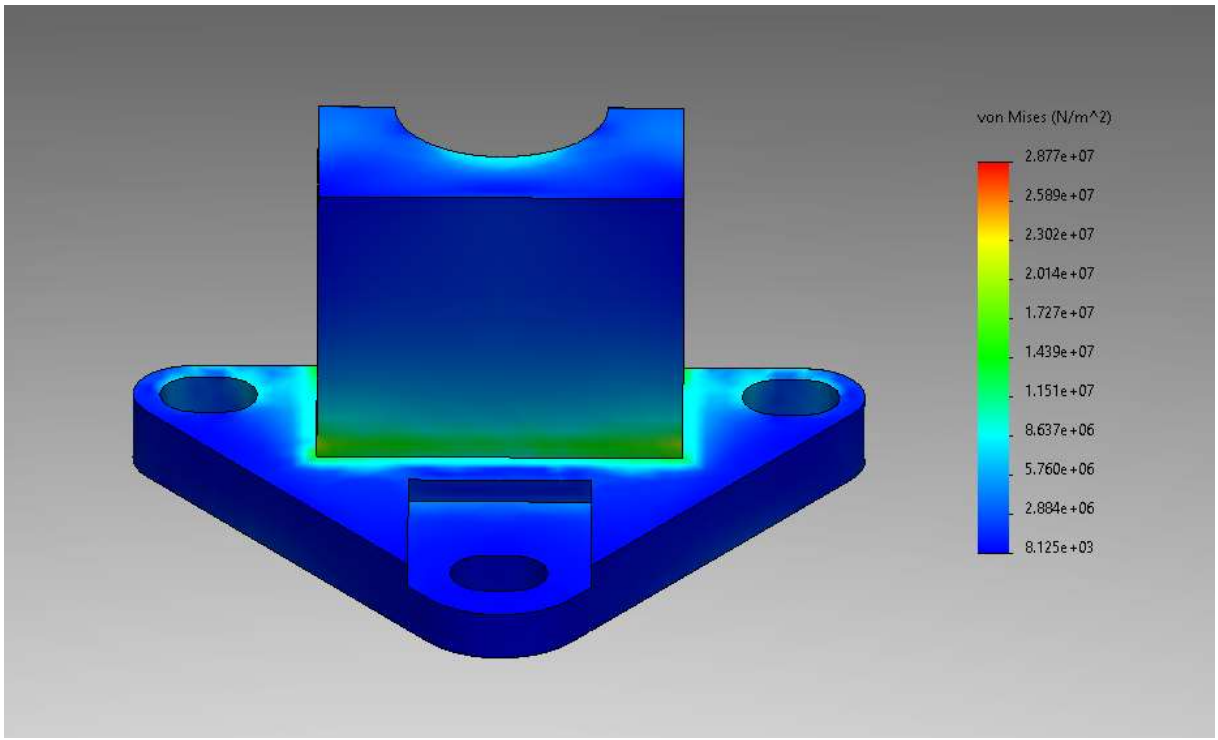
Violet Arrows: Force directions.

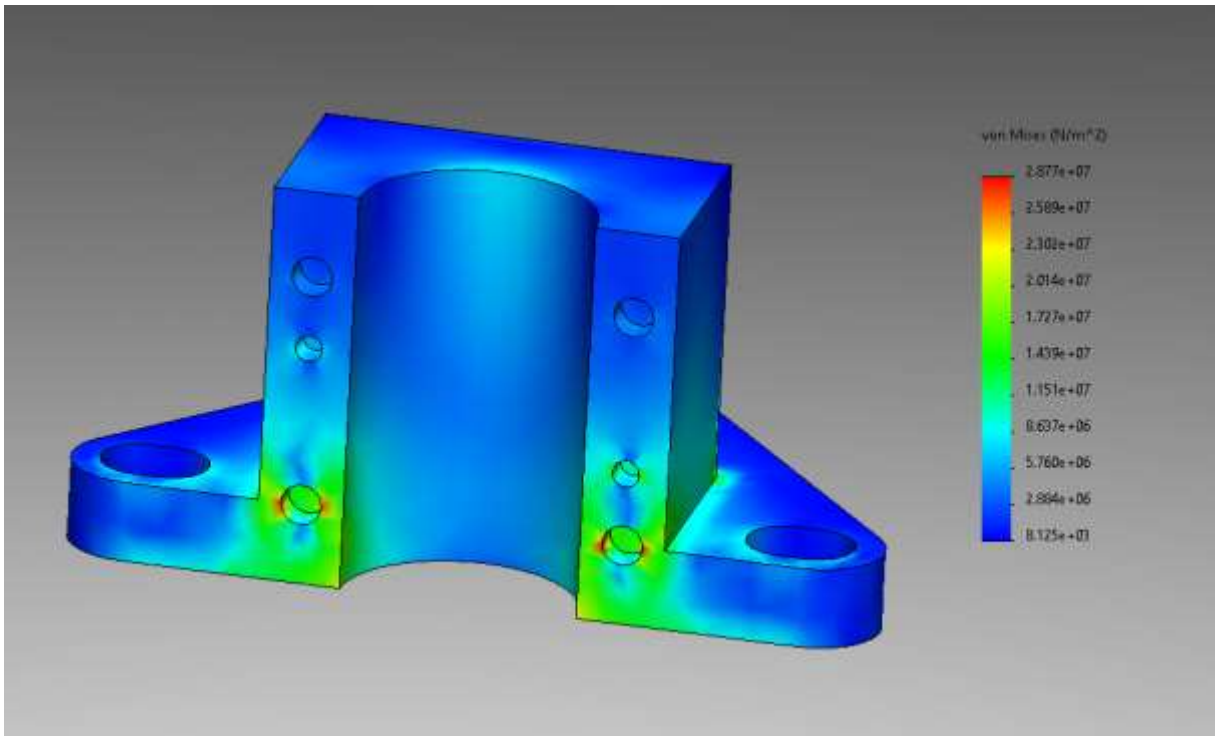


For this study, this is the final selections.



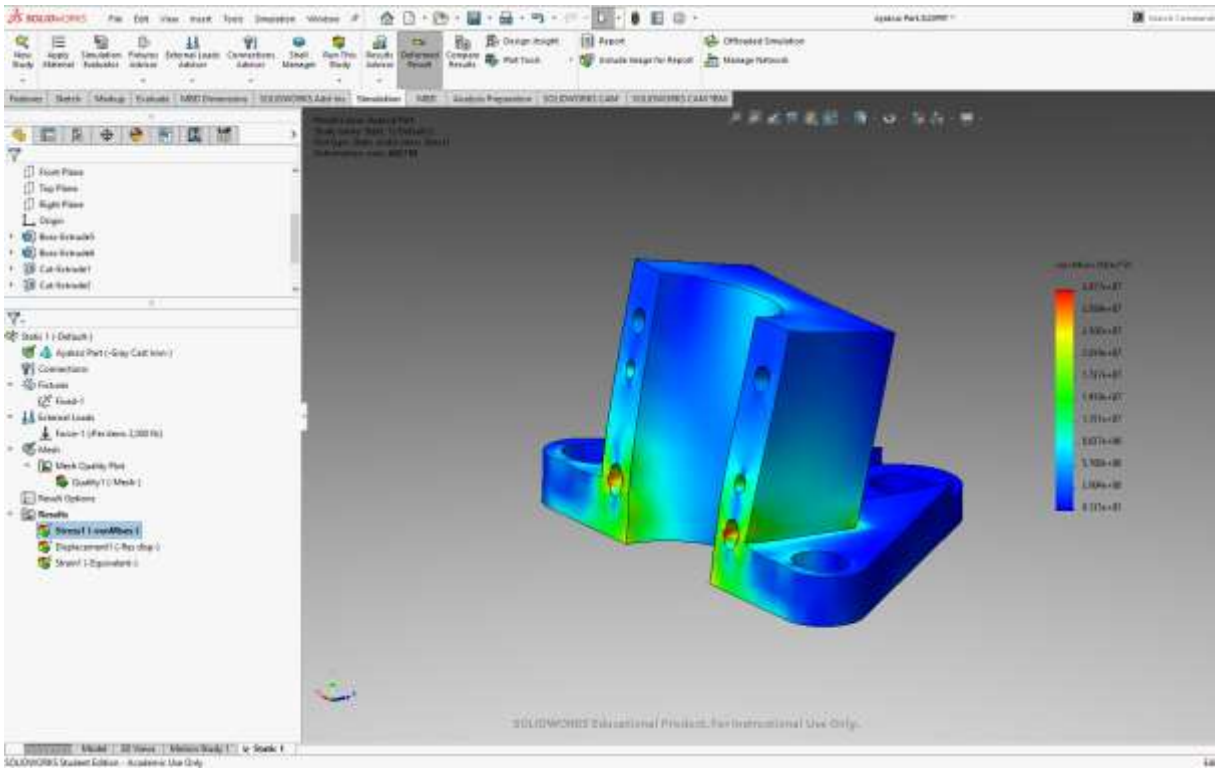
2.2 Stress Test



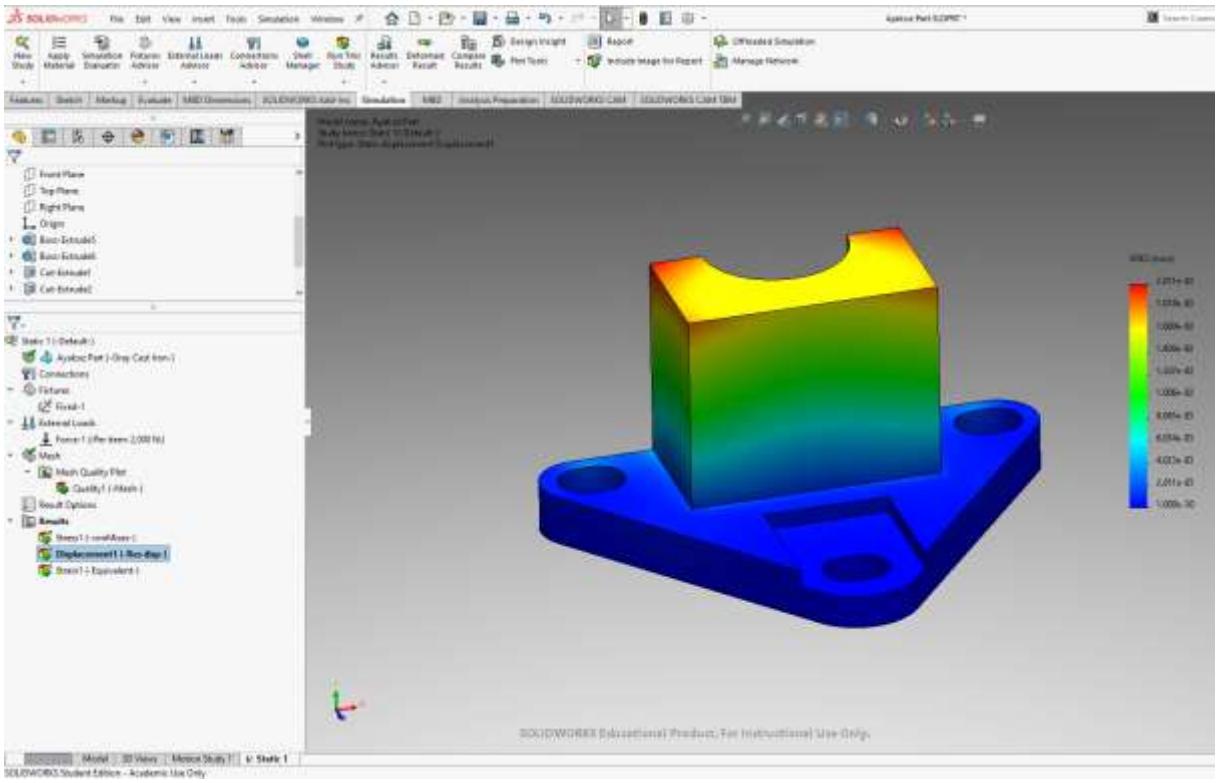


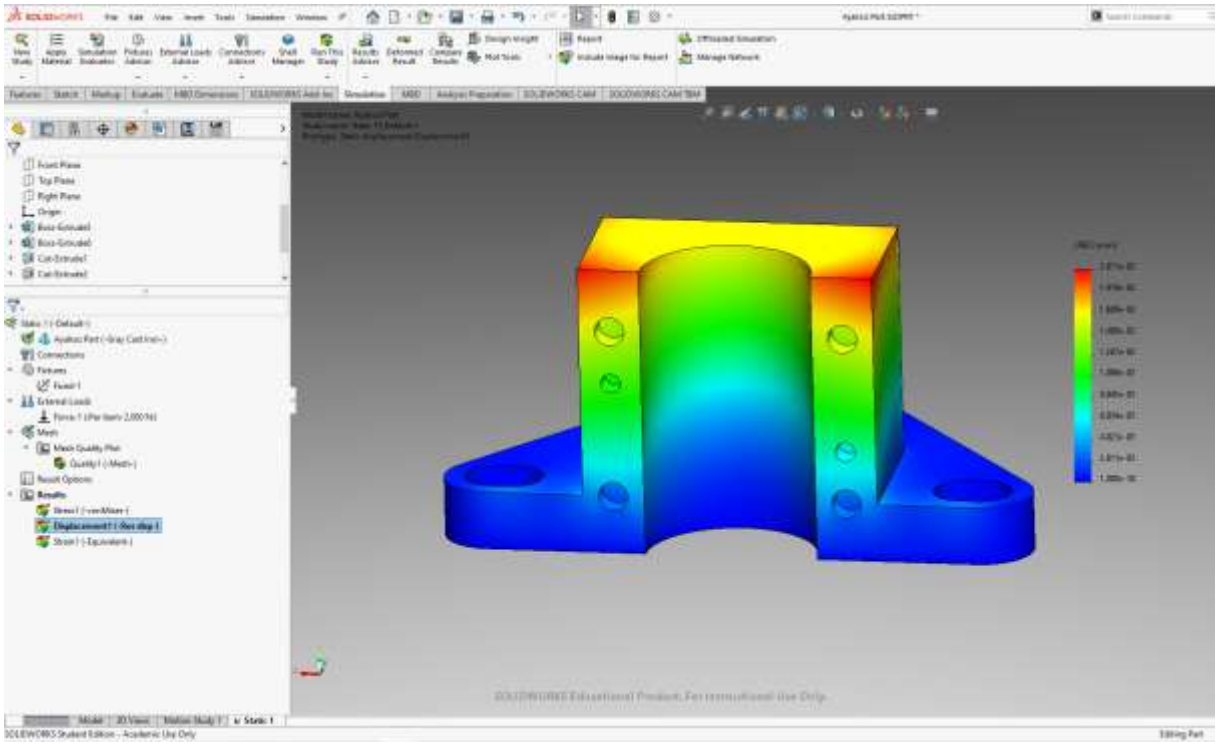
As we can see from the test result, the most deformation occurred at the edges of the hole, where part integrity was not ensured.

Here is the Deformed Part view after 2.000N Force.



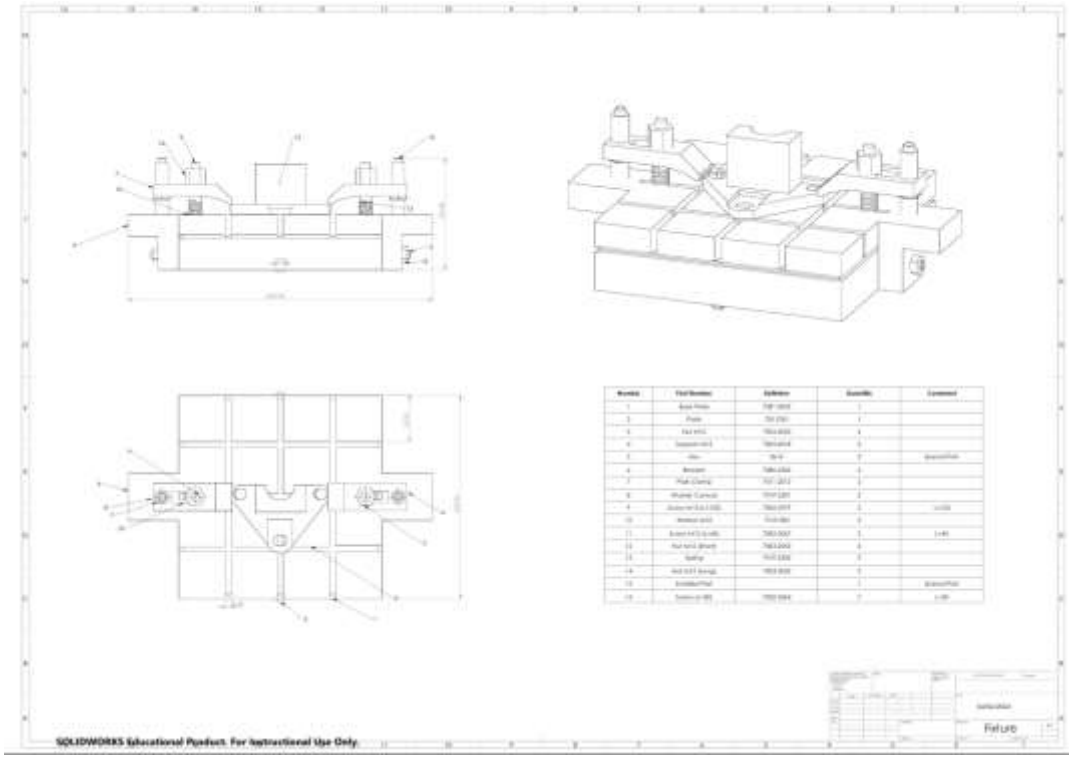
2.3 Displacement Results.

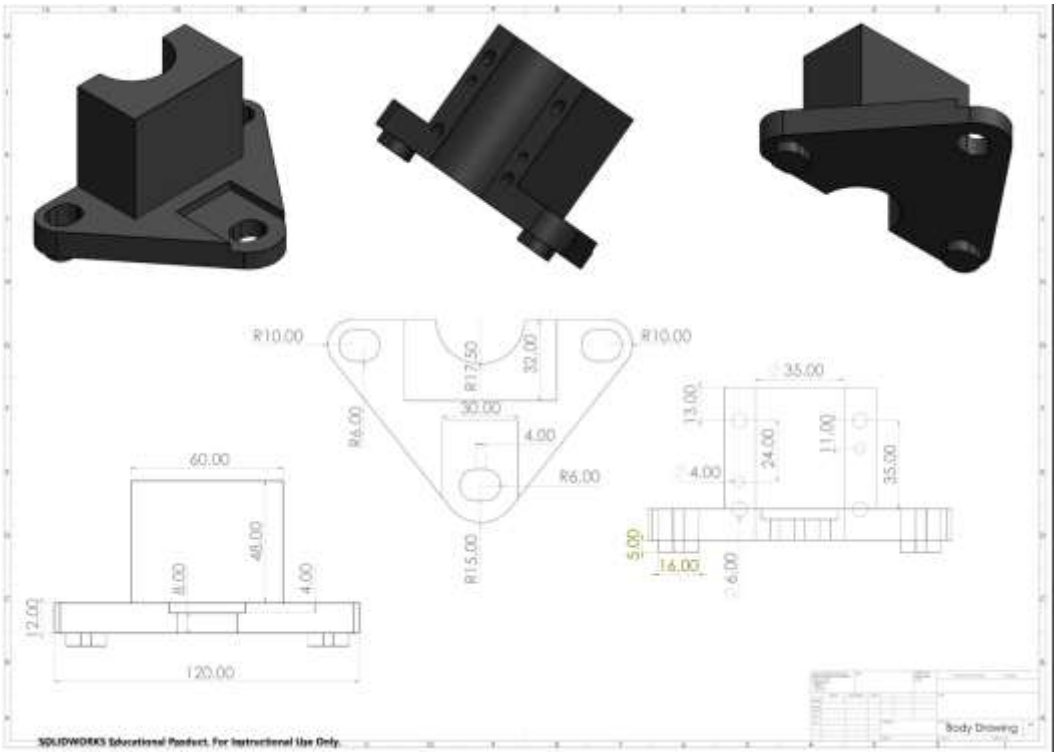




In the final step of our analysis, we examine the displacement levels on the model. The images above reveal that the biggest displacement occurs at the top back corner part of the model. This is primarily because this section is not fixed at any points and is subjected to an applied force.

CHAPTER 3. Fixture Design





3.1 Introduction to Fixture Designing Process

The fixture designing process begins with a thorough understanding of the workpiece, including its dimensions and material properties. For instance, for a workpiece measuring 120x80mm, a 240x240mm plate is selected as it provides the necessary accommodation and support. The process involves selecting an appropriate base plate, which should be the smallest size that can still support the workpiece and its clamping elements effectively. For this example, a 240x240mm plate is chosen due to its practical size and weight considerations. The design incorporates modular fixture systems with plates featuring T-shaped grooves, and includes essential elements such as square plates, screws, rectangular keys, body angles, and groove bolts. These components are carefully assembled to create a stable and secure fixture base, ensuring all parts are tightly secured to prevent any movement during machining. Estimating the clamping force is a critical step, involving the calculation of the cutting force encountered by the workpiece and determining the necessary frictional force to hold it in place. This includes calculating the output force required for generating the needed clamping force, with considerations for manual clamp force limits to ensure ergonomic safety.

Finally, the fixture design is verified to withstand machining forces and provide stable support throughout the process. This introduction outlines the essential steps and considerations in designing an effective fixture, ensuring the workpiece is securely supported during machining operations.

3.2 Analysis for The Work in General.

Important Features

Critical features of the fixture design are essential to ensure mechanical accuracy, precision and repeatability. These factors include:

1. Base plate selection: The base plate should be small enough to still support the work and its clamping elements effectively. For example, a 240x240mm plate is used to support a workstation of 120x80mm due to its useful size and weight consideration.

2. Modular Fixture Systems: T-shaped grooved plates and incorporates necessary components such as square plates, screws, rectangular keys, body angles, grooves and bolts. These components must be carefully assembled to form a sturdy and sturdy fixture base, ensuring that all parts are tightly coupled to any movement during machining.

3. Clamping Force Estimation: This allows the shear forces experienced by the work to be calculated to determine the frictional force required to hold it. This is accompanied by an estimate of the output force required to generate the required clamping force by considering manual clamping force limitations to ensure ergonomic safety.

Challenges

Several challenges must be addressed in fixture design to ensure its effectiveness:

Stabilization of workpiece: It is important to ensure that the workpiece does not move during machining. Any movement can cause inaccuracies and errors in the finished part.

Force distribution: Proper distribution of clamping and machining forces to avoid deformation of the workpiece. Abnormal forces can cause distortion and affect the part shape accuracy.

Ergonomic considerations: The system must account for manual and clamping capacity limitations to avoid user fatigue and injury, which can compromise system stability

Component Integration: Various fixing components such as screws, wrenches and bolts must be accurately integrated to ensure that the entire system works properly. Improper alignment or assembly can cause stabilizer failure.

Considerations

Key stabilizer design considerations ensure that the stabilizer performs properly under mechanical conditions:

Materials: Understanding the physical properties of materials and installations in order to select appropriate materials that can withstand mechanical strength and wear.

Mechanical strength: The design of the fixture has been checked to withstand the required mechanical strength without compromising the stability of the work. It involves simulations and calculations to predict power distribution and potential damage

Fixture Verification: The fixture design is thoroughly tested and verified under actual mechanical conditions to ensure that it provides stable support and maintains desired tolerances.

Modularity and flexibility: Fixtures should be designed to be modular and easily modified or reconfigured for parts or machining operations. This increases the versatility of the fixture and reduces the need for multiple dedicated fixtures.

By addressing these critical features, challenges, and considerations, the fixture design process ensures that the workpiece is securely supported, leading to high-quality machining results and efficient production processes.

3.3 Calculation of Clamping Force

Let's consider clamping a piece of steel with a desired clamping pressure of 10 MPa (megapascals) or 10 N/mm². The friction coefficient between the jaws and the steel is approximately 0.4.

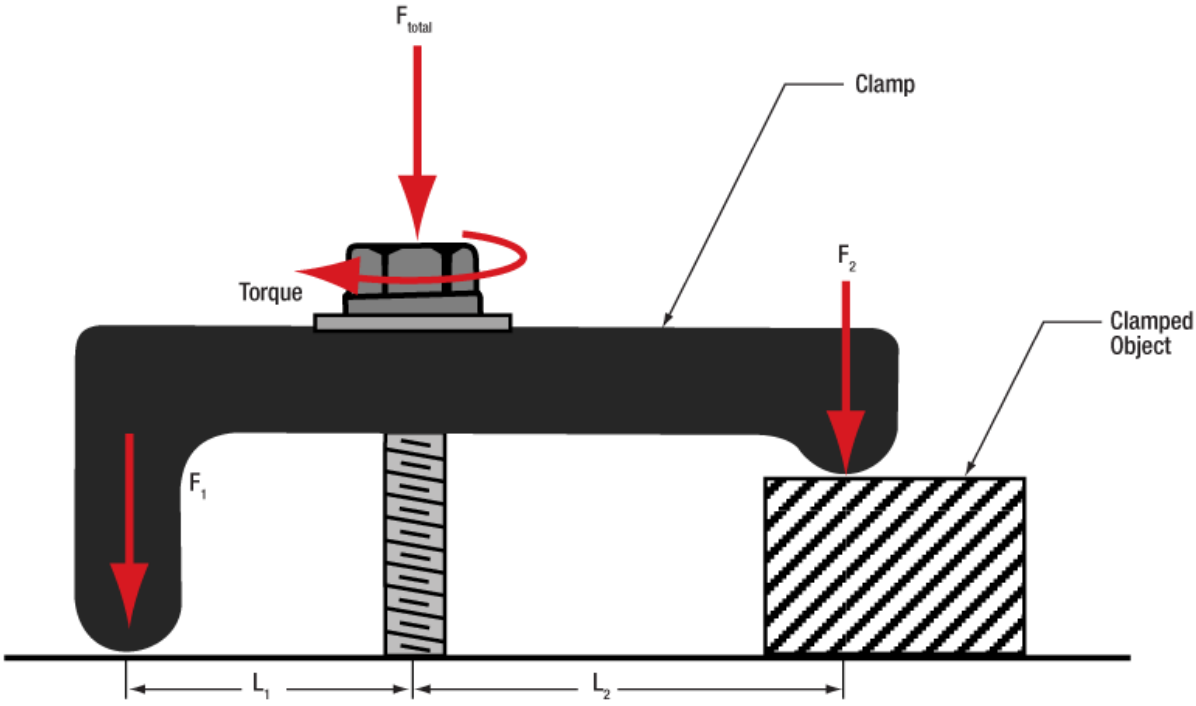
First, let's determine the contact area:

- **Contact Area**: Length × Width = 120 mm × 80 mm = 9,600 mm²

Next, we can calculate the required clamping force:

- **Clamping Force**: Contact Area × Clamping Pressure = 9,600 mm² × 10 N/mm² = 144,000 N

Therefore, for V-shaped jaws with a contact surface measuring 120 mm in length and 80 mm in width, and assuming a clamping pressure of 10 MPa with a friction coefficient of 0.4, the calculated clamping force is approximately 96,000 Newtons.


F total
Clamp
Torque
F2
Clamped Object
F1
L1
L2

CHAPTER 4. Economic Calculations

4.1 Cost Estimation for Operations

The design and complexity of manufacturing a bracket can significantly affect production costs. The intricacy of the part's design and geometry is a crucial factor in determining machining expenses. As the complexity increases, so does the cost of manufacturing. Several elements contribute to this rise in costs, such as the need for more advanced machinery, longer fabrication times for each unit, potential multiple setups and processes, and stringent quality control to meet tight tolerances. Additionally, non-standard parts with features like thin walls, deep cavities, irregular hole sizes, or high surface quality can lead to higher costs per unit.

The complexity of a bushing machine part pertains to the sophistication of its design and features. A more complex bushing machine part might have intricate geometries, multiple functional components, or advanced mechanisms. This complexity can impact the manufacturing process and the associated production costs. It may necessitate specialized machining techniques, extended production times, the use of advanced equipment, or additional quality control measures. Consequently, the more complex the bushing machine part, the higher the manufacturing costs are likely to be due to these factors.

Firstly, we need to consider the quantity of parts required for the manufacturing process to meet customer demands. In our case, we have an annual order of 3,000 parts. The material used will be cast iron.

The defect rate in manufacturing refers to the proportion or percentage of products or parts that are defective or non-conforming within the manufacturing process. It serves as an indicator of the quality performance and reliability of the

production process. A lower defect rate signifies higher product quality and greater process efficiency, whereas a higher defect rate highlights issues or problems that need to be resolved.

Figure. Stock information

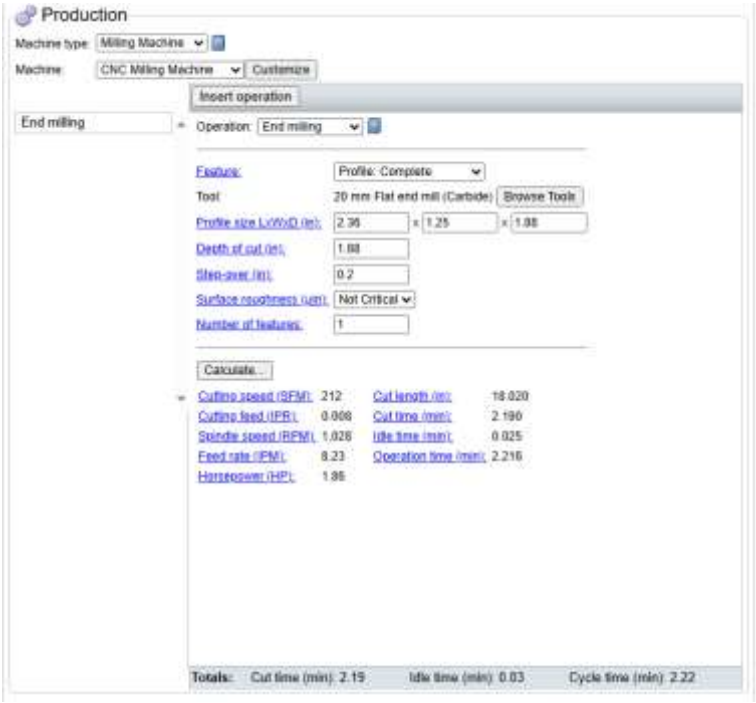
When we convert our dimensions (mm to in) there is the new dimensions of our part.

(small changes may occur because of the convertion)

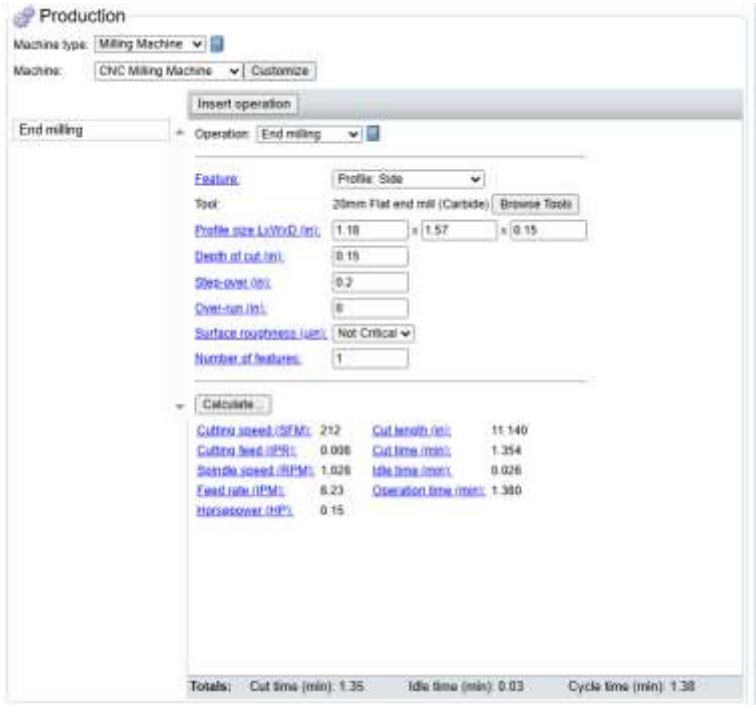
LxWxH : 120mm (4.72in) x 80mm (3.14in) x 60mm (2.36in)

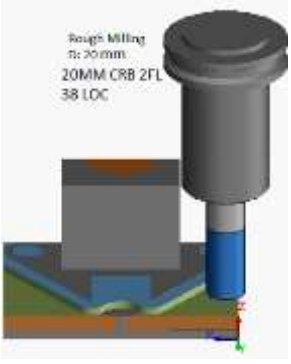
Weight: 0.913kg (2.01 lb).

End Milling Operation for the pictured area.


Production
Machine type: Milling Machine
Machine: CNC Milling Machine
Customize
Insert operation
End milling
Operation: End milling
Feature: Profile: Complete
Tool: 20 mm Flat end mill (Carbide)
Browse Tools
Profile size LxWxD (in): 2.36 x 1.25 x 1.88
Depth of cut (in): 1.88
Step-over (in): 0.2
Surface roughness (um): Not Critical
Number of features: 1
Calculate
Cutting speed (SFM): 212
Cut length (in): 18.020
Cutting feed (IPR): 0.008
Cut time (min): 2.190
Spindle speed (RPM): 1,026
Idle time (min): 0.025
Feed rate (IPM): 8.23
Operation time (min): 2.216
Horsepower (HP): 1.86
Totals: Cut time (min): 2.19
Idle time (min): 0.03
Cycle time (min): 2.22


Rough Milling
D: 20mm
20MM CRB
2FL 38 LOC


Production
Machine type: Milling Machine
Machine: CNC Milling Machine
Customize
Insert operation
End milling
Operation: End milling
Feature: Profile: Side
Tool: 20mm Flat end mill (Carbide)
Browse Tools
Profile size LxWxD (in): 1.18 x 1.57 x 0.15
Depth of cut (in): 0.15
Step-over (in): 0.2
Over-run (in): 0
Surface roughness (um): Not Critical
Number of features: 1
Calculate
Cutting speed (SFM): 212
Cut length (in): 11.140
Cutting feed (IPR): 0.008
Cut time (min): 1.354
Spindle speed (RPM): 1,026
Idle time (min): 0.026
Feed rate (IPM): 8.23
Operation time (min): 1.380
Horsepower (HP): 0.15
Totals: Cut time (min): 1.35
Idle time (min): 0.03
Cycle time (min): 1.38


Rough Milling
D: 20mm
20MM CRB 2FL
38 LOC

Production

Machine type: Milling Machine

Machine: CNC Milling Machine | Customize

Insert operation

End milling

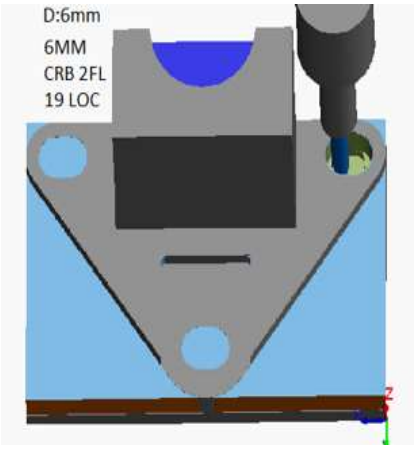
Operation: End milling

Feature:	Pocket: Cylinder
Tool:	6 mm Flat end mill (Carbide) Browse Tools
Pocket diameter (in):	0.39
Pocket depth (in):	0.47
Cutterpath type:	Rough only
Depth of cut (in):	1.41
Step-over (in):	0.2
Surface roughness (uin):	16 Ra
Number of features:	1

Calculate...

Cutting speed (SFM):	117	Cut length (in):	0.768
Cutting feed (IPR):	0.000	Cut time (min):	1.450
Spindle speed (RPM):	1,892	Idle time (min):	0.025
Feed rate (IPM):	0.53	Operation time (min):	1.474
Horsepower (HP):	0.09		

Totals: Cut time (min): 1.45 Idle time (min): 0.02 Cycle time (min): 1.47



Milling | Milling | Milling | Milling | Reports | Additional Processes

Production

Machine type: Milling Machine

Machine: CNC Milling Machine | Customize

Insert operation

End milling

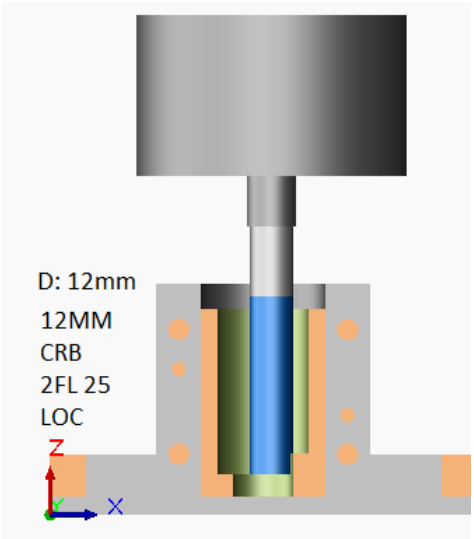
Operation: End milling

Feature:	Profile: Side
Tool:	12 mm Flat end mill (Carbide) Browse Tools
Profile size LxWxD (in):	2.36 x 1.25 x 2.36
Depth of cut (in):	0.68
Step-over (in):	0.2
Over-run (in):	0
Surface roughness (µin):	Not Critical
Number of features:	1

Calculate...

Cutting speed (SFM):	231	Cut length (in):	72.080
Cutting feed (IPR):	0.013	Cut time (min):	3.063
Spindle speed (RPM):	1,868	Idle time (min):	0.033
Feed rate (IPM):	23.53	Operation time (min):	3.096
Horsepower (HP):	1.92		

Totals: Cut time (min): 3.06 Idle time (min): 0.03 Cycle time (min): 3.10



Production

Machine type: Milling Machine

Machine: CNC Milling Machine | Customize

Insert operation

Drilling

Operation: Drilling

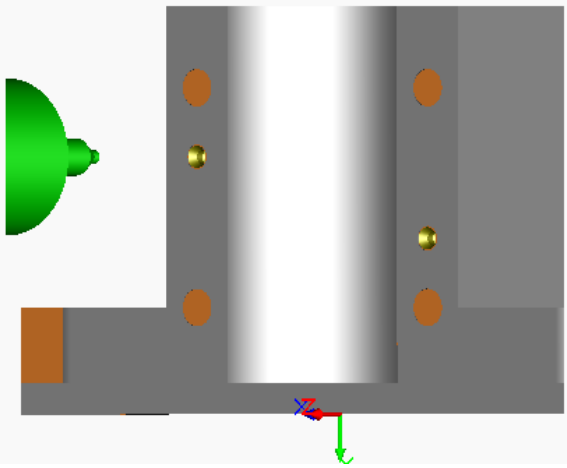
Tool:	2.1 mm Drill bit (HSS) Browse Tools		
Hole type:	Blind hole		
Hole depth (in):	0.19		
	to point		
Number of holes:	2		
Average spacing (in):			

Calculate...

Cutting speed (SFM):	106	Cut length (in):	0.580
Cutting feed (IPR):	0.003	Cut time (min):	0.041
Spindle speed (RPM):	4,896	Idle time (min):	0.025
Feed rate (IPM):	14.20	Operation time (min):	0.066
Horsepower (HP):	0.08		

Totals: Cut time (min): 0.04 Idle time (min): 0.02 Cycle time (min): 0.07

Tool Material: HSS
Center Drilling
D: 6mm
T06-6mmx60Deg



Production

Machine type: Milling Machine

Machine: CNC Milling Machine | Customize

Insert operation

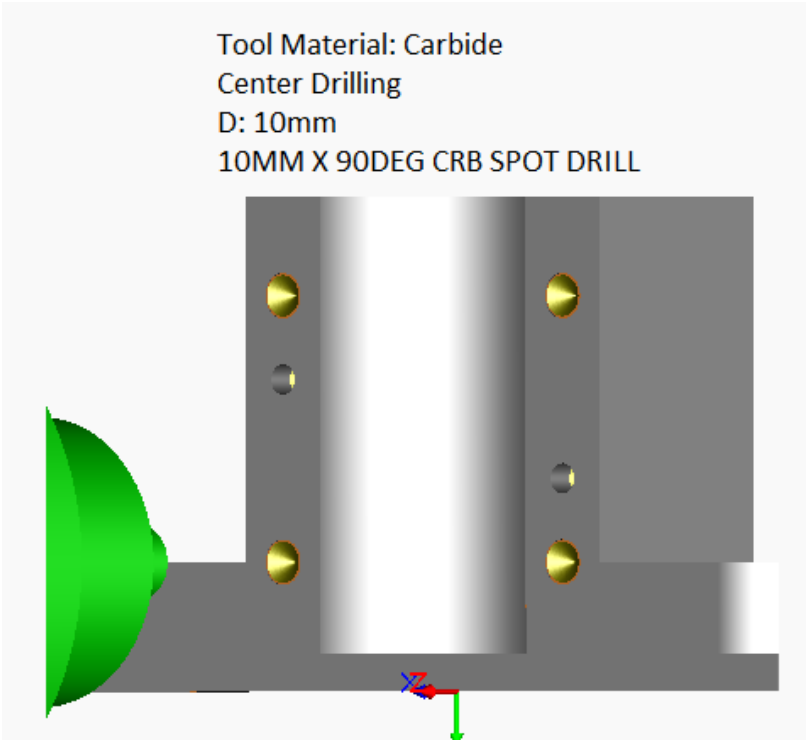
Drilling

Operation: Drilling

Tool:	10 mm Drill bit (Carbide) Browse Tools
Hole type:	Blind hole
Hole depth (in):	0.19
	to point
Number of holes:	4
Average spacing (in):	

Calculate...

Cutting speed (SFM):	242	Cut length (in):	1.160
Cutting feed (IPR):	0.003	Cut time (min):	0.183
Spindle speed (RPM):	2,348	Idle time (min):	0.026
Feed rate (IPM):	6.34	Operation time (min):	0.209
Horsepower (HP):	0.77		



4.2 Cost Summary

Part Information

Quantity: 3,000
Material: Ductile iron: Grade 80-55-06
Workpiece shape: Prefabricated part
Workpiece size (in): 4.72 x 3.14 x 2.36
Workpiece weight (lb): -3.32
Approx. part weight (lb): -3.33

Process Parameters

- **1. Machining - CNC Milling Machine**
- **2. Machining - CNC Milling Machine**
- **3. Machining - CNC Milling Machine**
- **4. Machining - CNC Milling Machine**
- **5. Machining - CNC Milling Machine**
- **6. Machining - CNC Milling Machine**

Cost Summary

1. Milling	$6,237 ($2.079 per part)
Material cost	$0 ($0.000 per part)
Production cost	$6,237 ($2.079 per part)
Tooling cost	$0 ($0.000 per part)
2. Milling	$3,939 ($1.313 per part)
Material cost	$0 ($0.000 per part)
Production cost	$3,939 ($1.313 per part)
Tooling cost	$0 ($0.000 per part)
3. Milling	$4,198 ($1.399 per part)
Material cost	$0 ($0.000 per part)
Production cost	$4,198 ($1.399 per part)
Tooling cost	$0 ($0.000 per part)
4. Milling	$8,657 ($2.886 per part)
Material cost	$0 ($0.000 per part)
Production cost	$8,657 ($2.886 per part)
Tooling cost	$0 ($0.000 per part)
5. Milling	$326 ($0.109 per part)
Material cost	$0 ($0.000 per part)
Production cost	$326 ($0.109 per part)
Tooling cost	$0 ($0.000 per part)
6. Milling	$721 ($0.240 per part)
Material cost	$0 ($0.000 per part)
Production cost	$721 ($0.240 per part)
Tooling cost	$0 ($0.000 per part)
Total cost	**$24,078**

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16. CNC Machining Handbook: Building, Programming, and Implementation" by Chuck Easttom

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Gazi Üniversitesi Teknik Eğitim Fakültesi Makine Eğitimi Bölümü, 06500 Ankara/TÜRKİYE
21.10.2005

19. "Manufacturing Processes for Engineering Materials" by Serope Kalpakjian and Steven R. Schmid

Appendix CNC Codes

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O00001
(This Post Processor is distributed on an "AS IS" BASIS, )
(WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied. )
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N2055 Y10.954
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N2170 X72.892
N2175 Y-9.418
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N3040 G01 X105.634
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N3080 G03 X109.634 Y-66.75 I-2.75 J0
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N3565 G03 X102.884 Y-69.5 I0 J-2.75

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N3585 G90 G54 X105.634 Y-70.35
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N3690 G03 X112.384 Y-70. I0 J2.75
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N3765 G01 Z-55. F237.5
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N3775 G01 X61.973
N3780 G03 X62.323 Y-15. I0 J.35
N3785 G01 Y-14.5
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N3795 G01 X57.973
N3800 G03 X57.623 Y-14.5 I0 J-.35
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N3825 G03 X64.723 Y-15. I0 J2.75
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N3845 G03 X55.223 Y-14.5 I0 J-2.75
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N3960 G03 X57.973 Y-17.75 I2.75 J0
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N4115 G03 X64.723 Y-15. I0 J2.75
N4120 G01 Y-14.5
N4125 G03 X61.973 Y-11.75 I-2.75 J0
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N4260 G03 X64.723 Y-15. I0 J2.75
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N4270 G03 X61.973 Y-11.75 I-2.75 J0
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N4280 G03 X55.223 Y-14.5 I0 J-2.75
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N4300 G03 X64.723 Y-15. I0 J2.75
N4305 G01 Y-14.5
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N4315 G01 X57.973
N4320 G03 X55.223 Y-14.5 I0 J-2.75
N4325 G01 Y-15.
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N4345 T02 M06 (10MM CRB 2FL 22 LOC)
N4350 G54 G90 G94
N4355 S7868 M03
N4360 G90 X62.387 Y-14.5
N4365 G43 H02 Z-49. M08
N4370 G01 Z-57. F219.843
N4375 G90 G41 X61.68 Y-13.793 D02 F659.529
N4380 G03 X60.973 Y-13.5 I-.707 J-.707
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N4390 G03 X56.973 Y-14.5 I0 J-1.
N4395 G01 Y-15.
N4400 G03 X57.973 Y-16. I1. J0
N4405 G01 X61.973

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N4415 G01 Y-14.5
N4420 G03 X61.973 Y-13.5 I-1. J0
N4425 G01 X58.973
N4430 G03 X58.265 Y-13.793 I0 J-1.
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N4455 G01 Z-60. F219.843
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N4545 G54 G90 G94
N4550 S6557 M03
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N4565 G01 Z-6. F183.202
N4570 Y-80. F732.81
N4575 G03 X57.498 I-2.394 J0
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N4590 Y-80. F732.81
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N4810 G01 Y-95.

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N4850 G01 Y-95.
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N5510 G43 H20 Z3. M08
N5515 G01 Z-4. F237.5
N5520 G90 G41 X73.158 Y-81.366 D20 F712.5
N5525 G03 X73.392 Y-80.8 I-.566 J.566
N5530 G01 Y-80. F950.
N5535 G03 X46.392 I-13.5 J0
N5540 G01 Y-80.8
N5545 G03 X46.627 Y-81.366 I.8 J0
N5550 G40 G01 X49.568 Y-84.307
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N5560 G90 G54 X70.217 Y-84.307
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N5570 G01 Z-8. F237.5
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N5585 G01 Y-80. F950.
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N5615 G90 G54 X70.217 Y-84.307
N5620 Z-5.
N5625 G01 Z-12. F237.5
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N5640 G01 Y-80. F950.
N5645 G03 X46.392 I-13.5 J0
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N5695 G01 Y-80. F950.
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N5725 G90 G54 X70.217 Y-84.307
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N5735 G01 Z-20. F237.5
N5740 G90 G41 X73.158 Y-81.366 D20 F712.5
N5745 G03 X73.392 Y-80.8 I-.566 J.566
N5750 G01 Y-80. F950.
N5755 G03 X46.392 I-13.5 J0
N5760 G01 Y-80.8
N5765 G03 X46.627 Y-81.366 I.8 J0
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N5780 G90 G54 X70.217 Y-84.307
N5785 Z-17.
N5790 G01 Z-24. F237.5
N5795 G90 G41 X73.158 Y-81.366 D20 F712.5
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N5805 G01 Y-80. F950.
N5810 G03 X46.392 I-13.5 J0
N5815 G01 Y-80.8
N5820 G03 X46.627 Y-81.366 I.8 J0
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N5835 G90 G54 X70.217 Y-84.307
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N5845 G01 Z-28. F237.5
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N5865 G03 X46.392 I-13.5 J0
N5870 G01 Y-80.8
N5875 G03 X46.627 Y-81.366 I.8 J0
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N5890 G90 G54 X70.217 Y-84.307
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N5915 G01 Y-80. F950.
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N5925 G01 Y-80.8
N5930 G03 X46.627 Y-81.366 I.8 J0
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N5970 G01 Y-80. F950.
N5975 G03 X46.392 I-13.5 J0
N5980 G01 Y-80.8
N5985 G03 X46.627 Y-81.366 I.8 J0
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N6065 G01 Z-44. F237.5

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N6080 G01 Y-80. F950.
N6085 G03 X46.392 I-13.5 J0
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N6095 G03 X46.627 Y-81.366 I.8 J0
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N6120 G01 Z-48. F237.5
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N6955 G01 X109.634
N6960 G03 X112.384 Y-70. I0 J2.75
N6965 G01 Y-69.5
N6970 G03 X109.634 Y-66.75 I-2.75 J0
N6975 G01 X105.634
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N7235 G01 Y-69.5
N7240 G03 X109.634 Y-69.15 I-.35 J0
N7245 G01 X105.634
N7250 G03 X105.284 Y-69.5 I0 J-.35
N7255 G01 X102.884
N7260 Y-70.
N7265 G03 X105.634 Y-72.75 I2.75 J0
N7270 G01 X109.634
N7275 G03 X112.384 Y-70. I0 J2.75
N7280 G01 Y-69.5
N7285 G03 X109.634 Y-66.75 I-2.75 J0
N7290 G01 X105.634
N7295 G03 X102.884 Y-69.5 I0 J-2.75
N7300 G00 Z-45.5
N7305 G90 G54 X105.284 Y-69.5
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N7315 G01 Z-60. F237.5
N7320 Y-70. F950.
N7325 G03 X105.634 Y-70.35 I.35 J0
N7330 G01 X109.634

N7335 G03 X109.984 Y-70. I0 J.35
N7340 G01 Y-69.5
N7345 G03 X109.634 Y-69.15 I-.35 J0
N7350 G01 X105.634
N7355 G03 X105.284 Y-69.5 I0 J-.35
N7360 G01 X102.884
N7365 Y-70.
N7370 G03 X105.634 Y-72.75 I2.75 J0
N7375 G01 X109.634
N7380 G03 X112.384 Y-70. I0 J2.75
N7385 G01 Y-69.5
N7390 G03 X109.634 Y-66.75 I-2.75 J0
N7395 G01 X105.634
N7400 G03 X102.884 Y-69.5 I0 J-2.75
N7405 G00 Z-45.5
N7410 G01 Z25. F500. M09
N7415 G00 G90 G53 G49 H0 Z0 M05
N7420 T02 M06 (10MM CRB 2FL 22 LOC)
N7425 G54 G90 G94
N7430 S7868 M03
N7435 G90 X14.565
N7440 G43 H02 Z-45. M08
N7445 G01 Z-53. F219.843
N7450 G90 G41 X13.858 Y-68.793 D02 F659.529
N7455 G03 X13.151 Y-68.5 I-.707 J-.707
N7460 G01 X10.151 F879.371
N7465 G03 X9.151 Y-69.5 I0 J-1.
N7470 G01 Y-70.
N7475 G03 X10.151 Y-71. I1. J0
N7480 G01 X14.151
N7485 G03 X15.151 Y-70. I0 J1.
N7490 G01 Y-69.5
N7495 G03 X14.151 Y-68.5 I-1. J0
N7500 G01 X11.151
N7505 G03 X10.444 Y-68.793 I0 J-1.
N7510 G40 G01 X9.737 Y-69.5
N7515 G00 Z-45.
N7520 G90 G54 X14.565 Y-69.5
N7525 Z-50.
N7530 G01 Z-56.5 F219.843
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N7570 G03 X15.151 Y-70. I0 J1.
N7575 G01 Y-69.5
N7580 G03 X14.151 Y-68.5 I-1. J0
N7585 G01 X11.151
N7590 G03 X10.444 Y-68.793 I0 J-1.
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N7640 G01 Y-70.
N7645 G03 X10.151 Y-71. I1. J0
N7650 G01 X14.151
N7655 G03 X15.151 Y-70. I0 J1.
N7660 G01 Y-69.5
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N7670 G01 X11.151
N7675 G03 X10.444 Y-68.793 I0 J-1.
N7680 G40 G01 X9.737 Y-69.5
N7685 G00 Z-45.
N7690 Z25.
N7695 G90 G54 X110.048 Y-69.5
N7700 Z-45.
N7705 G01 Z-53. F219.843
N7710 G90 G41 X109.341 Y-68.793 D02 F659.529
N7715 G03 X108.634 Y-68.5 I-.707 J-.707

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N7730 G01 Y-70.
N7735 G03 X105.634 Y-71. I1. J0
N7740 G01 X109.634
N7745 G03 X110.634 Y-70. I0 J1.
N7750 G01 Y-69.5
N7755 G03 X109.634 Y-68.5 I-1. J0
N7760 G01 X106.634
N7765 G03 X105.927 Y-68.793 I0 J-1.
N7770 G40 G01 X105.22 Y-69.5
N7775 G00 Z-45.
N7780 G90 G54 X110.048 Y-69.5
N7785 Z-50.
N7790 G01 Z-56.5 F219.843
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N7815 G01 Y-70.
N7820 G03 X105.634 Y-71. I1. J0
N7825 G01 X109.634
N7830 G03 X110.634 Y-70. I0 J1.
N7835 G01 Y-69.5
N7840 G03 X109.634 Y-68.5 I-1. J0
N7845 G01 X106.634
N7850 G03 X105.927 Y-68.793 I0 J-1.
N7855 G40 G01 X105.22 Y-69.5
N7860 G00 Z-45.
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N7875 G01 Z-60. F219.843
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N7900 G01 Y-70.
N7905 G03 X105.634 Y-71. I1. J0
N7910 G01 X109.634
N7915 G03 X110.634 Y-70. I0 J1.
N7920 G01 Y-69.5
N7925 G03 X109.634 Y-68.5 I-1. J0
N7930 G01 X106.634
N7935 G03 X105.927 Y-68.793 I0 J-1.
N7940 G40 G01 X105.22 Y-69.5
N7945 G00 Z-45.
N7950 G01 Z25. F500. M09
N7955 G00 G90 G53 G49 H0 Z0 M05
N7960 T01 M06 (6MM CRB 2FL 19 LOC)
N7965 G54 G90 G94
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N7980 G43 H01 Z-45.5 M08
N7985 G01 Z-51. F237.5
N7990 X127.24 F950.
N7995 G02 X119.861 Y-87.24 I-17.24 J9.861
N8000 G01 Y-87.5
N8005 Z-53.917 F237.5
N8010 Y-87.24 F950.
N8015 G03 X127.24 Y-79.861 I-9.861 J17.24
N8020 G01 X127.5
N8025 Z-56.833 F237.5
N8030 X127.24 F950.
N8035 G02 X119.861 Y-87.24 I-17.24 J9.861
N8040 G01 Y-87.5
N8045 Z-59.75 F237.5
N8050 Y-87.24 F950.
N8055 G03 X127.24 Y-79.861 I-9.861 J17.24
N8060 G01 X127.5
N8065 Z-60. F237.5
N8070 X127.24 F950.
N8075 G02 X119.861 Y-87.24 I-17.24 J9.861
N8080 G01 Y-87.5
N8085 G00 Z-45.5
N8090 G90 G54 X117.658 Y-87.5
N8095 G01 Z-51. F237.5
N8100 Y-85.911 F950.
N8105 G03 X125.911 Y-77.658 I-7.658 J15.911
N8110 G01 X127.5
N8115 Z-53.917 F237.5
N8120 X125.911 F950.
N8125 G02 X117.658 Y-85.911 I-15.911 J7.658

N8130 G01 Y-87.5
N8135 Z-56.833 F237.5
N8140 Y-85.911 F950.
N8145 G03 X125.911 Y-77.658 I-7.658 J15.911
N8150 G01 X127.5
N8155 Z-59.75 F237.5
N8160 X125.911 F950.
N8165 G02 X117.658 Y-85.911 I-15.911 J7.658
N8170 G01 Y-87.5
N8175 Z-60. F237.5
N8180 Y-85.911 F950.
N8185 G03 X125.911 Y-77.658 I-7.658 J15.911
N8190 G01 X127.5
N8195 G00 Z-45.5
N8200 G90 G54 X127.5 Y-75.454
N8205 G01 Z-51. F237.5
N8210 X124.5 F950.
N8215 G02 X124.46 I0 J5.454
N8220 X115.454 Y-84.46 I-14.46 J5.454
N8225 Y-84.5 I-5.454 J-.04
N8230 G01 Y-87.5
N8235 Z-53.917 F237.5
N8240 Y-84.5 F950.
N8245 G03 Y-84.46 I-5.454 J0
N8250 X124.46 Y-75.454 I-5.454 J14.46
N8255 X124.5 I.04 J5.454
N8260 G01 X127.5
N8265 Z-56.833 F237.5
N8270 X124.5 F950.
N8275 G02 X124.46 I0 J5.454
N8280 X115.454 Y-84.46 I-14.46 J5.454
N8285 Y-84.5 I-5.454 J-.04
N8290 G01 Y-87.5
N8295 Z-59.75 F237.5
N8300 Y-84.5 F950.
N8305 G03 Y-84.46 I-5.454 J0
N8310 X124.46 Y-75.454 I-5.454 J14.46
N8315 X124.5 I.04 J5.454
N8320 G01 X127.5
N8325 Z-60. F237.5
N8330 X124.5 F950.
N8335 G02 X124.46 I0 J5.454
N8340 X115.454 Y-84.46 I-14.46 J5.454
N8345 Y-84.5 I-5.454 J-.04
N8350 G01 Y-87.5
N8355 G00 Z-45.5
N8360 G90 G54 X113.25 Y-87.5
N8365 G01 Z-51. F237.5
N8370 Y-84.5 F950.
N8375 G03 X112.851 Y-82.94 I-3.25 J0
N8380 X122.94 Y-72.851 I-2.851 J12.94
N8385 X124.5 Y-73.25 I1.56 J2.851
N8390 G01 X127.5
N8395 Z-53.917 F237.5
N8400 X124.5 F950.
N8405 G02 X122.94 Y-72.851 I0 J3.25
N8410 X112.851 Y-82.94 I-12.94 J2.851
N8415 X113.25 Y-84.5 I-2.851 J-1.56
N8420 G01 Y-87.5
N8425 Z-56.833 F237.5
N8430 Y-84.5 F950.
N8435 G03 X112.851 Y-82.94 I-3.25 J0
N8440 X122.94 Y-72.851 I-2.851 J12.94
N8445 X124.5 Y-73.25 I1.56 J2.851
N8450 G01 X127.5
N8455 Z-59.75 F237.5
N8460 X124.5 F950.
N8465 G02 X122.94 Y-72.851 I0 J3.25
N8470 X112.851 Y-82.94 I-12.94 J2.851
N8475 X113.25 Y-84.5 I-2.851 J-1.56
N8480 G01 Y-87.5
N8485 Z-60. F237.5
N8490 Y-84.5 F950.
N8495 G03 X112.851 Y-82.94 I-3.25 J0
N8500 X122.94 Y-72.851 I-2.851 J12.94
N8505 X124.5 Y-73.25 I1.56 J2.851
N8510 G01 X127.5
N8515 Z-51. F237.5
N8520 X124.5 F950.
N8525 G02 X122.94 Y-72.851 I0 J3.25
N8530 X112.851 Y-82.94 I-12.94 J2.851
N8535 X113.25 Y-84.5 I-2.851 J-1.56
N8540 G01 Y-87.5
N8545 Z-53.917 F237.5
N8550 Y-84.5 F950.

N8555 G03 X112.851 Y-82.94 I-3.25 J0
N8560 X122.94 Y-72.851 I-2.851 J12.94
N8565 X124.5 Y-73.25 I1.56 J2.851
N8570 G01 X127.5
N8575 Z-56.833 F237.5
N8580 X124.5 F950.
N8585 G02 X122.94 Y-72.851 I0 J3.25
N8590 X112.851 Y-82.94 I-12.94 J2.851
N8595 X113.25 Y-84.5 I-2.851 J-1.56
N8600 G01 Y-87.5
N8605 Z-59.75 F237.5
N8610 Y-84.5 F950.
N8615 G03 X112.851 Y-82.94 I-3.25 J0
N8620 X122.94 Y-72.851 I-2.851 J12.94
N8625 X124.5 Y-73.25 I1.56 J2.851
N8630 G01 X127.5
N8635 Z-60. F237.5
N8640 X124.5 F950.
N8645 G02 X122.94 Y-72.851 I0 J3.25
N8650 X112.851 Y-82.94 I-12.94 J2.851
N8655 X113.25 Y-84.5 I-2.851 J-1.56
N8660 G01 Y-87.5
N8665 G00 Z-45.5
N8670 G01 Z25. F500. M09
N8675 G00 G90 G53 G49 H0 Z0 M05
N8680 T22 M06 (6MM CRB 2FL 19 LOC)
N8685 G54 G90 G94
N8690 S5500 M03
N8695 G90 X122.691 Y-68.385
N8700 G43 H22 Z-45. M08
N8705 G01 Z-49.5 F237.5
N8710 G90 G41 X121.588 Y-69.488 D22 F712.5
N8715 G03 X121.5 Y-69.7 I.212 J-.212
N8720 G01 Y-70. F950.
N8725 G02 X110. Y-81.5 I-11.5 J0
N8730 G01 X109.7
N8735 G03 X109.488 Y-81.588 I0 J-.3
N8740 G40 G01 X108.385 Y-82.691
N8745 G00 Z-45.
N8750 G90 G54 X122.691 Y-68.385
N8755 Z-46.5
N8760 G01 Z-51. F237.5
N8765 G90 G41 X121.588 Y-69.488 D22 F712.5
N8770 G03 X121.5 Y-69.7 I.212 J-.212
N8775 G01 Y-70. F950.
N8780 G02 X110. Y-81.5 I-11.5 J0
N8785 G01 X109.7
N8790 G03 X109.488 Y-81.588 I0 J-.3
N8795 G40 G01 X108.385 Y-82.691
N8800 G00 Z-45.
N8805 G90 G54 X122.691 Y-68.385
N8810 Z-48.
N8815 G01 Z-52.5 F237.5
N8820 G90 G41 X121.588 Y-69.488 D22 F712.5
N8825 G03 X121.5 Y-69.7 I.212 J-.212
N8830 G01 Y-70. F950.
N8835 G02 X110. Y-81.5 I-11.5 J0
N8840 G01 X109.7
N8845 G03 X109.488 Y-81.588 I0 J-.3
N8850 G40 G01 X108.385 Y-82.691
N8855 G00 Z-45.
N8860 G90 G54 X122.691 Y-68.385
N8865 Z-49.5
N8870 G01 Z-54. F237.5
N8875 G90 G41 X121.588 Y-69.488 D22 F712.5
N8880 G03 X121.5 Y-69.7 I.212 J-.212
N8885 G01 Y-70. F950.
N8890 G02 X110. Y-81.5 I-11.5 J0
N8895 G01 X109.7
N8900 G03 X109.488 Y-81.588 I0 J-.3
N8905 G40 G01 X108.385 Y-82.691
N8910 G00 Z-45.
N8915 G90 G54 X122.691 Y-68.385
N8920 Z-51.
N8925 G01 Z-55.5 F237.5
N8930 G90 G41 X121.588 Y-69.488 D22 F712.5

N8935 G03 X121.5 Y-69.7 I.212 J-.212
N8940 G01 Y-70. F950.
N8945 G02 X110. Y-81.5 I-11.5 J0
N8950 G01 X109.7
N8955 G03 X109.488 Y-81.588 I0 J-.3
N8960 G40 G01 X108.385 Y-82.691
N8965 G00 Z-45.
N8970 G90 G54 X122.691 Y-68.385
N8975 Z-52.5
N8980 G01 Z-57. F237.5
N8985 G90 G41 X121.588 Y-69.488 D22 F712.5
N8990 G03 X121.5 Y-69.7 I.212 J-.212
N8995 G01 Y-70. F950.
N9000 G02 X110. Y-81.5 I-11.5 J0
N9005 G01 X109.7
N9010 G03 X109.488 Y-81.588 I0 J-.3
N9015 G40 G01 X108.385 Y-82.691
N9020 G00 Z-45.
N9025 G90 G54 X122.691 Y-68.385
N9030 Z-54.
N9035 G01 Z-58.5 F237.5
N9040 G90 G41 X121.588 Y-69.488 D22 F712.5
N9045 G03 X121.5 Y-69.7 I.212 J-.212
N9050 G01 Y-70. F950.
N9055 G02 X110. Y-81.5 I-11.5 J0
N9060 G01 X109.7
N9065 G03 X109.488 Y-81.588 I0 J-.3
N9070 G40 G01 X108.385 Y-82.691
N9075 G00 Z-45.
N9080 G90 G54 X122.691 Y-68.385
N9085 Z-55.5
N9090 G01 Z-60. F237.5
N9095 G90 G41 X121.588 Y-69.488 D22 F712.5
N9100 G03 X121.5 Y-69.7 I.212 J-.212
N9105 G01 Y-70. F950.
N9110 G02 X110. Y-81.5 I-11.5 J0
N9115 G01 X109.7
N9120 G03 X109.488 Y-81.588 I0 J-.3
N9125 G40 G01 X108.385 Y-82.691
N9130 G00 Z-45.
N9135 G01 Z25. F500. M09
N9140 G00 G90 G53 G49 H0 Z0 M05
N9145 T05 M06 (20MM CRB 2FL 38 LOC)
N9150 G54 G90 G94
N9155 S3323 M03
N9160 G90 X-25. Y-6.415
N9165 G43 H05 Z-49.5 M08
N9170 G01 Z-59.75 F185.687
N9175 X-.169 Y25. F742.749
N9180 Z-60. F185.687
N9185 X-25. Y-6.415 F742.749
N9190 G00 Z-49.5
N9195 G90 G54 X-25. Y-18.95
N9200 G01 Z-59.75 F185.687
N9205 X9.548 Y24.758 F742.749
N9210 G02 X9.74 Y25. I50.299 J-39.758
N9215 G01 Z-60. F185.687
N9220 G03 X9.548 Y24.758 I50.107 J-40. F742.749
N9225 G01 X-25. Y-18.95
N9230 G00 Z-49.5
N9235 G90 G54 X-25. Y-28.658
N9240 G01 Z-59.75 F185.687
N9245 X-22.766 F742.749
N9250 X15.646 Y19.938
N9255 G02 X18.505 Y23.279 I44.201 J-34.938
N9260 G01 Y25.
N9265 Z-60. F185.687
N9270 Y23.279 F742.749
N9275 G03 X15.646 Y19.938 I41.342 J-38.279
N9280 G01 X-22.766 Y-28.658
N9285 X-25.
N9290 G00 Z-49.5
N9295 G90 G54 X-25. Y-36.431
N9300 G01 Z-59.75 F185.687

N9305 X-19.002 F742.749
N9310 X21.744 Y15.118
N9315 G02 X26.278 Y20.101 I38.103 J-30.118
N9320 G01 Y25.
N9325 Z-60. F185.687
N9330 Y20.101 F742.749
N9335 G03 X21.744 Y15.118 I33.569 J-35.101
N9340 G01 X-19.002 Y-36.431
N9345 X-25.
N9350 G00 Z-49.5
N9355 G90 G54 X-25. Y-44.204
N9360 G01 Z-59.75 F185.687
N9365 X-15.238 F742.749
N9370 X27.842 Y10.298
N9375 G02 X34.051 Y16.605 I32.005 J-25.298
N9380 G01 Y25.
N9385 Z-60. F185.687
N9390 Y16.605 F742.749
N9395 G03 X27.842 Y10.298 I25.796 J-31.605
N9400 G01 X-15.238 Y-44.204
N9405 X-25.
N9410 G00 Z-49.5
N9415 G90 G54 X-25. Y-51.977
N9420 G01 Z-59.75 F185.687
N9425 X-15. F742.749
N9430 G02 X-11.713 Y-52.279 I0 J-18.023
N9435 G01 X33.94 Y5.478
N9440 G02 X41.963 Y12.761 I25.907 J-20.478
N9445 X41.824 Y15. I17.883 J2.239
N9450 G01 Y25.
N9455 Z-60. F185.687
N9460 Y15. F742.749
N9465 G03 X41.963 Y12.761 I18.023 J0
N9470 X33.94 Y5.478 I17.883 J-27.761
N9475 G01 X-11.713 Y-52.279
N9480 G03 X-15. Y-51.977 I-3.287 J-17.721
N9485 G01 X-25.
N9490 G00 Z-49.5
N9495 G90 G54 X-25. Y-59.75
N9500 G01 Z-59.75 F185.687
N9505 X-15. F742.749
N9510 G02 X-8.6 Y-61.994 I0 J-10.25
N9515 X-5.887 Y-57.443 I18.6 J-8.006
N9520 G01 X40.038 Y.658
N9525 G02 X51.628 Y8.875 I19.809 J-15.658
N9530 X49.597 Y15. I8.219 J6.125
N9535 G01 Y25.
N9540 Z-60. F185.687
N9545 Y15. F742.749
N9550 G03 X51.628 Y8.875 I10.25 J0
N9555 X40.038 Y.658 I8.219 J-23.875
N9560 G01 X-5.887 Y-57.443
N9565 G03 X-8.6 Y-61.994 I15.887 J-12.557
N9570 X-15. Y-59.75 I-6.4 J-8.006
N9575 G01 X-25.
N9580 Z-59.75 F185.687
N9585 X-15. F742.749
N9590 G02 X-8.6 Y-61.994 I0 J-10.25
N9595 X-5.887 Y-57.443 I18.6 J-8.006
N9600 G01 X40.038 Y.658
N9605 G02 X51.628 Y8.875 I19.809 J-15.658
N9610 X49.597 Y15. I8.219 J6.125
N9615 G01 Y25.
N9620 Z-60. F185.687
N9625 Y15. F742.749
N9630 G03 X51.628 Y8.875 I10.25 J0
N9635 X40.038 Y.658 I8.219 J-23.875
N9640 G01 X-5.887 Y-57.443
N9645 G03 X-8.6 Y-61.994 I15.887 J-12.557
N9650 X-15. Y-59.75 I-6.4 J-8.006
N9655 G01 X-25.
N9660 G00 Z-49.5
N9665 G01 Z25. F500. M09
N9670 G00 G90 G53 G49 H0 Z0 M05
N9675 T01 M06 (6MM CRB 2FL 19 LOC)
N9680 G54 G90 G94
N9685 S6926 M03
N9690 G90 X-5.382 Y-73.23

N9695 G43 H01 Z-49. M08
N9700 G01 Z-55. F237.5
N9705 G90 G41 X-3.176 Y-71.024 D01 F712.5
N9710 G03 X-3. Y-70.6 I-.424 J.424
N9715 G01 Y-70. F950.
N9720 G02 X-.199 Y-61.939 I13. J0
N9725 G01 X45.725 Y-3.838
N9730 G02 X59.847 Y3. I14.121 J-11.162
N9735 G01 X60.447
N9740 G03 X60.871 Y3.176 I0 J.6
N9745 G40 G01 X63.077 Y5.382
N9750 G00 Z-49.
N9755 G90 G54 X-5.382 Y-73.23
N9760 Z-52.
N9765 G01 Z-57.5 F237.5
N9770 G90 G41 X-3.176 Y-71.024 D01 F712.5
N9775 G03 X-3. Y-70.6 I-.424 J.424
N9780 G01 Y-70. F950.
N9785 G02 X-.199 Y-61.939 I13. J0
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N9795 G02 X59.847 Y3. I14.121 J-11.162
N9800 G01 X60.447
N9805 G03 X60.871 Y3.176 I0 J.6
N9810 G40 G01 X63.077 Y5.382
N9815 G00 Z-49.
N9820 G90 G54 X-5.382 Y-73.23
N9825 Z-54.5
N9830 G01 Z-60. F237.5
N9835 G90 G41 X-3.176 Y-71.024 D01 F712.5
N9840 G03 X-3. Y-70.6 I-.424 J.424
N9845 G01 Y-70. F950.
N9850 G02 X-.199 Y-61.939 I13. J0
N9855 G01 X45.725 Y-3.838
N9860 G02 X59.847 Y3. I14.121 J-11.162
N9865 G01 X60.447
N9870 G03 X60.871 Y3.176 I0 J.6
N9875 G40 G01 X63.077 Y5.382
N9880 G00 Z-49.
N9885 G01 Z25. F500. M09
N9890 G00 G90 G53 G49 H0 Z0 M05
N9895 T05 M06 (20MM CRB 2FL 38 LOC)
N9900 G54 G90 G94
N9905 S3323 M03
N9910 G90 X119.991 Y25.
N9915 G43 H05 Z-49.5 M08
N9920 G01 Z-59.75 F185.687
N9925 X145. Y-6.43 F742.749
N9930 Z-60. F185.687
N9935 X119.991 Y25. F742.749
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N9945 G90 G54 X110.04 Y25.
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N9955 G02 X110.07 Y24.963 I-50.194 J-40. F742.749
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N9965 Z-60. F185.687
N9970 X110.07 Y24.963 F742.749
N9975 G03 X110.04 Y25. I-50.223 J-39.963
N9980 G00 Z-49.5
N9985 G90 G54 X101.243 Y25.
N9990 G01 Z-59.75 F185.687
N9995 Y23.3 F742.749
N5 G02 X103.977 Y20.114 I-41.396 J-38.3
N10 G01 X142.742 Y-28.604
N15 X145.
N20 Z-60. F185.687
N25 X142.742 F742.749
N30 X103.977 Y20.114
N35 G03 X101.243 Y23.3 I-44.13 J-35.114
N40 G01 Y25.
N45 G00 Z-49.5
N50 G90 G54 X93.456 Y25.
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N60 Y20.118 F742.749
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N70 G01 X138.987 Y-36.391
N75 X145.

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N90 X97.884 Y15.266
N95 G03 X93.456 Y20.118 I-38.037 J-30.266
N100 G01 Y25.
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N110 G90 G54 X85.67 Y25.
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N120 Y16.618 F742.749
N125 G02 X91.791 Y10.418 I-25.823 J-31.618
N130 G01 X135.232 Y-44.177
N135 X145.
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N150 X91.791 Y10.418
N155 G03 X85.67 Y16.618 I-31.944 J-25.418
N160 G01 Y25.
N165 G00 Z-49.5
N170 G90 G54 X77.883 Y25.
N175 G01 Z-59.75 F185.687
N180 Y15. F742.749
N185 G02 X77.745 Y12.768 I-18.037 J0
N190 X85.698 Y5.57 I-17.898 J-27.768
N195 G01 X131.717 Y-52.265
N200 G02 X135. Y-51.964 I3.283 J-17.735
N205 G01 X145.
N210 Z-60. F185.687
N215 X135. F742.749
N220 G03 X131.717 Y-52.265 I0 J-18.037
N225 G01 X85.698 Y5.57
N230 G03 X77.745 Y12.768 I-25.851 J-20.57
N235 X77.883 Y15. I-17.898 J2.232
N240 G01 Y25.
N245 G00 Z-49.5
N250 G90 G54 X70.097 Y25.
N255 G01 Z-59.75 F185.687
N260 Y15. F742.749
N265 G02 X68.066 Y8.875 I-10.25 J0
N270 X79.605 Y.722 I-8.219 J-23.875
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N290 G01 X145.
N295 Z-60. F185.687
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N310 X125.846 Y-57.392 I-18.6 J-8.006
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N325 X70.097 Y15. I-8.219 J6.125
N330 G01 Y25.
N335 Z-59.75 F185.687
N340 Y15. F742.749
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N350 X79.605 Y.722 I-8.219 J-23.875
N355 G01 X125.846 Y-57.392
N360 G02 X128.6 Y-61.994 I-15.846 J-12.608
N365 X135. Y-59.75 I6.4 J-8.006
N370 G01 X145.
N375 Z-60. F185.687
N380 X135. F742.749
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N390 X125.846 Y-57.392 I-18.6 J-8.006
N395 G01 X79.605 Y.722
N400 G03 X68.066 Y8.875 I-19.758 J-15.722
N405 X70.097 Y15. I-8.219 J6.125
N410 G01 Y25.
N415 G00 Z-49.5
N420 G01 Z25. F500. M09
N425 G00 G90 G53 G49 H0 Z0 M05
N430 T01 M06 (6MM CRB 2FL 19 LOC)
N435 G54 G90 G94
N440 S6926 M03
N445 G90 X56.616 Y5.382
N450 G43 H01 Z-49. M08
N455 G01 Z-55. F237.5
N460 G90 G41 X58.823 Y3.176 D01 F712.5
N465 G03 X59.247 Y3. I.424 J.424

N470 G01 X59.847 F950.
N475 G02 X73.932 Y-3.792 I0 J-18.
N480 G01 X120.173 Y-61.906
N485 G02 X123. Y-70. I-10.173 J-8.094
N490 G01 Y-70.6
N495 G03 X123.176 Y-71.024 I.6 J0
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N505 G00 Z-49.
N510 G90 G54 X56.616 Y5.382
N515 Z-52.
N520 G01 Z-57.5 F237.5
N525 G90 G41 X58.823 Y3.176 D01 F712.5
N530 G03 X59.247 Y3. I.424 J.424
N535 G01 X59.847 F950.
N540 G02 X73.932 Y-3.792 I0 J-18.
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N550 G02 X123. Y-70. I-10.173 J-8.094
N555 G01 Y-70.6
N560 G03 X123.176 Y-71.024 I.6 J0
N565 G40 G01 X125.382 Y-73.23
N570 G00 Z-49.
N575 G90 G54 X56.616 Y5.382
N580 Z-54.5
N585 G01 Z-60. F237.5
N590 G90 G41 X58.823 Y3.176 D01 F712.5
N595 G03 X59.247 Y3. I.424 J.424
N600 G01 X59.847 F950.
N605 G02 X73.932 Y-3.792 I0 J-18.
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N615 G02 X123. Y-70. I-10.173 J-8.094
N620 G01 Y-70.6
N625 G03 X123.176 Y-71.024 I.6 J0
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N635 G00 Z-49.
N640 G01 Z25. F500. M09
N645 G00 G90 G53 G49 H0 Z0 M05
N650 T22 M06 (6MM CRB 2FL 19 LOC)
N655 G54 G90 G94
N660 S5500 M03
N665 G90 X1.123 Y-83.75
N670 G43 H22 Z-45.5 M08
N675 G01 Z-49.5 F237.5
N680 G02 X-3.75 Y-78.877 I8.877 J13.75 F950.
N685 G01 Z-50.964 F237.5
N690 G03 X1.123 Y-83.75 I13.75 J8.877 F950.
N695 G01 Z-52.429 F237.5
N700 G02 X-3.75 Y-78.877 I8.877 J13.75 F950.
N705 G01 Z-53.893 F237.5
N710 G03 X1.123 Y-83.75 I13.75 J8.877 F950.
N715 G01 Z-55.357 F237.5
N720 G02 X-3.75 Y-78.877 I8.877 J13.75 F950.
N725 G01 Z-56.821 F237.5
N730 G03 X1.123 Y-83.75 I13.75 J8.877 F950.
N735 G01 Z-58.286 F237.5
N740 G02 X-3.75 Y-78.877 I8.877 J13.75 F950.
N745 G01 Z-59.75 F237.5
N750 G03 X1.123 Y-83.75 I13.75 J8.877 F950.
N755 G01 Z-60. F237.5
N760 G02 X-3.75 Y-78.877 I8.877 J13.75 F950.
N765 G00 Z-45.5
N770 G90 G54 X-3.75 Y-76.508
N775 G01 Z-49.5 F237.5
N780 G03 X3.492 Y-83.75 I13.75 J6.508 F950.
N785 G01 Z-50.964 F237.5
N790 G02 X-3.75 Y-76.508 I6.508 J13.75 F950.
N795 G01 Z-52.429 F237.5
N800 G03 X3.492 Y-83.75 I13.75 J6.508 F950.
N805 G01 Z-53.893 F237.5
N810 G02 X-3.75 Y-76.508 I6.508 J13.75 F950.

N815 G01 Z-55.357 F237.5
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N825 G01 Z-56.821 F237.5
N830 G02 X-3.75 Y-76.508 I6.508 J13.75 F950.
N835 G01 Z-58.286 F237.5
N840 G03 X3.492 Y-83.75 I13.75 J6.508 F950.
N845 G01 Z-59.75 F237.5
N850 G02 X-3.75 Y-76.508 I6.508 J13.75 F950.
N855 G01 Z-60. F237.5
N860 G03 X3.492 Y-83.75 I13.75 J6.508 F950.
N865 G00 Z-45.5
N870 G90 G54 X5.942 Y-83.75
N875 G01 Z-49.5 F237.5
N880 Y-83.46 F950.
N885 G02 X-3.46 Y-74.058 I4.058 J13.46
N890 G01 X-3.75
N895 Z-50.964 F237.5
N900 X-3.46 F950.
N905 G03 X5.942 Y-83.46 I13.46 J4.058
N910 G01 Y-83.75
N915 Z-52.429 F237.5
N920 Y-83.46 F950.
N925 G02 X-3.46 Y-74.058 I4.058 J13.46
N930 G01 X-3.75
N935 Z-53.893 F237.5
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N945 G03 X5.942 Y-83.46 I13.46 J4.058
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N1010 G01 X-3.75
N1015 Z-59.75 F237.5
N1020 X-3.46 F950.
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N1035 Z-60. F237.5
N1040 Y-83.46 F950.
N1045 G02 X-3.46 Y-74.058 I4.058 J13.46
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N1065 G01 Z-49.5 F237.5
N1070 X-2.573 F950.
N1075 G03 X7.096 Y-82.573 I12.573 J2.904
N1080 G01 Y-83.75
N1085 Z-50.964 F237.5
N1090 Y-82.573 F950.
N1095 G02 X-2.573 Y-72.904 I2.904 J12.573
N1100 G01 X-3.75
N1105 Z-52.429 F237.5
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N1115 G03 X7.096 Y-82.573 I12.573 J2.904
N1120 G01 Y-83.75
N1125 Z-53.893 F237.5
N1130 Y-82.573 F950.
N1135 G02 X-2.573 Y-72.904 I2.904 J12.573
N1140 G01 X-3.75
N1145 Z-55.357 F237.5
N1150 X-2.573 F950.
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N1160 G01 Y-83.75
N1165 Z-56.821 F237.5
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N1180 G01 X-3.75
N1185 Z-58.286 F237.5
N1190 X-2.573 F950.
N1195 G03 X7.096 Y-82.573 I12.573 J2.904
N1200 G01 Y-83.75
N1205 Z-59.75 F237.5
N1210 Y-82.573 F950.
N1215 G02 X-2.573 Y-72.904 I2.904 J12.573
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N1235 G03 X7.096 Y-82.573 I12.573 J2.904
N1240 G01 Y-83.75
N1245 G00 Z-45.5
N1250 G90 G54 X8.25 Y-83.75
N1255 G01 Z-49.5 F237.5
N1260 Y-82.25 F950.

N1265 G02 X8.362 Y-81.635 I1.75 J0
N1270 X-1.635 Y-71.638 I1.638 J11.635
N1275 X-2.25 Y-71.75 I-.615 J1.638
N1280 G01 X-3.75
N1285 Z-50.964 F237.5
N1290 X-2.25 F950.
N1295 G03 X-1.635 Y-71.638 I0 J1.75
N1300 X8.362 Y-81.635 I11.635 J1.638
N1305 X8.25 Y-82.25 I1.638 J-.615
N1310 G01 Y-83.75
N1315 Z-52.429 F237.5
N1320 Y-82.25 F950.
N1325 G02 X8.362 Y-81.635 I1.75 J0
N1330 X-1.635 Y-71.638 I1.638 J11.635
N1335 X-2.25 Y-71.75 I-.615 J1.638
N1340 G01 X-3.75
N1345 Z-53.893 F237.5
N1350 X-2.25 F950.
N1355 G03 X-1.635 Y-71.638 I0 J1.75
N1360 X8.362 Y-81.635 I11.635 J1.638
N1365 X8.25 Y-82.25 I1.638 J-.615
N1370 G01 Y-83.75
N1375 Z-55.357 F237.5
N1380 Y-82.25 F950.
N1385 G02 X8.362 Y-81.635 I1.75 J0
N1390 X-1.635 Y-71.638 I1.638 J11.635
N1395 X-2.25 Y-71.75 I-.615 J1.638
N1400 G01 X-3.75
N1405 Z-56.821 F237.5
N1410 X-2.25 F950.
N1415 G03 X-1.635 Y-71.638 I0 J1.75
N1420 X8.362 Y-81.635 I11.635 J1.638
N1425 X8.25 Y-82.25 I1.638 J-.615
N1430 G01 Y-83.75
N1435 Z-58.286 F237.5
N1440 Y-82.25 F950.
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N1450 X-1.635 Y-71.638 I1.638 J11.635
N1455 X-2.25 Y-71.75 I-.615 J1.638
N1460 G01 X-3.75
N1465 Z-59.75 F237.5
N1470 X-2.25 F950.
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N1480 X8.362 Y-81.635 I11.635 J1.638
N1485 X8.25 Y-82.25 I1.638 J-.615
N1490 G01 Y-83.75
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N1500 Y-82.25 F950.
N1505 G02 X8.362 Y-81.635 I1.75 J0
N1510 X-1.635 Y-71.638 I1.638 J11.635
N1515 X-2.25 Y-71.75 I-.615 J1.638
N1520 G01 X-3.75
N1525 G00 Z-45.5
N1530 G90 G54 X8.25 Y-83.75
N1535 G01 Z-49.5 F237.5
N1540 Y-82.25 F950.
N1545 G02 X8.362 Y-81.635 I1.75 J0
N1550 X-1.635 Y-71.638 I1.638 J11.635
N1555 X-2.25 Y-71.75 I-.615 J1.638
N1560 G01 X-3.75
N1565 Z-50.964 F237.5
N1570 X-2.25 F950.
N1575 G03 X-1.635 Y-71.638 I0 J1.75
N1580 X8.362 Y-81.635 I11.635 J1.638
N1585 X8.25 Y-82.25 I1.638 J-.615
N1590 G01 Y-83.75
N1595 Z-52.429 F237.5
N1600 Y-82.25 F950.
N1605 G02 X8.362 Y-81.635 I1.75 J0
N1610 X-1.635 Y-71.638 I1.638 J11.635
N1615 X-2.25 Y-71.75 I-.615 J1.638
N1620 G01 X-3.75
N1625 Z-53.893 F237.5
N1630 X-2.25 F950.
N1635 G03 X-1.635 Y-71.638 I0 J1.75
N1640 X8.362 Y-81.635 I11.635 J1.638
N1645 X8.25 Y-82.25 I1.638 J-.615
N1650 G01 Y-83.75
N1655 Z-55.357 F237.5
N1660 Y-82.25 F950.
N1665 G02 X8.362 Y-81.635 I1.75 J0
N1670 X-1.635 Y-71.638 I1.638 J11.635

N1675 X-2.25 Y-71.75 I-.615 J1.638
N1680 G01 X-3.75
N1685 Z-56.821 F237.5
N1690 X-2.25 F950.
N1695 G03 X-1.635 Y-71.638 I0 J1.75
N1700 X8.362 Y-81.635 I11.635 J1.638
N1705 X8.25 Y-82.25 I1.638 J-.615
N1710 G01 Y-83.75
N1715 Z-58.286 F237.5
N1720 Y-82.25 F950.
N1725 G02 X8.362 Y-81.635 I1.75 J0
N1730 X-1.635 Y-71.638 I1.638 J11.635
N1735 X-2.25 Y-71.75 I-.615 J1.638
N1740 G01 X-3.75
N1745 Z-59.75 F237.5
N1750 X-2.25 F950.
N1755 G03 X-1.635 Y-71.638 I0 J1.75
N1760 X8.362 Y-81.635 I11.635 J1.638
N1765 X8.25 Y-82.25 I1.638 J-.615
N1770 G01 Y-83.75
N1775 Z-60. F237.5
N1780 Y-82.25 F950.
N1785 G02 X8.362 Y-81.635 I1.75 J0
N1790 X-1.635 Y-71.638 I1.638 J11.635
N1795 X-2.25 Y-71.75 I-.615 J1.638
N1800 G01 X-3.75
N1805 G00 Z-45.5
N1810 Z25.
N1815 G90 G54 X11.615 Y-82.691
N1820 Z-45.
N1825 G01 Z-49.5 F237.5
N1830 G90 G41 X10.512 Y-81.588 D22 F712.5
N1835 G03 X10.3 Y-81.5 I-.212 J-.212
N1840 G01 X10. F950.
N1845 G02 X-1.5 Y-70. I0 J11.5
N1850 G01 Y-69.7
N1855 G03 X-1.588 Y-69.488 I-.3 J0
N1860 G40 G01 X-2.691 Y-68.385
N1865 G00 Z-45.
N1870 G90 G54 X11.615 Y-82.691
N1875 Z-46.5
N1880 G01 Z-51. F237.5
N1885 G90 G41 X10.512 Y-81.588 D22 F712.5
N1890 G03 X10.3 Y-81.5 I-.212 J-.212
N1895 G01 X10. F950.
N1900 G02 X-1.5 Y-70. I0 J11.5
N1905 G01 Y-69.7
N1910 G03 X-1.588 Y-69.488 I-.3 J0
N1915 G40 G01 X-2.691 Y-68.385
N1920 G00 Z-45.
N1925 G90 G54 X11.615 Y-82.691
N1930 Z-48.
N1935 G01 Z-52.5 F237.5
N1940 G90 G41 X10.512 Y-81.588 D22 F712.5
N1945 G03 X10.3 Y-81.5 I-.212 J-.212
N1950 G01 X10. F950.
N1955 G02 X-1.5 Y-70. I0 J11.5
N1960 G01 Y-69.7
N1965 G03 X-1.588 Y-69.488 I-.3 J0
N1970 G40 G01 X-2.691 Y-68.385
N1975 G00 Z-45.
N1980 G90 G54 X11.615 Y-82.691
N1985 Z-49.5
N1990 G01 Z-54. F237.5
N1995 G90 G41 X10.512 Y-81.588 D22 F712.5
N2000 G03 X10.3 Y-81.5 I-.212 J-.212
N2005 G01 X10. F950.
N2010 G02 X-1.5 Y-70. I0 J11.5
N2015 G01 Y-69.7
N2020 G03 X-1.588 Y-69.488 I-.3 J0
N2025 G40 G01 X-2.691 Y-68.385
N2030 G00 Z-45.
N2035 G90 G54 X11.615 Y-82.691
N2040 Z-51.
N2045 G01 Z-55.5 F237.5
N2050 G90 G41 X10.512 Y-81.588 D22 F712.5
N2055 G03 X10.3 Y-81.5 I-.212 J-.212
N2060 G01 X10. F950.
N2065 G02 X-1.5 Y-70. I0 J11.5
N2070 G01 Y-69.7

N2075 G03 X-1.588 Y-69.488 I-.3 J0
N2080 G40 G01 X-2.691 Y-68.385
N2085 G00 Z-45.
N2090 G90 G54 X11.615 Y-82.691
N2095 Z-52.5
N2100 G01 Z-57. F237.5
N2105 G90 G41 X10.512 Y-81.588 D22 F712.5
N2110 G03 X10.3 Y-81.5 I-.212 J-.212
N2115 G01 X10. F950.
N2120 G02 X-1.5 Y-70. I0 J11.5
N2125 G01 Y-69.7
N2130 G03 X-1.588 Y-69.488 I-.3 J0
N2135 G40 G01 X-2.691 Y-68.385
N2140 G00 Z-45.
N2145 G90 G54 X11.615 Y-82.691
N2150 Z-54.
N2155 G01 Z-58.5 F237.5
N2160 G90 G41 X10.512 Y-81.588 D22 F712.5
N2165 G03 X10.3 Y-81.5 I-.212 J-.212
N2170 G01 X10. F950.
N2175 G02 X-1.5 Y-70. I0 J11.5
N2180 G01 Y-69.7
N2185 G03 X-1.588 Y-69.488 I-.3 J0
N2190 G40 G01 X-2.691 Y-68.385
N2195 G00 Z-45.
N2200 G90 G54 X11.615 Y-82.691
N2205 Z-55.5
N2210 G01 Z-60. F237.5
N2215 G90 G41 X10.512 Y-81.588 D22 F712.5
N2220 G03 X10.3 Y-81.5 I-.212 J-.212
N2225 G01 X10. F950.
N2230 G02 X-1.5 Y-70. I0 J11.5
N2235 G01 Y-69.7
N2240 G03 X-1.588 Y-69.488 I-.3 J0
N2245 G40 G01 X-2.691 Y-68.385
N2250 G00 Z-45.
N2255 G01 Z25. F500. M09
N2260 G00 G90 G53 G49 H0 Z0 M05
N2265 T20 M06 (6MM CRB 2FL 19 LOC)
N2270 G54 G90 G94
N2275 S8500 M03
N2280 G90 X56.223 Y-14.5
N2285 G43 H20 Z-49.5 M08
N2290 G01 Z-56. F237.5
N2295 Y-15. F950.
N2300 G03 X57.973 Y-16.75 I1.75 J0
N2305 G01 X61.973
N2310 G03 X63.723 Y-15. I0 J1.75
N2315 G01 Y-14.5
N2320 G03 X61.973 Y-12.75 I-1.75 J0
N2325 G01 X57.973
N2330 G03 X56.223 Y-14.5 I0 J-1.75
N2335 G01 Y-15.
N2340 G03 X57.973 Y-16.75 I1.75 J0
N2345 G01 X61.973
N2350 G03 X63.723 Y-15. I0 J1.75
N2355 G01 Y-14.5
N2360 G03 X61.973 Y-12.75 I-1.75 J0
N2365 G01 X57.973
N2370 G03 X56.223 Y-14.5 I0 J-1.75
N2375 G00 Z-49.5
N2380 Z-53.5
N2385 G01 Z-59.75 F237.5
N2390 Y-15. F950.
N2395 G03 X57.973 Y-16.75 I1.75 J0
N2400 G01 X61.973
N2405 G03 X63.723 Y-15. I0 J1.75
N2410 G01 Y-14.5
N2415 G03 X61.973 Y-12.75 I-1.75 J0
N2420 G01 X57.973
N2425 G03 X56.223 Y-14.5 I0 J-1.75
N2430 G01 Y-15.
N2435 G03 X57.973 Y-16.75 I1.75 J0
N2440 G01 X61.973
N2445 G03 X63.723 Y-15. I0 J1.75
N2450 G01 Y-14.5
N2455 G03 X61.973 Y-12.75 I-1.75 J0
N2460 G01 X57.973
N2465 G03 X56.223 Y-14.5 I0 J-1.75
N2470 G00 Z-49.5
N2475 Z-57.25
N2480 G01 Z-60. F237.5

N2485 Y-15. F950.
N2490 G03 X57.973 Y-16.75 I1.75 J0
N2495 G01 X61.973
N2500 G03 X63.723 Y-15. I0 J1.75
N2505 G01 Y-14.5
N2510 G03 X61.973 Y-12.75 I-1.75 J0
N2515 G01 X57.973
N2520 G03 X56.223 Y-14.5 I0 J-1.75
N2525 G01 Y-15.
N2530 G03 X57.973 Y-16.75 I1.75 J0
N2535 G01 X61.973
N2540 G03 X63.723 Y-15. I0 J1.75
N2545 G01 Y-14.5
N2550 G03 X61.973 Y-12.75 I-1.75 J0
N2555 G01 X57.973
N2560 G03 X56.223 Y-14.5 I0 J-1.75
N2565 G00 Z-49.5
N2570 G01 Z25. F500. M09
N2575 G00 G90 G53 G49 H0 Z0 M05
N2580 T02 M06 (10MM CRB 2FL 22 LOC)
N2585 G54 G90 G94
N2590 S7868 M03
N2595 G90 X62.387
N2600 G43 H02 Z-49. M08
N2605 G01 Z-57. F219.843
N2610 G90 G41 X61.68 Y-13.793 D02 F659.529
N2615 G03 X60.973 Y-13.5 I-.707 J-.707
N2620 G01 X57.973 F879.371
N2625 G03 X56.973 Y-14.5 I0 J-1.
N2630 G01 Y-15.
N2635 G03 X57.973 Y-16. I1. J0
N2640 G01 X61.973
N2645 G03 X62.973 Y-15. I0 J1.
N2650 G01 Y-14.5
N2655 G03 X61.973 Y-13.5 I-1. J0
N2660 G01 X58.973
N2665 G03 X58.265 Y-13.793 I0 J-1.
N2670 G40 G01 X57.558 Y-14.5
N2675 G00 Z-49.
N2680 G90 G54 X62.387 Y-14.5
N2685 Z-54.
N2690 G01 Z-60. F219.843
N2695 G90 G41 X61.68 Y-13.793 D02 F659.529
N2700 G03 X60.973 Y-13.5 I-.707 J-.707
N2705 G01 X57.973 F879.371
N2710 G03 X56.973 Y-14.5 I0 J-1.
N2715 G01 Y-15.
N2720 G03 X57.973 Y-16. I1. J0
N2725 G01 X61.973
N2730 G03 X62.973 Y-15. I0 J1.
N2735 G01 Y-14.5
N2740 G03 X61.973 Y-13.5 I-1. J0
N2745 G01 X58.973
N2750 G03 X58.265 Y-13.793 I0 J-1.
N2755 G40 G01 X57.558 Y-14.5
N2760 G00 Z-49.
N2765 G01 Z25. F500. M09
N2770 G00 G90 G53 G49 H0 Z0 M05
N2775 T06 M06 (6MM X 60DEG HSS CENTERDRILL)
N2780 G54 G90 G94
N2785 S9605 M03
N2790 G90 X-83.642 Y37.
N2795 G43 H06 Z105. M08
N2800 G98 G82 Z76.701 R83. P00 F829.493
N2805 X-36.142 Y24.
N2810 G80
N2815 G01 Z105. F1000. M09
N2820 G00 G90 G53 G49 H0 Z0 M05
N2825 T14 M06 (4.0mm JOBBER DRILL)
N2830 G54 G90 G94
N2835 S10389 M03
N2840 G90 X-83.642 Y37.
N2845 G43 H14 Z105. M08
N2850 G98 G83 Z75. Q2. R83. F950.
N2855 X-36.142 Y24.
N2860 G80
N2865 G01 Z105. F1000. M09
N2870 G00 G90 G53 G49 H0 Z0 M05

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N2875 T15 M06 (10MM X 90DEG CRB SPOT DRILL)
N2880 G54 G90 G94
N2885 S5500 M03
N2890 G90 X-83.642 Y48.
N2895 G43 H15 Z105. M08
N2900 G98 G82 Z77.3 R83. P00 F950.
N2905 Y13.
N2910 X-36.142
N2915 Y48.
N2920 G80
N2925 G01 Z105. F1000. M09
N2930 G00 G90 G53 G49 H0 Z0 M05
N2935 T16 M06 (6.0mm JOBBER DRILL)
N2940 G54 G90 G94
N2945 S10389 M03
N2950 G90 X-83.642
N2955 G43 H16 Z105. M08
N2960 G98 G83 Z75. Q2. R83. F950.
N2965 Y13.
N2970 X-36.142
N2975 Y48.
N2980 G80
N2985 G01 Z105. F1000. M09
N2990 G00 G90 G53 G49 H0 Z0 M05
N2995 G54 X0 Y0
N3000 M30
%
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