CZĘSTOCHOWA,9 SEPTEMBER 2015

TECHNICAL AND OPERATING DOCUMENTATION

BPF 1731 Industrial Plotter

PRODUCER:

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CONTENTS:

1. Introduction

BPF machines are designed for processing materials using the cutting method based on computer-controlled tool paths. The materials used to construct our machines are of the highest quality, which ensures stability of parameters and trouble-free operation of the machine for many years

Warning:

Before you start using the machine, read carefully this technical documentation. In case of doubt, please contact the manufacturer for further clarification. The guidelines on how to use will help to reduce the risk of failure and to avoid the costs resulting from the improper use of the device.

The terms Windows XP, Windows Embedded, Pentium are registered trademarks not owned by the manufacturer of the machine. They have been used in the user guide for information purposes only.

BPF machines are controlled with a PC that is running Windows XP or Windows Embedded. The Software is not tested and may not work on other operating systems.

Control computer requirements:

- Processor 1 GHz, x86 or x64
- 1 GB (x86) or 2 GB (x64) RAM
- 50 MB free space on the hard disk for the program files,
- Graphics card and colour monitor with a resolution of 1024/768
- Free LAN socket

Recommended requirements for the control computer

- Processor 2 GHz, x86 or x64
- 2 GB RAM
- 50 MB free space on the hard disk for the program files,
- Graphics card and colour monitor with a resolution of 1440/900
- Free LAN socket

Note !!!

Although at a minimum configuration the work of the control program PC CAM is possible, the recommended configuration will provide a convenient and efficient operation of the machine. When using large G-Code files (for sizes bigger than 30 MB), the computer must be equipped with adequate main memory (RAM). It is assumed that 256MB RAM is enough to run the Windows environment and the program. To load large files it is necessary to add the amount of memory that is equal to twice the size of the file.

Requirements for power and compressed air connections:

Power:

- ⅄ Three-phase and five-pin socket for 32A plug with a neutral and grounding wire connected according to standard
- ⅄ Suggested protection for the machine socket: C25 fuse

Compressed ait:

- ⅄ Cable with a 1 / 4 "AG - 26KAAW13MPX quick coupler G or a compatible one
- ⅄ Cross section of cables powered by air should be large enough that the pressure indicated on the manometer was never below 8 bar at the main connection
- ⅄ The dew point of the compressed air should be a maximum of 3 degrees Celsius, and the size of particles should not exceed 2μm (the need to use a dryer and filters)
- ⅄ The dehydrator installed in the machine does not protect it from the consequences of the appearance of water in the compressed air system. Not complying with the above instructions may result in damage to the machine, in particular spindles, bearings and solenoids, and will void your warranty.

2. Transportation and storage of the machine

2.1. The terms of the storage

BPF machines should be stored at 5° to 40°C, with humidity below 90%.

2.2. Dimensions and weight
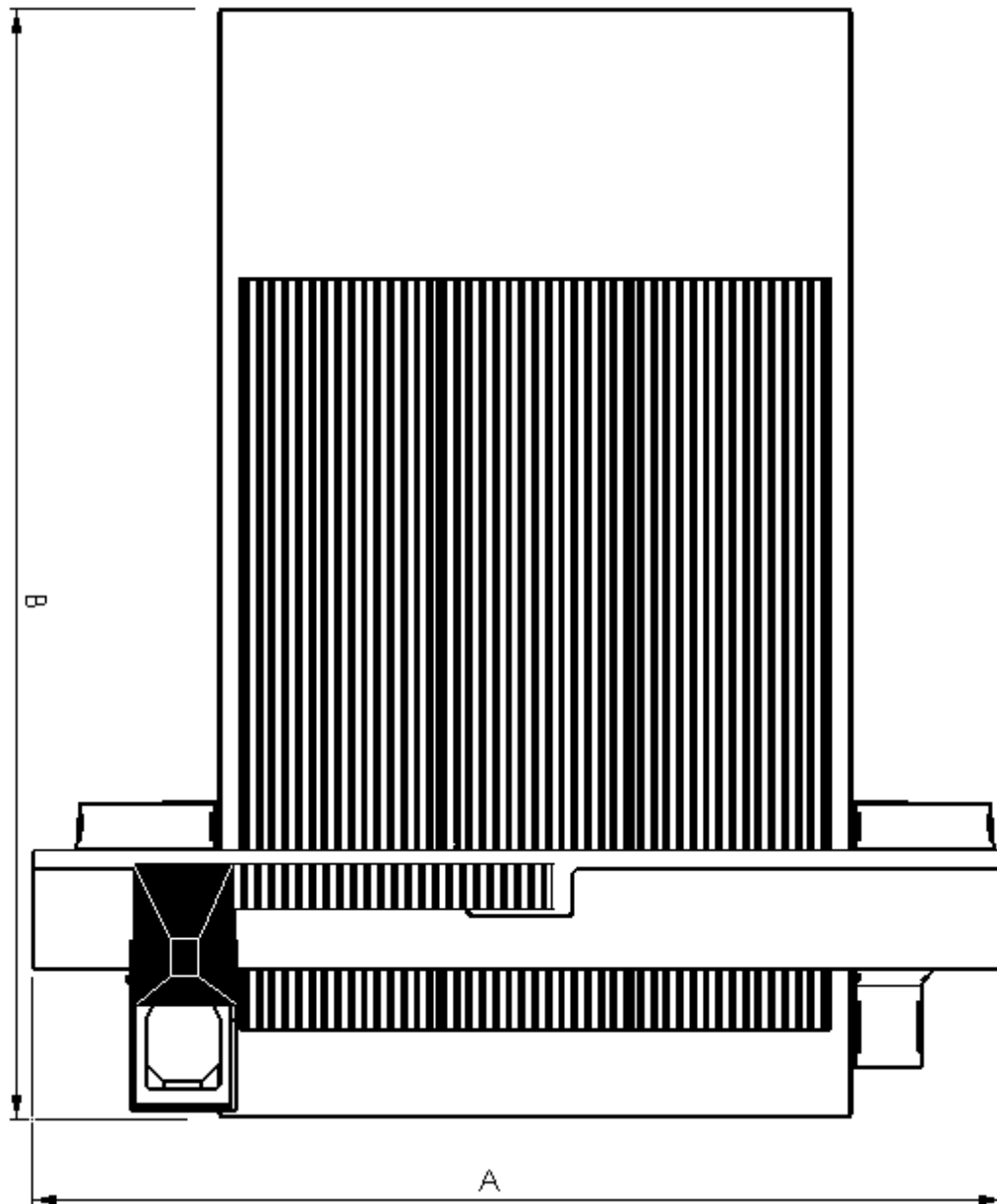
Figure 1: BPF machine - top view
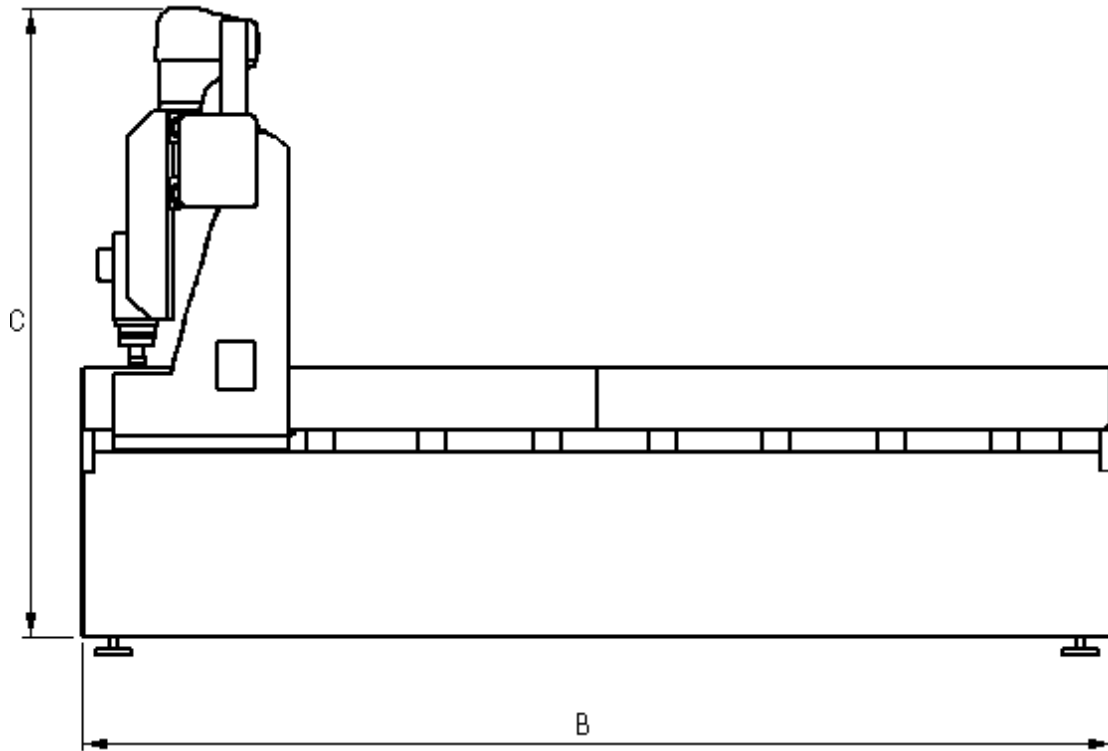
Figure 2: BPF machine - side view
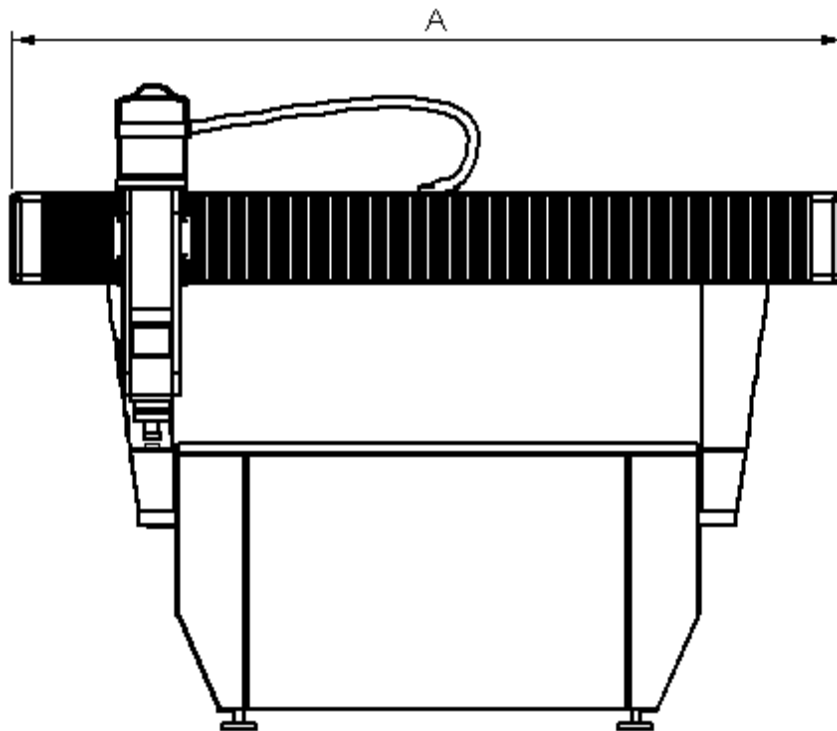
Figure 3: BPF machine - front view

BPF machine model	Movement area [mm]			Dimensions for the transport			Weight [kg]
	X	Y	Z	A	B	C	
1015	1000	1500	200	2000	2500	2000	1300
1015	1000	1500	300	2000	2500	2000	1300
1020	1000	2000	260	2000	3000	2000	1200
1020	1000	2000	300	2000	3000	2000	1200
1025	1000	2500	300	2000	3500	2100	1300
1060	1000	6000	500	2000	7000	2300	4500
1121	1100	2100	300	2100	3100	2100	1400
1222	1200	2200	200	2200	3200	2000	1400
1315	1300	1500	300	2300	2500	2000	1300
1315	1300	1500	300	2300	2500	2000	1700
1320	1300	2000	200	2300	3000	2100	1700
1325	1300	2500	200	2300	3500	2000	1300
1515	1500	1500	200	2500	2500	2000	1200
1515	1500	1500	600	2500	2500	2400	1300
1520	1500	2000	200	2500	3000	2000	1300
1520	1500	2000	260	2500	3000	2000	1500
1522	1500	2200	300	2500	3200	2100	1800
1525	1500	2500	500	2500	3500	2300	1400
1530	1500	3000	200	2500	4000	2000	1600
1531	1500	3100	400	2500	4100	2300	2000
1620	1600	2000	300	2600	3000	2200	1400
1625	1600	2500	200	2600	3500	2000	1600
1630	1600	3000	300	2600	4000	2000	2000
1630	1600	3000	350	2600	4000	2300	2000
1632	1600	3200	200	2600	4200	2000	1500
1725	1700	2500	200	2700	3500	2000	1300
2020	2000	2000	900	3000	3000	2900	3300
2030	2000	3000	200	3000	4000	2000	1200
2030	2000	3000	400	3000	4000	2300	2000
2030	2000	3000	500	3000	4000	2300	1800
2030	2000	3000	500	3000	4000	2300	1800
2030	2000	3000	700	3000	4000	2500	2000
2129	2100	2900	200	3100	3900	2000	1300
2131	2100	3100	300	3100	4100	2200	2000
2131	2100	3100	400	3100	4100	2300	1300
2131	2100	3100	500	3100	4100	2300	2000
2140	2100	4000	300	3100	5000	2100	3000
2230	2200	3000	200	3200	4000	2000	2000
2640	2600	4000	700	3600	5000	2600	2000

Table 1: Approximate weight and dimensions for the transport of selected machines of BPF series

Note !!!

Weight and dimensions may be changed depending on the equipment of the machine. Please contact us before ordering transportation

2.3. Transportation of the machine

- Due to the movable Y axis gate and the Z axis slide which moves along the X axis it is not possible to define precisely the centre of gravity.

- It is prohibited to move the machine without disconnecting it from the mains and to power it by compressed air.

- Before you start moving the machine it is recommended to place the Z axis in the extreme lower position..

- When transporting the machine it is required for all driving elements to be immobilized (e.g. tightening belts). In particular it applies to the movable Y-axis gate and the Z-axis slide moving along the Z-axis. The X-axis itself is secured by a mechanical lock preventing the movement of the machine without connection to the mains.

- The machine must be lifted by a forklift truck with a lifting capacity adjusted to the weight of the machine ensuring that the forks are put forward at least 10 cm from the opposite side of the machine.

- In the case when the machine is to be transported over greater distances the correct attachment of the machine on the means of transport must be ensured. It is recommended to apply four tightening belts (with the strength adequate to the mass of the machine), one belt for extreme feet of the machine. Particular attention should be paid to the correct mounting of fasteners to the feet of the machine (e.g. use washers on the screws of the machine feet).

- Do not mount the machine to the ground with belts through the working table

- Belts covering the working table can be used only to secure the tarpaulin protecting the table, and the belt tension strength should not exceed 20 kg.

2.5. Setting the machine, operator's working position
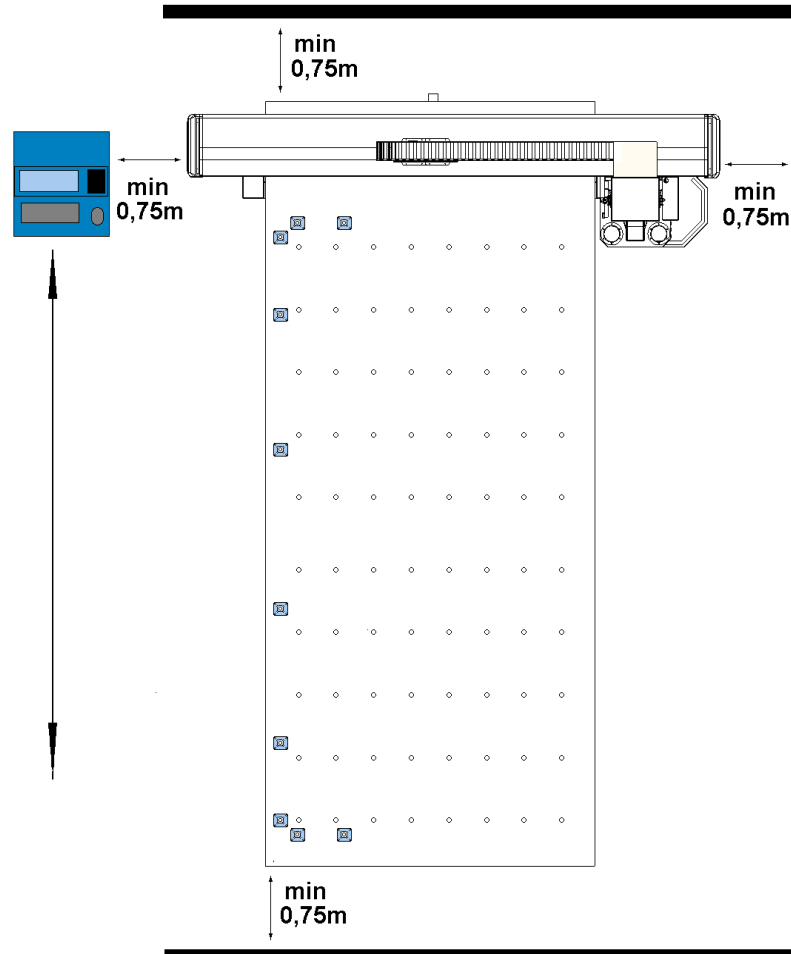
The operator's work-place is located at the control cabinet attached to the machine.

The control cabinet is connected to the machine with a cable enabling its mobility. It should be ensured that the cabinet and the operator's work-place are moved away from the most protruding parts of the machine (in particular the movable Y-axis gate) of at least 0.75 m. It is unacceptable to set the control cabinet in such a way that the operator is turned back to the machine. When setting the machine, it is essential to remember to leave the space (minimum 0.75 m) between the most protruding parts of the machine (in particular the movable Y-axis gate) and the wall (or other obstacle).

Note !!!

The figure above shows the area covering 75 cm from the most protruding parts of the machine (in particular from the movable Y-axis gate). It is a dangerous zone. The operator or any other persons are not allowed to remain in this zone during operation. Failure to this condition by the user releases the manufacturer from liability resulting from the declared conformity of machinery with the essential requirements.

In a situation when a user will be setting the machine in publicly available places, the manufacturer may provide elements protecting the danger zone on request.

3. Startup of the machine

3.1. Technical data of the machine

Technical data concerning a particular type of the machine are contained in Appendix B "Technical parameters of the machine" of this manual.

3.2. Working environment terms

- ⌃ Ambient temperature - 15-35 º C.
- ⌃ Humidity - less than 80%.
- ⌃ Required space around the machine - at least 0.75 m from the most protruding parts of the machine (movable Y-axis gate).
- ⌃ Compressed air with pressure of minimum 8 bar should be supplied to the machine. The quality of the feeding air must correspond to standards relating to industrial installations of compressed air feeding. In particular it applies to solids and condensed water impurities. The dew point of the compressed air should not exceed 3 degrees Celsius, and the size of particles should not exceed 2um (the need to use the dryer, and filters).
- ⌃ The machine does not require additional lighting. In the room in which it will be used the light of normal intensity will be sufficient enough.

Note !!!

The dehydrator installed in the machine does not protect it against the appearance of water in the compressed air installation. Not complying with the above recommendations may result in damage to the machine, in particular to bearings, spindles and solenoids, and will void your warranty.

- ⌃ The machine should stand on a flat surface and before the launch of the machine it must be leveled by screwing or unscrewing the screws on which the feet of the machine are embedded. Then this setting should be blocked by tightening lock nuts on these screws. The machine must be leveled after each shifting.
- ⌃ The cross section of air feeding cables should be large enough that the pressure indicated on the manometer at the main reduction valve, was never below 8 bars, which should be checked primarily during automatic tool change.
- ⌃ The power socket for a three-phase machine must have a neutral and grounding wire connected according to standard. Do not connect the machine to a four-wire network. Current plug of the machine: 32A. Do not use smaller plugs. The suggested fuse for the socket of the machines: C25.
- ⌃ If the machine has a vacuum table and a vacuum pump is attached to the machine, then the pump should be connected to a separate socket with a five-pin 32A plug.

WARNING! Make sure that the direction of rotation is consistent with the designation.

DO NOT! start the pump on the "left-hand" rotations for longer than 20 seconds. Otherwise, you may damage the pump. If necessary, reverse the order of phases in the plug - it should be done by a qualified electrician. The current plug - 32A. Do not use smaller plugs! The suggested fuse to the vacuum pump socket with a capacity of 250m3/h - C40.

3.3. Assembly

BPF machines are fully prepared to work and require only a connection with the control computer with the software installed and connections to the mains and to the compressed air.

3.4. Preparing the PC to control the machine via Ethernet

Internet Protocol (TCP/IP) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically

● Use the following IP address:

IP address:	10 . 251 . 1 . 1
Subnet mask:	255 . 0 . 0 . 0
Default gateway:	. . .

○ Obtain DNS server address automatically

● Use the following DNS server addresses:

| Preferred DNS server: | . . . |
| Alternate DNS server: | . . . |

Advanced...

OK   Cancel

We connect the machine to the network card in the computer. Do not extend the cable through Hub / Switch type devices and do not connect the machine to the LAN. We do not recommend the use of wireless network cards. You must set the computer IP address to the address of the 10.251.xx group, where x is any number 0-255, with the exception of addresses of the PLC module and the sockets of individual axes of the machine driver (Fig. 9). The subnet mask should be set to the address 255.0.0.0. After setting the IP address you may need to reset the computer.

After starting your computer, you have to upload the control software supplied by the manufacturer on the hard disk. Note that the program requires full access to reading and writing files. If necessary, the files attribute "Read Only" should be deleted. In case of delivering a CD with the installer, you must install the program.

3.5. Information on the machine

3.5.1. Destination of the machine

⚓ milling with a ballnose cutter (injection moulds, press tools, dies made of steel or aluminum, treatment of cast models for thermoforming, treatment of forging dies)

⚓ cutting,

⚓ engraving,

⚓ cutting textile materials, materials for seals, rubber, cardboard ... etc. (machine with an oscillating knife attached)

⚓ creasing (machine with an oscillating knife and a creasing wheel attached)

⚓ scanning (machine with a touch or optical scanner)

3.5.2. Ranges of motion of the machine

The specified ranges of the machine indicate its extreme position on a given axis, which is not synonymous with the possibility of processing the material of these overall dimensions. The maximum thickness and size that it is possible to machine

3.5.3. Connecting

We connect the plug to the driver according to the scheme of the electrical documentation. We connect the computer to the machine driver with the Ethernet cable (the machine without a control cabinet). We check the condition of the machine. In case of necessity, we have to clean and lubricate the machine, according to the recommendations contained in the chapter "Maintenance Recommendations." We check whether the emergency stop switch is not pressed. We check whether the emergency stop switch is not pressed. We connect power to the machine and the computer control. The power supply socket must be equipped with a ground wire. The computer and the machine are powered with a single phase. We start the machine by the main switch. We start the computer and the control program. It is important to remember about the necessity of the initialization of the machine and the procedure of the exchange of tools. The machine should be operated only by trained personnel. In case of ambiguity or uncertainty concerning the operation, please contact the manufacturer. Description of the control program is contained in the section "Description of the program."

3.5.4. Main panel

The main panel is located on the control panel on the right side of the monitor. The button of emergency stop of the machine is located in the upper part. Next to it is located vacuum gauge (optional). Below this button may be located the following switches depending on the equipment:

⤷ Cooling - (option) with oil mist (or with air when oil tank is empty)

> "0" – switched off
>
> "1" – always switched on
>
> "Auto" – turned on during operation of the spindle

⤷ Lift guard - (option) controls

> "0" – guard position controlled by program
>
> "1" – guard lifted

⤷ Base(Basis) - (optional) extends the dowel pins on the machine only when the machine is not working

> "0" - pins hidden
>
> "1" - pins protruding

⤷ "START" - starts the execution of the currently selected step. Pressing the "STOP" button will start work from the beginning of the vector on which the operation has been stopped.

⤷ "STOP" - stops execution of the project (the machine stops and turns off the rotations when the disc cutter option is not selected, raises the Z axis to the lift height), the button does not cut the power.
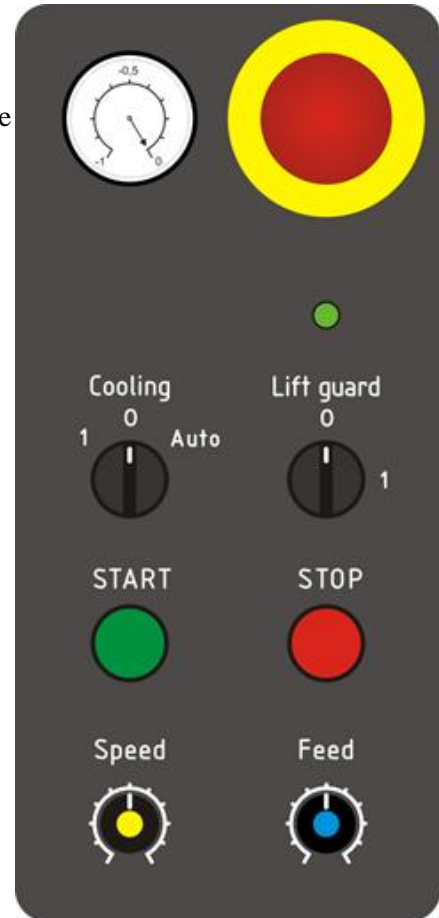
Figure 4:Sample main panel

Below there are the buttons "START" and "STOP" and potentiometers of the feed and rotation of the spindle. They are active when we open the main program window: control panel (see chap.5). The buttons are similar to those in the program and can be used interchangeably.

Potentiometers on the main panel take precedence over the program and allow you to smoothly adjust the speed of work (in the range from zero to the values given in a stage as operating speed) and the spindle speed (in the range from the minimum spindle speed to the value specified in a given stage as the spindle speed).

On the main panel there is also a green LED indicating a power connection to the machine. When turn on the main power switch located on the right side of the control cabinet and the LED is off, it means that one or more emergency stop buttons are pressed

3.5.5. Construction of the BPF machine
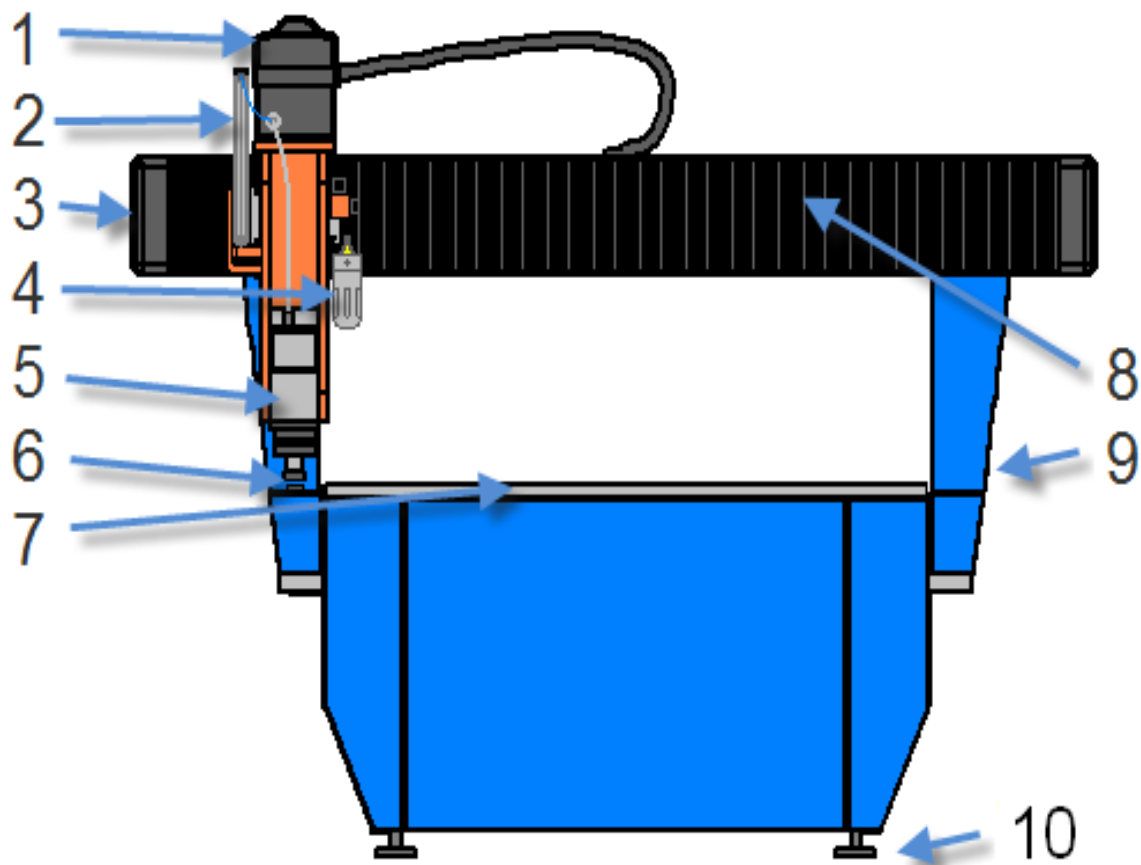
Firure 1 BPF type machine

1. Cover allowing access to the motor of the Z-axis

2. Pneumatic servo-motor balancing the weight of the Z axis during operation

3. Cover allowing access to the engine and the X-axis gear

4. Oil tank and the regulator of oil mist cooling mechanism (optional)

5. Spindle

6. Sensor of the tool length

7. Working table

8. Accordion type cover protecting mechanisms against dirt

9. Y-axis movable gate

10. Foot

3.5.6. Noise level

Taking into account the location of the working position and the analysis of noise sources in the machine, the intensity of noise is dependent on operating conditions and the tools applied.

During tests carried out at the manufacturer the noise level did not exceed 70 dB.

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4. Operation of the machine

4.1. Description of meanings of pictograms placed on the machine

	Before you begin working read the instructions.
	Protect your ears.
	Protect your eyes.
	Caution, a loud noise and flying chips, protect your ears and eyes.
	Caution, circular saw! Be careful!
	Caution, rapidly rotating elements cay seriously injure. Be careful!
	Caution, oscillating blade cay seriously injure! Be careful!
	Caution, hazardous voltage!
	Caution, moving parts of the machine can cut off fingers! Be careful!
	Caution, the moving parts of machines can hit from the left (right). Be careful!
	Danger of crushing a hand from above.

Danger of crushing a hand from the left (right).

4.2. Tools applied

Note !!!

Use only the monolithic tools with a diameter of 8mm. The operator must wear protective clothing and eye protection, as in the case of chipping protective clothing and eye shield is sufficient protection for the operator.

Note !!!

If you want to use a brazed cutters or tools with diameter greater than 8 mm in the case of a machine without guards, you must install guards or protective cab on your own. It must protect the operator against possible damage to the tool.

Tools should be designed to work with the spindle speed, i.e. 24,000 or 50,000 rpm.

Follow the recommendations of the manufacturer of tools concerning the rotational speed and cutting speed. The gripping part of the tool should be in the shape of a cylinder and the diameter of collets mounting the cutter must be closely aligned to the gripping part of the tool.

4.3. REGO-FIX Assembly instructions for REGO-FIX collets and tools

Note !!!

Steps should be performed in the order presented, which guarantees the correct and safe operation. All parts should be clean, free from chips and other dirt. If necessary, clean the dirty items (e.g. with compressed air).

1. First, we insert the collet into the nut as shown in the figure below.
   (1) We find the notch on the upper surface.
   (1) It indicates a place where we should hook the collet tooth on the nut tooth.
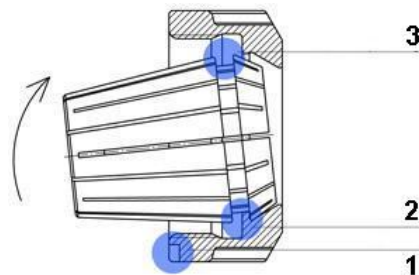   (2) We press the collet to the nut until it snaps on the tooth on the opposite side.

Firure 5: The way of inserting the collet into the nut

2. Then we gently twist the collet on the spindle or the cone, so that the insertion of the tool was still possible. Remember to use the appropriate size of the collets to the size of the tool.
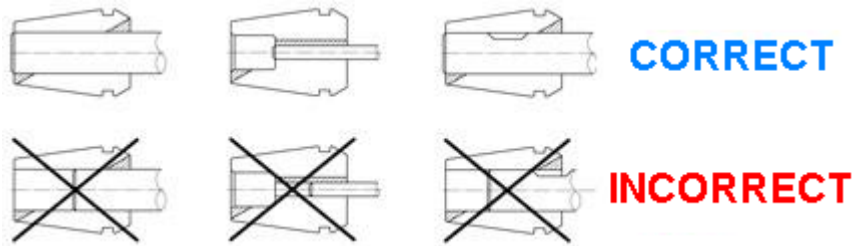

Figure 7: Mounting tool in the collet

3. Insert the tool into the collet and tighten it firmly. Be careful that the cutter was inserted in the collet as far as the gripping part of the collet allows it. If the cutter has a notch, it should be completely hidden in the collet (see the figure above).
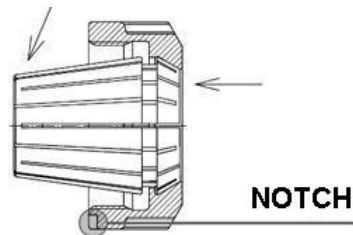
Figure 6: Removing the collet from the nut

4. After work, first, we unscrew the nut gently and remove the tool.. Next we unscrew the nut from the collet completely and slightly pushing the collet toward the notch on the nut, we separate both parts. If it is necessary, we clean them with compressed air, wipe them dry, then protect against corrosion. For the separation of the collet and the nut you cannot use tools that can damage ground surfaces or threads. It is forbidden to use a damaged collet. Failure to do so can result in death or damage to health or\and the destruction of the spindle, the machine, or the material.

4.3.1. HSK cones
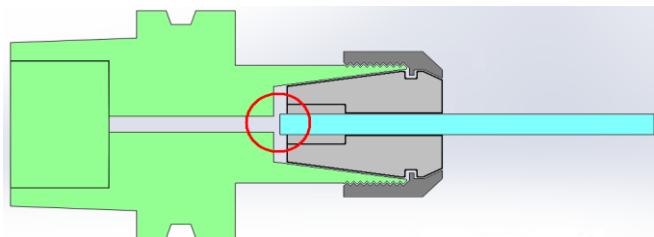
Figure 8: HSK 25E Cone - correct attachment of the cutter

In case of the machine equipped with a spindle with a HSK chuck, you must remember not to feed the tool to the end during fixing the tool in the tool cone, because it will clog the through-hole of the cone and it may cause problems with the replacement of the cone. The cone can be tightened incorrectly and/or problems may occur with replacing the cone to the tool storage. This can result in damage to the spindle and/or to the tool storage.

4.4. Special safety recommendations

4.4.1. Tool storage – safe operating

The machine can be equipped with a tool storage with a capacity specified in Appendix C.

Storage is operated automatically.

To insert the tool in the tool storage:

1. We check if the machine is connected to the electrical and pneumatic installation and we make sure that the pressure on the main gauge positioned on the right side of the machine is appropriate (8 bar).

2. We run the machine and the control program.

3. We connect with the machine by pressing F1 or clicking the icon

4. We initialize the machine.

5. We click the storage opening button to check the availability of sockets

6. We click on "Measure, change" - the machine drives up to the lower left corner of the working table

7. We make sure that the spindle is stopped

8. If there is a cone in the spindle, we grasp it taking care not to injure ourselves with the installed tool; we press the tool exchange button holding the other hand on the cone all the time; we remove the cone and insert it properly; we release the tool exchange button and then we check if the cone has been properly clamped.

9. The cone has been properly tightened; the cone and the tool are aligned with the central axis of the spindle; a window appears on the computer screen.

10. If the tool is properly gripped, we choose the empty port number in the storage and we click "ok"; the machine will measure the tool

11. We click "RETURN" and the machine opens the cover of the tool storage and puts the tool aside.

To take a tool from the tool storage:

1. We click on the tool number we want to take

2. If the machine has a cone fixed on the spindle, it will automatically put it in the place and will take the tool from the tool storage.

3. If there is no such a socket under that number in the tool storage, the machine will report an error. Please let it continue the motion or remove the spindle independently from the storage area. Slow feed or step operation are recommended.

To take the tool out from the magazine:

1. If the machine is not turned on and uninitialized, we repeat steps 1-6.

2. We click the tool number which we want to take.

3. The automatic tool change will take place.

4. Then we click on "Measure, change". The machine drives up to the left front edge of the table.

5. We check whether the spindle is not turning and we take care so as not to injure ourselves with the tool.

6. While holding the tool in the right hand, we click the button under the strip cover with your left hand.

7. We take out the cone and release the button.

8. The program signals the lack of the tool.

9. We click "Cancel".

Note !!!

You must not manipulate with the tool storage in a way different than the described one. In particular it is forbidden to place and remove tools manually into and from the tool storage even if the machine is unplugged from the electrical and pneumatic installation.

Note !!!

Angular aggregates (optional) should be placed (put aside) only in the selected seatings.

Placing the aggregate in another seat can cause a collision while putting tools into adjacent seatings.

4.4.2. Procedure in case of typical hazards

If as a result of improper fixing the material on the table it leaps up or move during operation, you must:

1. stop the operation immediately with the STOP button (or emergency button) on the main panel of the machine,
2. go with the Z-axis maximally up and with the Y-axis maximally backward so that the working table was available in the point of attachment of the material (if the machine is stopped, the emergency button should be released to restore the communication with the machine by turning off and on the control panel to initialize the machine again),
3. turn the potentiometer of operating speed to minimum (0%) and turn off the machine control panel in the program,
4. evaluate damage to the material,
5. if the material is suitable for further processing, the attachment must be corrected (if it is a machine with an underpressure pump or a vacuum pump, make sure that the area bounded by seals is suitable for the processed material),
6. evaluate the state of the cutting tool and if necessary, exchange the tool - you must not work with a damaged tool,
7. turn on the control panel to initialize the machine and measure the tool,
8. if necessary, set the basing point of the project again
9. after following the above, you can start work safely

If the cutting tool or the drill is damaged (e.g. broken) during operation, you must:

1. stop the operation immediately with the STOP button (or the emergency button) on the main panel of the machine,
2. go with the Z-axis maximally up and with the Y-axis maximally backward so that the working table was available in the point of attachment of the material (if the machine is stopped, the emergency button should be released to restore the communication with the machine by turning off and on the control panel to initialize the machine again),
3. turn the potentiometer of operating speed to minimum (0%) and turn off the machine control panel in the program,
4. evaluate damage to the material, check if there are any parts of the tool in the material processed, if there are any, you must remove them before you start work again,
5. turn on the control panel and click the "Mwasure, change" button,
6. approach to the machine and remove the cone grabbing it and being careful not to hurt yourself with the fitted tool; holding your hand on the cone all the time, press the tool change button and remove it (if the machine does not have the automatic tool change system, use the keys attached to the machine to unscrew the nut and remove the tool from the collet),
7. change the tool
8. place the cone in the spindle holding the tool exchange button,
9. give the number of the tool and click "OK", the machine will automatically take measurements,
10. if you find that the material has been damaged in the way that prevents further processing or has been moved in the fixing, stop the execution of the running stage, fix the new material and start the operation from the first stage, otherwise we can continue operating by pressing the "START" button on the main panel or the "Continue" on the control panel of the PC-CAM program;
11. If a new tool is also damaged by doing a particular stage, you should assume that processing parameters are inadequate to the tool applied and/or to the processed material; they must be adjusted before restarting work (e.g. reducing operating speed or plunge cutting speed, or by increasing the number of stages of the plunge cutting)

4.5. General principles of the Health and Safety at Work

- It is forbidden to operate the machine by people without training conducted by the manufacturer.
- It is forbidden to operate the machine in gloves.
- Work in the buttoned clothes with narrow cuffs.

- Work with hair pinned.

- It is forbidden to operate the machine under the influence of alcohol, drugs or medicines that affect your ability to drive/use machines.

- Children must not approach to the machine.

- It is forbidden to leave the machine working without supervision.

- It is forbidden to work without protective glasses and without headphones or stoppers to protect against noise.

- In the case of processing hazardous materials or causing excessive dust, operators of the machine should adequately protect the respiratory system (such as a mask with the corresponding absorber).

- During operation of the machine keep your hands away from the rotating tool.

4.6. Prohibited methods of use

- **The figure in the chapter "Setting the machine, operator's working position" shows the area covering 75 cm from the most protruding parts of the machine (in particular from the movable Y axis gate). <u>It is a dangerous zone.</u> The operator or any other persons are not allowed to remain in this zone during operation. Failure to this condition by the user releases the manufacturer from liability resulting from the declared conformity of machinery with the essential requirements.**

- It is forbidden to move the machine if anyone is staying in the prohibited area, that is closer than 75 cm from the most protruding parts of the machine (in particular, the movable Y-axis gate).

- It is forbidden to operate the machine by more than one person (the operator) at a time. It relates particularly to the situation when one person is operating the machine while the other one is manipulating in the workspace (e.g. fixing the material). Fixing material in the workspace should be performed only when the machine control panel in the program is closed and, in addition, the potentiometer of the feed (operating speed) is in the leftmost position (0%).

- It is forbidden to connect the equipment to the socket other than the 5-pin socket with grounding and zero. Connecting the machine to the network without the neutral conductor may result in serious damage to the machine.

- Use only monolithic tools with a diameter up to 8mm

- If you want to use indexable cutters or cutters with a diameter greater than 8 mm, and your machine is not equipped with guards, you must install them or you may install a cabin protecting the operator against the effects of a potential break out of the tool. You have to do it on your own.

- You must follow the recommendations of the manufacturer of tools concerning maximum rotational speed and cutting speed. The gripping part of the tool should be in the shape of a cylinder, and the diameter of the collets fixing the cutter must be closely aligned with the gripping part of the tool.

- The cutting tool rotates at high speed and therefore, you have to take special care and follow the rules of operation in direct proximity to rotating parts.

- The manual tool exchange should be made only through "Measure, change" at the time of displaying the message "Install end mill/drill" on the panel.

- The red STOP button is not an emergency switch and does not cut off power from the machine. The buttons cutting off voltage are: Main switch and Emergency switch. The main switch is located next to the power socket or on the control cabinet. The double socket which is placed on the side of the machine (if any) is powered all the time, regardless of the location of the main and emergency switches.

- Using the emergency stop extends the spindle stop time. After using the emergency stop, wait for the spindle to stop completely before taking any action in the workspace.

- If you notice any abnormalities in the operation of the machine, stop work immediately and contact the service.

- The machine must be levelled and stand on the firm ground not allowing for its wobble. After levelling the machine, the counters of screws which fix the feet should be tightened to prevent the change of inclination of the machine.

- The diameter of the gripping part of the tool must be carefully adjusted to the collet that fixes the tool in the spindle. It is unacceptable to use e.g. a tool with a 3-mm grip together with a 1/8-inch collet (3.175 mm). This can cause disruption of the collet or the crack of the spindle.

- In case of using indexable tools or tools with brazed elements, it is absolutely essential to protect environment and the operator against the possibility of impact of a splinter of the damaged tool. Instead of safety net, you should use full covers made of the material resistant to cracking (e.g. 3mm-thick polycarbonate)

- During operation of the machine you are not allowed to perform any operations in the vicinity of the tool storage. The space between the driving gate and the storage is particularly dangerous. Failure to do so may result in disability. The exchange of tool cones in the tool storage should be performed only automatically (TAKE / RETURN / MESURE, CHANGE).

- In the case of the tool storage with different sizes of sockets, you should remember to use the appropriate cones. An attempt to put the tool cone into the wrong size socket may result in damage to the tool storage and/or the tool and/or the spindle.

- Pressure mats and light curtains are optional equipment.

- If you connect additional safety protection (safety mats, light barriers, opening door sensors, etc.) please contact the manufacturer of the machine.

- The control computer (if it is powered separately) must be connected to the socket with a grounding pin.

- The computer controlling the machine should be designed to operate in industrial environments.

- The signal cable between the computer and the machine must be properly placed in the sockets.

- It is forbidden to install a different system than Windows XP or Windows Embedded on the computer used to control the machine.

- It is forbidden to install software interfering with network connections or that can disrupt the communication of Ethernet network, i.e. Ethernet network monitors, firewalls. In addition, you have to turn off the firewall system.

- You must not extend the Ethernet cable connecting the control computer with the PLC controller through Hub/Switch type devices or connect the machine to the local network. We do not recommend the use of wireless network cards.

- Flammable material can undergo spontaneous ignition (the friction of the cutter and the material may cause its ignition) during milling with worn tools, or with abnormal processing parameters.

- machine. Take care of cleanliness in the workplace. After processing flammable materials clean up their chips and waste. In the vicinity of the machine there must be a fire extinguisher.

4.7. Consumables

Some elements in the machine are consumables that wear naturally and are not subject to warranty. These elements include in particular:

- electro spindles

- collets

- tool cones

- ⚔ sliding bushings in oscillating

As for warranties on other items, please contact the seller.

4.8. Maintenance of the machine

> **Note !!!**
>
> Maintenance should be performed by trained personnel. Maintenance operations concerning electrical equipment should be performed by qualified personnel. The servicer authorized to repair the machine is the manufacturer of the machine.
>
> Before you start maintenance operations make sure that the machine's electrical and compressed air lines are disconnected from main supplies.

4.8.1. Cleaning the cone holder

For machines equipped with the automatic tool change spindle.

Before using the spindle, make sure that conical surfaces of the tool cone and the conical surface in the spindle fixing the cone (indicated in the figures below with black, and the number 1) are thoroughly cleaned without a trace of dust, grease, coolant, oil, chips, rust or scale.
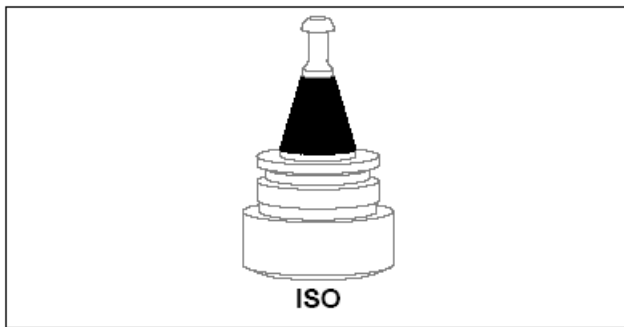
Figure 10: ISO cone

Figure 9: HSK cone

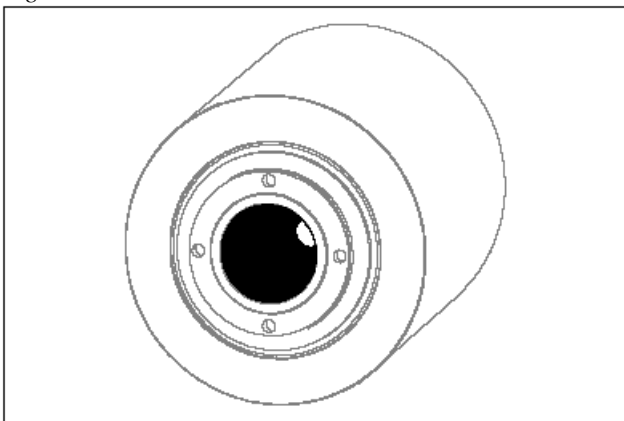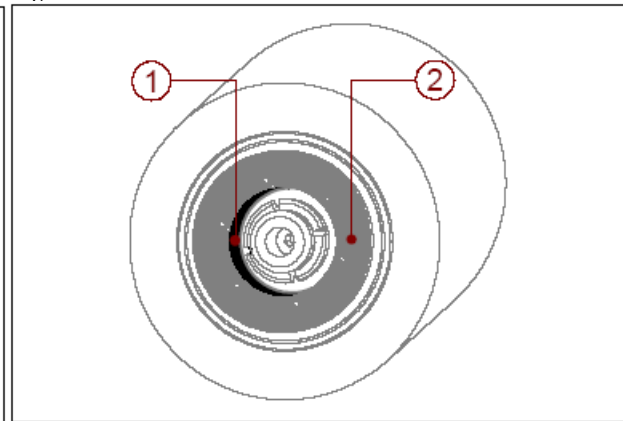*Figure 12: Spindle with ISO socket*

Figure 11: Spindle with HSK socket

ONLY FOR HSK MODELS

The same checking should be performed for a flat surface adjacent to the figure indicated in gray and the number 2.

⚠ A dirty cone may cause an error when taking the tool or may be clamped incorrectly. This can damage the machine and/or pose a threat to the operator and people in the vicinity.

⚔ Dirty surfaces should be cleaned with a soft and clean cloth moistened with alcohol, and then preserved with oil or grease spray. Excess oil or grease should be removed with a soft, dry, and clean cloth.

⚔ For cleaning you must not use any abrasive materials, acids, rotary tools or other tools or resources that may damage the polished surfaces.

> **Note !!!**
>
> To clean the conical surface in the spindle that fixes the cone, **DO NOT USE COMPRESSED AIR**. This can damage the elements fixing the cone in the spindle and cause a risk to the operator (and unauthorized persons), as well as faster wear or even damage to the spindle

4.8.2. Schedule of maintenance operations

		If necessary	After each change	Once a week	Once a month	Once a quarter
Szafa sterownicza	Cables, plugs, sockets	K				
	Controller filter				C	
	Cabinet filter			C		
X	Linear guides				C	S
	Toothed bars					CS
Y	Linear guides			C	S	
	Toothed bars				CS	
Z	Linear guides			C	S	
	Toothed bars / ball screw				CS	
Spindle	Temperature	K				
	Socket of the cone/collet		K	C		
OTHER	Condition of the cone/collet/nut	K				
	Filters of the vacuum table / vacuum pump	W	K	C		
	Workspace		C			
	Level of the liquid in the refrigerator	W*			K*	
	Limit switches of XYZ axes	K				
	Tool length sensor	C				

Table 2: L - Lubrication,   C - Cleaning,   K - Control,   E – Exchange

NOTES:

⚔ Any self-repairs should be performed only after prior consultation with the manufacturer. Failure to do so during the guarantee will result in its loss.

⚔ Inspection of cables, plugs, sockets in the control cabinet: These activities include control of connections on the controller board and of the inverter of the machine. All cables should be tightened. Please ensure free access of air to the vents. Cables outgoing from the controller board should not be bent excessively. The signal cable should not be extended through a combination of connecting a cable with another cable. If you need to increase the length of the cable, replace the cable for a longer one, however, its length cannot exceed 5 m. The power cable should be in good condition. In case of damages to insulation, the filament line of the power cable or the plug, the damaged element should be replaced after consultation with the manufacturer. Diameter of the filament line of the power cable should not be less than 1.5 mm. Please check the power socket and the grounding wire.

⚔ Checking the state of the spindle and devices fixing the cutter. The cover of voltage supply to the spindle should be screwed down and sealed with a washer. Elements of the collet and the nut which fix the cutter must be kept clean. In case of cracks or wear the collet must be necessarily replaced. Do not use collets and nuts which are damaged, remanufactured, inconsistent with the specification or coming from an unknown source.

⚔ Linear guides of axes feed rates should be lubricated with a greaser with the tip corresponding to grease fittings placed on trolleys. Guides must be cleaned with a dry cloth to remove any impurities from between trolleys of the movable gate.

⚔ The maintenance of propellers and toothed bars involves cleaning - removing used grease and re-lubrication on their entire length with a small amount of grease.

⚔ We recommend using AGIP GREASE 30 lithium grease (or substitute).

⚔ Do not use compressed air to clean the accordion type covers of the X-axis. Chips and other impurities that fall under the covers should fall themselves through the holes in the bottom sheet of the covers. Compressed air can blow in pollution on the guides and the ball screw/toothed bar of the X-axis.

28
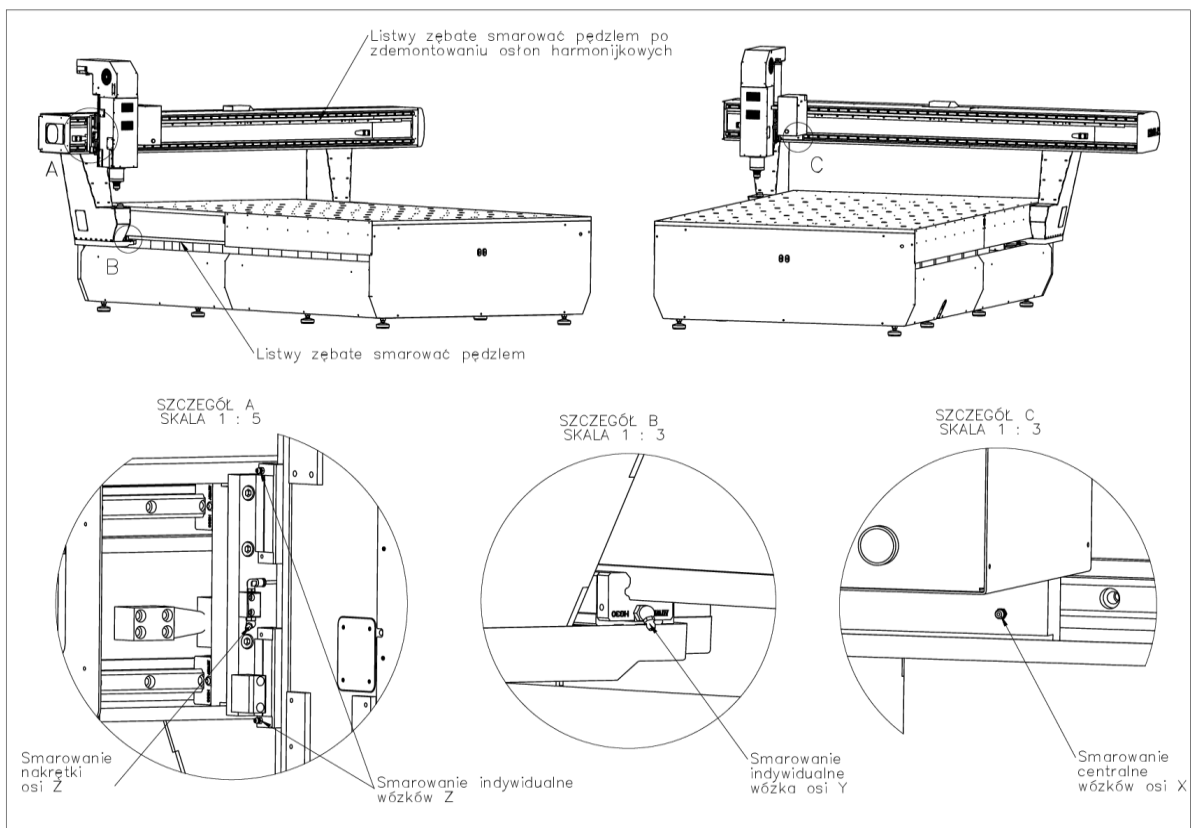
To lubricate the toothed bar of the X axis, you need to:
- ⚲ unscrew the plastic cover on the left side of the X beam
- ⚲ unscrew the screws that hold the left bellows cover
- ⚲ move the left bellows cover maximally toward the Z axis.
- ⚲ lubricate the carts and the screw / toothed bar
- ⚲ draw the bellows cover aside, screw the plastic cover
- ⚲ repeat these steps at the right side similarly

* In case of machines equipped with the spindle cooled by a refrigerating unit, you have to check the coolant level on the machine which is turned on (checking the level because on the machine which is switched off can give a false reading). If you notice the loss of the coolant, you have to complete it not exceeding the maximum level with a mixture of distilled water and Antifrogen-N (ethyl glycol) in the ratio 3:1. Coolant should be replaced annually or more frequently if we notice the sludge in the tank cooler. In case of sludge, the installation should be rinsed several times with tap water (do not clean the cooler, cables and the spindle with any chemicals). You can also blow (spindle and cables) with compressed air (maximum 8 bar) to check their permeability. Do not blow off the cooler. To clean the installation, you have to fill the cooler tank with water, unplug the input cable (inlet), direct it to the sewage system and turn the cooler on. The pump forcing the circulation will pump the water out of the cooler by pipes and the spindle. Repeat the procedure until the water pumped out is clean. If it appears that the sludge has blocked cooling channels of the spindle, you should contact the service.

4.9. Common causes of malfunction of the machine

Symptoms	Probable cause	Removal of fault
The message: „Error! Communication with the driver has not been established."" appeared during the start-up of the program.	The machine is not turned on or the emergency stop button is pressed. Unable to connect the controller with the computer, the Ethernet cable damaged, a cable without interleave has been used. The incorrect setting of the IP address.	Turn on the machine. Check if the emergency switch is pressed out. Check if the fan in the driver rotates. Check if LED diodes (green and orange) on the Ethernet socket in the driver light up. If not, check the cable and the connection to your computer. Use a crossover cable. Check the IP address, set the address and the network mask as directed.
During the initialization the drive motor does not stop.	Damage to the limit switch, damage to the cable connecting the switch with the driver, incorrect installation of the cable.	Check the connection of limit switches and the driver. Check the condition of the cable connecting the limit switch.
After starting the spindle, during the speed regulation, during the stop - the spindle slows down very much and turns off.	Too high parameters of controlling the spindle, excessive load on the spindle.	Contact the manufacturer to adjust the parameters.
After replacing the tool the machine goes slowly up.	Contaminated height sensor of the tool, faulty height sensor.	Check cleanliness and condition of the sensor.
During operation the program displays the message "X (Y, Z) - axis overload"	The machine hit the limiter axis. Machining with too high speed.	Initialize the machine, reduce the speed of operation.
Service Centre: ul. Bałtycka 30, 42-202 Częstochowa, POLAND Tel. 0048 34 365 88 85		

4.10. Common causes of malfunction of the spindle water-cooling

Symptoms	Probable cause	Removal of fault
Refrigerator does not work. None of the refrigeration equipment works. The display is turned off.	No power supply.	Before opening the refrigerator, check the automation feeding and controlling the work of the refrigerator.
Insufficient cooling. Compressor, pump and fan are working. Raised temperature of coolant at the outlet of the refrigerator. High power consumption. Symbol "ALU" appears on the display (maximum temperature).	High temperature of the cooler environment. The compressor or filter are very dirty. The air blown out by the cooler is sucked into it again. Raised pressure in the head.	Clean the air filter and the cooler using detergents containing caustic compounds. Remove obstacles that prevent the free air circulation around the refrigerator.
Insufficient cooling. Pump and fan are working. The compressor operates intermittently. Symbol "ALU" appears on the display (maximum temperature).	No condensation in the cooler. Too high pressure in the compressor circulation triggers the pressure and current switch protecting the compressor.	Make sure that: the fan is running and turning in the right direction; the filter and the cooler are clean; the coolant does not flow out hotter from the heat exchanger; the temperature of the coolant incoming to the refrigerator does not exceed the maximum allowable temperature.
Insufficient cooling. The temperature of the coolant flowing out of the heat exchanger is slightly higher than the temperature of the coolant flowing in. The pump is running. The compressor operates intermittently. The symbol "La2" on the display.	The coolant flows with insufficient speed or the preset temperature exceeds the capacity of the refrigerator. Possible activation of the anti-icing switch.	Check the coolant level and its flow. Check the permeability of the tank and the pump. Check if the coolant does not leak at the spindle or between the spindle and the refrigerator. Check if the heat exchanger is not clogged with dirt or lime scale.
No cooling. The compressor is hot and runs intermittently. The pump and the fan work. The symbol "ALU" on the display (maximum temperature).	The reason may be leakage or no gas in the compressor. Too high pressure of condensation activates the thermal-overload switch.	Repairing leakages and gas loading should be performed by qualified personnel.
The compressor does not work and is very hot. The pump and the fan work. The symbol "ALU" on the display (maximum temperature).	The compressor has been blocked by internal protection. Blocking was caused by too long activation time or an unsuccessful attempt to switch the compressor on caused by too low voltage.	Check the temperature and the amount of coolant and the compliance of supply voltage with the value on the nameplate. Check the correctness of the condenser operation.

| Symptoms	Probable cause	Removal of fault
		Check the presence of gas in the compressor.
Everything works correctly. Power consumption corresponds to that on the nameplate. Cooling efficiency is too low. The symbol "ALU" on the display (maximum temperature).	Possible error in estimating the cooling capacity.	Check if power consumption corresponds to that on the nameplate. Check the cleanliness and operation of the condenser. Check if the amount of heat absorbed by the cooler corresponds to the amount of heat generated in the system.
Service Centre: ul. Bałtycka 30, 42-202 Częstochowa, POLAND Tel. 0048 34 365 88 85		

5. Software

At the start of the program shows the following window:

PcCamPlus v5.09.15.6655 (BBox w 113)

Initialization of main window

When turning the program will appear information about the loading progress of the program. The program can be used on computers not connected to the prior preparation of projects*. When running the program on your computer connected to the machine is not required to enable the machine. This is required during the change to the software part of the CNC. After a short time, a welcome window will disappear and you will see the main window of PC-CAM.
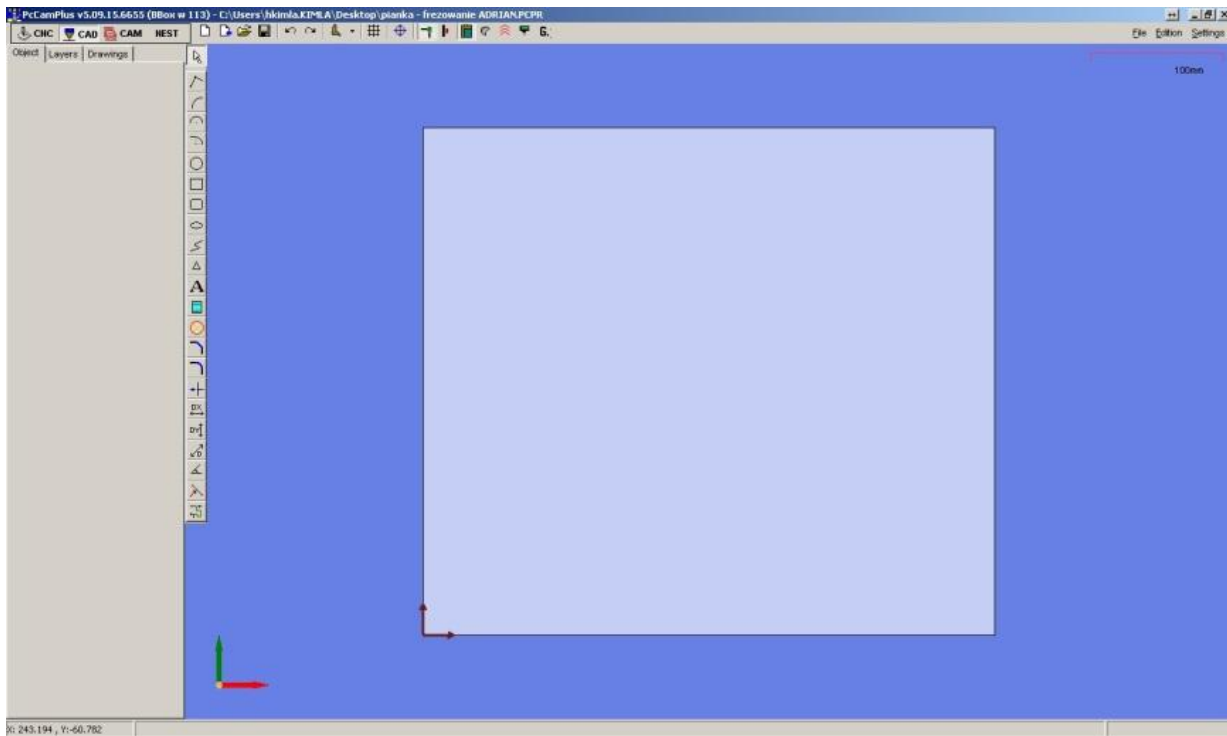
5.1. Main window of the program

From this level we can access most of the necessary functions in the program. On the right side of the window there appears a bright rectangle on the blue background. The dimensions of the rectangle are proportional to the size of the workspace in the plotter. In the upper right corner of the view we scale indicating the distance unit, depending on the degree of approximation. Zoom in / out is realized using the mouse wheel, the screen increases / decreases in the direction of the current position of the mouse cursor. Tri-coordinate system in the lower left corner indicates the position of the X axis red Y green with blue. The default view is the view from the top while working table can be rotated in space while pressing the mouse wheel + CTRL on your keyboard and moving the mouse while not letting any of the buttons go. Pressing and holding down the mouse wheel and shift it will move the object in X and Y. Double-clicking the left mouse button will restore the view " from the top" and centering the work table on the screen.

5.1.1. Main menu

The program was divided into four modes::

 CNC – module to communicate with machines and control them

 CAD – module design elements

 CAM – module to generate tool paths

 NEST – a module for the nesting of elements (option)

5.1.2. The main window toolbar

 Create a new project - creates a new project in the program, we lose the previous changes.

 Import to the project – allows you to import the program file and its extensions as well:

   ⋏ PCPR – PC-CAM program file version 5

- PWF – PC-CAM program file version 4 and previous
- DXF – AutoCAD drawing file – compatible version is DXF 2000 ASCII.
- PLT – HPGL project file
- NC – file from G-code

Open – opens files

Save - saves

Changing the view - changes the view in the project - the default view is the top view.

Center - switches to the view top, and sets the zoom so that all elements are visible on the screen. If there are no objects in the project, sets the zoom onto the area of working table.

Undo / Redo - we can undo / redo the last 4 moves

Show grid - displays on the screen dynamically scalable grid to which the vertices are attracted

Display nodes - displays / hides the nodes on the screen

Show table in CAD - displays / hides the table area on the screen

Generator of stages – automatic generating stages on the basis of the drawing

Fill in details - displays parts not as contours, but as objects filled

Display path in bold - apart from the tool route, it displays the trace that the tool leaves in the material

Display Figure in CAM - displays / hides contours on the screen

Dispaly path in CAM – displays / hides the tool route on the screen

Display performed path - shows / hides the trace of the performed route on the screen

Display scanned surface - shows / hides the scanned surface with the scanner

Show grid of scanned surface - live display of the grid of the scanned surface with the scanner

Colorize speeds - coloring the route displayed according to the speed set on individual vectors

Display arrows on the path - displays arrows on vectors indicating their direction

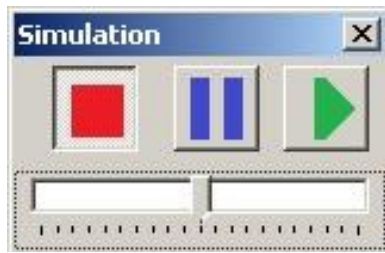Display natural line on joint space - displays the tool direction

Display natural line on taskspace - displays the tool direction

Display common cuts - highlights the route fragments identified as common cuts

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 Simulator of executing path - displays the simulation window

 Display places of entry - it shows on the screen the place of entry of the tool into the material, so that we can define the places of entries (piercings) for individual contours

 Display path collisions - displays on the screen places where the path intersects, that is probable places of collision

 Path information - displays a report on the generated route

 Edit cutting contours - the mode of drawing and setting contours used to cut material (equal cutting of waste) - option for laser

 Display part names - show / hide the names of details

 Spreading details - enabling manual spreading details on a visible sheet

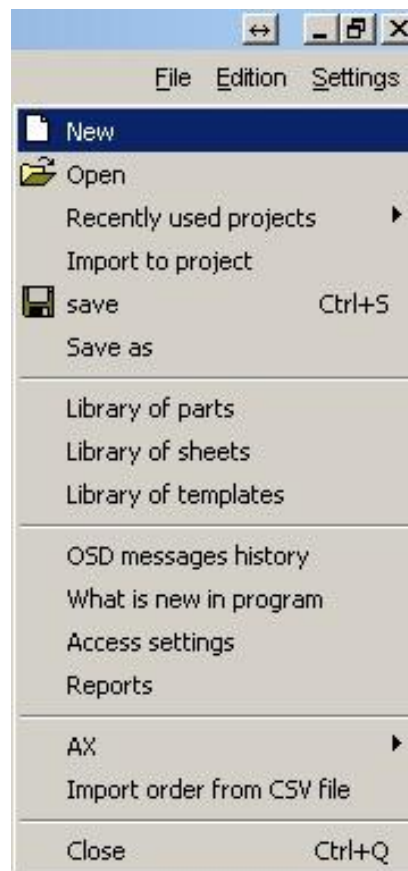 Edycja zlecenia – edycja ilości detali do wykonania w ramach projektu

 Edit nested sheets - editing the number of completed copies of sheets

 Edit sequence - editing the sequence of cutting details

5.1.3. The main window menu

5.1.3.1 . "File" Menu

↑   New – creates a new project
↑   Open – allows you to load project files as well as files with extensions: PWF, DXF, PLT
↑   Recently used projects – remembers recently loaded and saved projects and allows you to re-open them quickly
↑   Import to project – allows us to load drawings from other files to the project
↑   Save – saves the current project version to the file, in case of new projects entering the name and location of the save is required
↑   Save as – saves the project under a new name
↑   Parts Library - allows you to select a library directory to read / write files of parts
↑   Sheets Library - allows you to select a library directory to read / write files of sheets
↑   Templates Library - allows you to select a library directory with sets of machining parameters
↑   Access Settings - limiting the rights of the operator of the machine (after protecting the program with a password, the operator will only be able to load the finished project and execute it on the machine without the possibility of editing the drawing)
↑   Close - closes the program

⅄

5.1.3.2 . "Edition" Menu
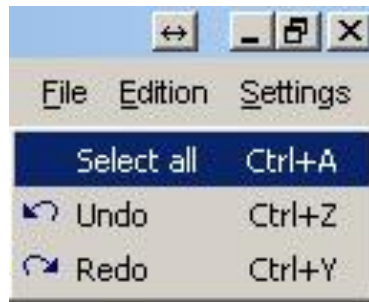
⅄ Select all – selects all the objects, contours and details according to the operating mode
⅄ Undo - allows you to undo up to 4 moves
  ⅄ Redo - allows you to redo undone changes (maximum 4)
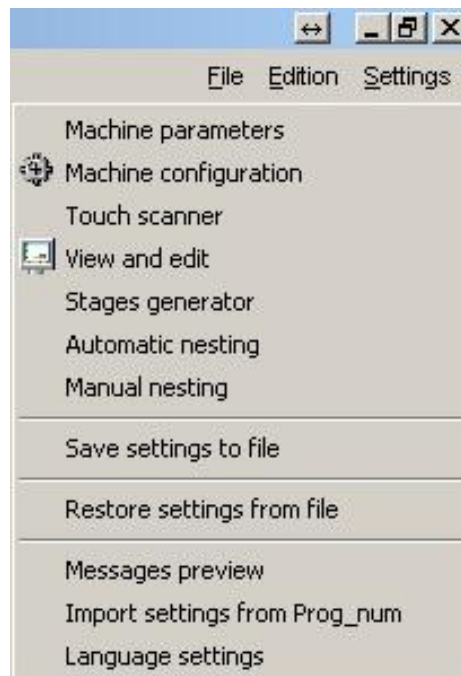
5.1.3.3 . "Settings" Menu

⅄ Machine parameters - displays "Machine parameters" panel
⅄ Machine Configuration - displays "Service Parameters" panel
⅄ View and Editting - displays "Display parameters" panel
⅄ Generator of stages – configurator of the generator of stages
⅄ Automatic nesting - configurator of the automatic nesting
⅄ Manual nesting - configurator of the manual nesting
⅄ Save the settings to the file - forcing a save of current machine settings to the file
⅄ Restore the settings from the file - reads the current settings of the machine from the backup, replacing the current ones
⅄ Preview of messages - displays a preview of internal messages of the program
⅄ Language settings - allows you to change the language version of the program

5.2. CAD

A part of CAD is intended to perform drawings: custom, parts or sheets. It has a developed menu that allows you to create and edit advanced shapes.

5.2.1. Selecting

Selecting – selection is possible by clicking, as well as by dragging with the mouse. Dragging from left to right selects only objects that are entirely included in the rectangle of selection. Dragging from right to left selects all the objects if any part of them was found in the rectangle of selection.

5.2.2. Drawing new objects

When drawing continuous objects (eg. polyline), the drawing is finished by ESC or right mouse button. However, the tool is still active and we can immediately start drawing the next continuous object. If you click the right mouse button again or ESC instead, the cursor of selecting objects will be active.

Draw with lines - drawing a polyline consisting of segments. Subsequent segment has its beginning at the end of the previous one, we need to determine the end.

Means a line parallel to the 0Y axis (line properties | the vertical)

Means a line parallel to the 0X axis (line properties | the horizon)

When you select the line after drawing, the following panel will appear in the edit panel:

Line		
Start	36.866	246.147
End	77.875	205.138
Center	57.370	225.642
ANGLE	315.000	
Lenght	57.996	

Properties
- ⦿ Lack
- ○ Vertical
- ○ Level

Allows you to read and edit the properties of the line. The first lines are X and Y coordinates of the beginning, the end and the center of the line, below the angle value and the length. Further down there is information concerning whether the line is vertical or horizontal.

Draw with arcs - drawing a curve consisting of arcs. The first left mouse button click - marks the beginning of the arc, the second click - the end, the third click - a point on the arc. The next arc is the beginning of the end of the previous one, we need to determine the end and a point on the arc.

Draw with half circles - drawing a curve consisting of semicircles. The first click - marks the beginning of the arc, the second click - the end. The next arc is the beginning of the end of the previous one, we need to determine the end. For reversal of the semicircle it is required to pass once again through the beginning of the semicircle.

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Draw with tangent arcs - drawing a curve consisting of arcs. The first left mouse button click - marks the beginning of the arc, the second - the end. The next arc is the beginning of the end of the previous, we need to determine the end. For the reversal of the arc it is required to pass once again through the beginning of the arc.

When you select the arc after drawing, the following panel will appear in the edit panel:

Arc		
Start	49.040	85.314
End	131.059	106.459
Center	91.051	92.001
angle 1	-170.955	
angle 2	19.869	Change into circle
Radius	-42.540	
rDelta	-169.176	

Allows you to read and edit the properties of the arc. The first lines are X and Y coordinates of the beginning, the end and the center of the arc, below are given: the value of the angle 1 (center - beginning), the angle 2 (center - end), the radius of the arc.

Draw circle - drawing circles

When you select the circle after drawing, the following panel will appear in the edit panel: .

Circle		
Center	109.287	214.946
Radius	14.281	

Allows you to read and edit the properties of the circle.

Draw quadrilateral - drawing rectangles

Draw bean - drawing the object whose shorter side is always a semicircle.

Draw ellipse - for the ellipse you can define "Segment length", that is accuracy, the standard value is 0.1mm

Draw with arcs (Bézier curve) - - drawing a curve consisting of Bézier curves. The first left mouse button click - marks the beginning of the curve, the second - the first leading point, the third - another leading point. Minimally, the curve consists of 4 points. The next time you click, the curve is increased. ESC or right mouse button - ends drawing, marking previous point as the end of the curve

Draw regular polygon - drawing regular polygons with a given number of vertices. When you draw with ALT key pressed, one of the sides will be parallel to the 0X axis.

Chamfering - allows you to chamfer the corner with a given value

Rounding – allows you to round the corner with a given radius

A Insert caption - allows you to add the caption, which can be edited: you can change the font (the default simplex font is a linear font), size, spacing, angle of inclination of letters and the angle the caption and the X and Y coordinates of the position of the beginning of the caption

Insert image - allows you to select an image from the hard disk and add it to the project

Insert measuring marker – adds a special object which is used for basing e.g. with a camera or a scanner

Crop - removes the segment of an object between two obstacles (objects that intersect). Click the icon and indicate the fragment to be removed. Not working on contours.

Dimensioning

DX Dimension horizontally - allows dimensioning objects drawn in relation to the X-axis.

DY Dimension vertically - allows dimensioning objects drawn in relation to the Y-axis.

Dimension diagonally - allows flexible dimensioning objects drawn.

Dimension angle - allows dimensioning angles. The first click means a corner angle, the first arm is located in relation to the 0X-axis. We set the point on the other arm with the second click.

In addition, when you double-click on the dimension value, you can change the distance between the dimension nodes. For a change in the right direction, we can block the opposite node by selecting the appropriate command from its context menu.

Insert node – a node is added at the indicated location on the object or intersection of objects

Selects the edge between the selected nodes - we click this option and then two nodes. If the object was locked, arrows coming out of the circle appear, by clicking the circle we choose the part we want to select.

5.2.3. Vertices

The default option is dragging to vertices. If dragging to nodes is enabled, pressing <u>CTRL</u> on the keyboard temporarily disable it and we can draw freely.

- ⌃ blue vertex - the vertex is not connected
- ⌃ green vertex – the vertex is connected
- ⌃ orange vertex – the vertex with more than two connections
- ⌃ vertex with an anchor symbol - the vertex is blocked

Vertices can be combined or separated by using the function:

- ⌃ Dragging a vertex to another one results in automatic connection of the vertices.
- ⌃ Connect vertices - connects all elements whose vertices are located at a given point
- ⌃ Separate vertices - separates all elements whose vertices are located at a given point, vertices can be caught and moved individually
- ⌃ Connect all - it changes all vertices into connected ones, where possible
- ⌃ Lock vertex (unlock vertex) - locks (unlocks) vertex for editing (you can also lock the center of the segment or the center of the arc)
- ⌃ Lock all (unlock all) – locks(unlocks) all vertices for editing
- ⌃ Lock object (unlock object) – locks(unlocks) all vertices of the selected object

If we catch the vertex of the segment marked as a vertical / horizontal to the axis, the other end will be moved so as not to lose this property.

Double click of the left mouse button on the connected vertex will cause its separation.

5.2.4. Additional panels and object editing options

<u>Drag the base to the corner</u> - selected objects are dragged to the base point, we choose if the base is to be the center, the half of the edge, or the corner of the rectangle covering the selected objects.


On this panel, we also have a numeric value specifying the position of the center of the selection rectangle in X and Y axes. You can also enter an offset value of all selected elements in X and Y axes.

<u>Drag the corner to the point</u> - the object is dragged with the mouse to the specified location (we decide if the indicated place is to be the center or the corner of selected objects)

Resizing - the panel displays dimensions of the object and gives the possibility to change them. Resizing does not move objects - the position of the center of selection is unchanged. The objects are evenly enlarged / reduced in relation to this center. The lock icon locks / unlocks the coefficient of proportion (when arcs occur in selection, the proportion is automatically switched on).
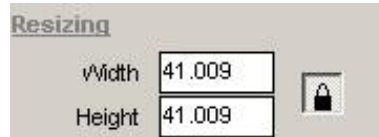
Scaling - works like resizing, except that we give the scale value. The option "The same X and Y" - locks / unlocks the possibility of using a different scale in X and Y axes
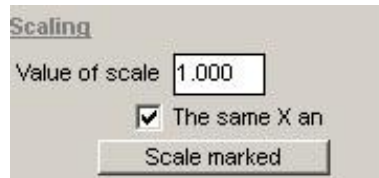
Rotation - allows you to rotate the selected elements in relation to any point (the default is the center of
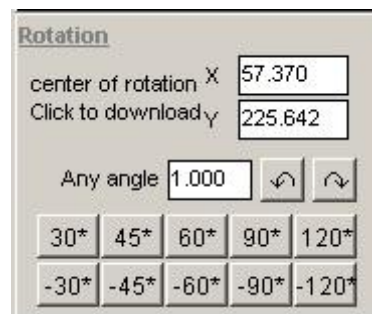
selection) by any angle

Layer – the change results in the assignment of the selected objects / contours to the selected layer

Edge quality – sets the cutting quality the currently selected edges. In practice, the edges of different qualities will be cut at different speeds. Along with the change of quality, the colours of edges will also change (option available depending on the tool).

Sheet area quality – allows you to choose the quality of the material from which you want to cut a contour, which is important in case of cutting e.g. leather, where may be areas of varying quality on the
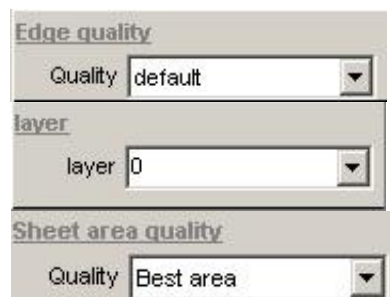

material. (Example: When cutting elements for natural leather shoes, some parts have to be cut from high quality leather, as they are visible, while others are less visible and can be cut from areas of lower quality.)

Create group - creates a group from selected objects

Mark selected - marks active contours

<u>Create polylines from selected</u> – turns sequence of objects into one sequence consisting of lines
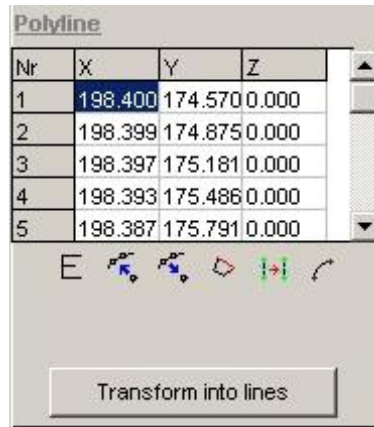
<u>Edit nodes</u> – allows you to edit a polyline, chamfer and round corners, and add or subtract nodes.

<u>Smooth</u> – each run doubles the number of nodes and also smoothes the run of the polyline

<u>Reduce</u> – removes redundant and multiple nodes in the polyline

<u>Close</u> – draws a line connecting the beginning with the end of the polyline

<u>Reverse nodes sequence</u> – reverses the sequence of nodes

<u>Convert into arcs</u> – option which smooths selected sequences of objects while maintaining a given deviation. This consists in turning the sequence of tiny objects into bigger ones to reduce their amount.

<u>Group in sheet</u> – create a sheet from the selected sequences of objects and / or contours. The sheet may consist of one external contour and many internal contours that are nor nested.

5.2.5. Creating contours

After selecting an object, a toolbar editing contours is displayed

 Creat contours – as long as contours are not created from segments and curves in the drawing, we will not be able to do any work. The button <u>Create contours</u> ends editing the object and makes it visible in the CAM mode, which allows for its implementation.

 Separate contours into elements – allows you to separate the group (if any) into contours or contours into elements and re-edit them

 Round sharp corners - this function allows you to round corners in selected drawing elements. When we select corners, we click the icon of the function, then we choose corners to be rounded: internal, external or all, and finally we define the radius of rounding

⊞ Arrange – allows easy distribution of elements using rectangular array. The following keyboard shortcuts are available while arranging:
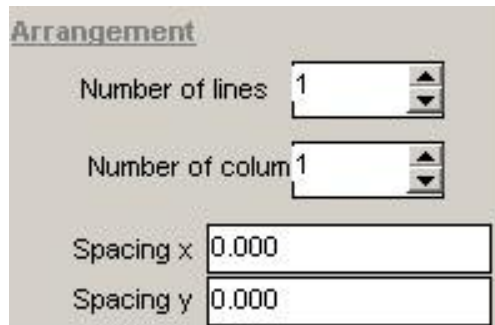
⅄	↑	–	add line
⅄	↓	–	remove line
⅄	→	–	add column
⅄	←	–	remove column
⅄	CTRL + ↑	–	increase spacing between lines
⅄	CTRL + ↓	–	decrease spacing between lines
⅄	CTRL + →	–	increase spacing between columns
⅄	CTRL + ←	–	decrease spacing between columns
⅄	mouse wheel	–	rotation of all objects

▣ Create part – creates a part from selected sequences of objects and / or contours. A part is an external coutour together with internal ones forming its holes. Parts are stored in the library from where we can easily add them to future projects. Additional advantage of part is that when there are multiple copies of one part, the path is calculated only once, which significantly speeds up the process of generating the toolpath for large projects.

▤ Group the selected into parts – allows you to select many sequences of objects and / or contours and to create many parts from them (the program will detect nested parts).

⊿ Select chain – opcja ta spowoduje zaznaczenia wszystkich obiektów które stanowią jeden złączony ciąg z zaznaczonymi obiektami

⊢⁞ Set (non) constructional – allows you to change a regular line into a constructional line or a constructional line into a regural line

⊹ Mirror towards constructional – allows you to reflect selected objects in relatio to the indicated constructional line

⌐⁾ Create offset from selected objects – generates an offset from selected drawing elements on the preset offset value with maintaining straight corners (or not). Straight corners will be created when we move a sharp corner on the outside. We determine the offset direction by clicking the left mouse button at one side of the selected elements.

Λ Round Sharp corners – this function allows you to round corners in selected drawing elements. When we select corners, we click the icon of the function, then we choose corners to be rounded: internal, external or all, and finally we define the radius of rounding

KiMLA

 Mirror image Vertical / Horizontal – allows mirror image of selected elements of the drawing in relation to the center, maximum or minimum of the value entered or taken from the drawing by clicking
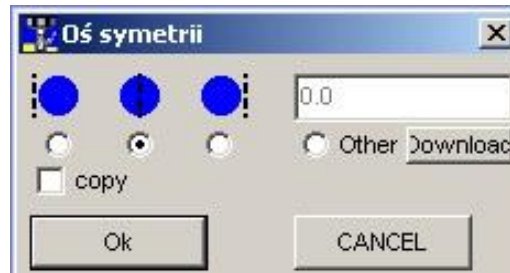

 Create array – allows you to create a rectangular or circular array as it was in version 4.9xxx PC-CAM.

- ⚘ Creating a rectangular array requires giving a number of rows, columns, and the distance (between contours or absolute), you can not change the account or position, the selected elements are the beginning of the array, elements will be added to the right and up
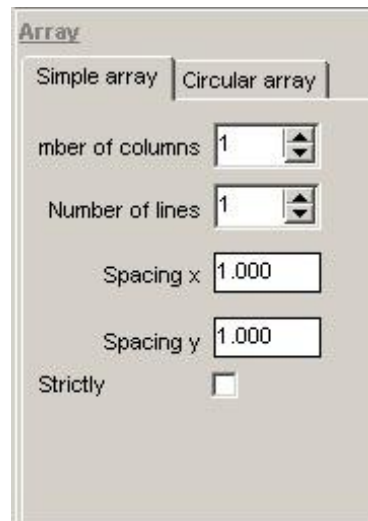
- ⚘ The circular array requires giving the center of rotation (you can enter or download the point with the mouse), the radius (calculated from the center of the circle to the center of selected objects), the starting angle, the number of objects, the end angle or the angle increment, the objects in the array can be rotated
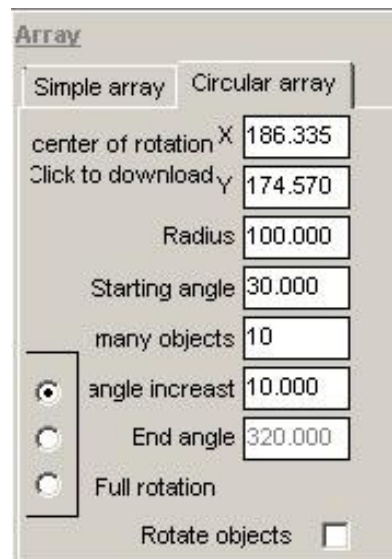
5.2.6. Drawings and layers

By default, we have one Figure in a new project and one layer in this drawing.

At the same time, you can display only one Figure, and we make the choice in the "Drawings" tab.
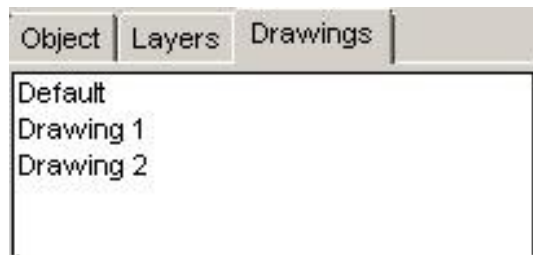

Figure must contain a default layer defined as "0", in addition to this layer, it may contain any number of layers.

Layers can be added, deleted, as well as selected to be displayed.

We set blanking / displaying of layers in the "Layers" tab. There is a point at the layer name. If it is yellow, the layer is visible, when the point is gray - the layer is hidden. We make a change with a single left mouse button click. You can not blank all the layers, at least one must be visible, and you can
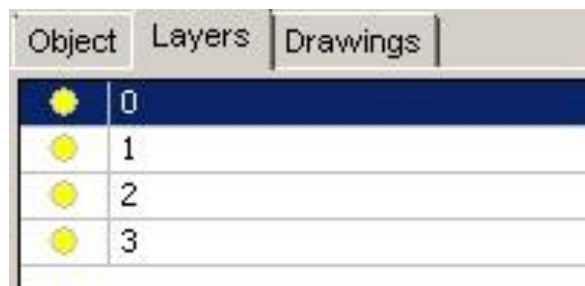
not blank the currently selected layer. When you draw new objects, they will be assigned to the currently selected layer of the active drawing.

5.3. CAM

5.3.1. View of contours

After going to the CAM module of the project, on the screen you can see only those figures, from which contours or groups of contours have been created . Editing is blocked as well. If you want to make changes in the project, you have to go back to the CAD module..

The contours in the stage are divided into active and inactive. The toolpath will not be generated from inactive contours. The contours differ in thickness of lines: thin lines are inactive contours and thick lines are active contours. If you want the contour to be executed in the current stage, it must be set as active.

To do this, you have to select the desired contour by moving the mouse cursor on it. Object will turn green, and after clicking the left mouse button, the object will turn yellow again. We can repeat the action on other contours with the <u>Ctrl</u> key. Objects can also be selected by dragging the selection cursor
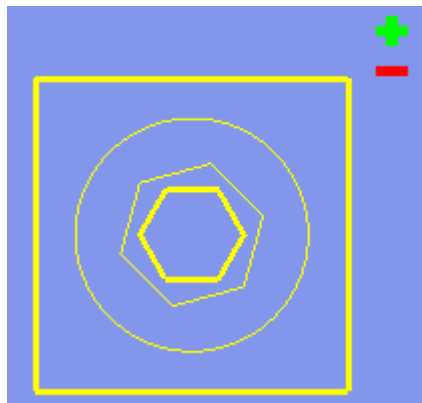
with the left mouse button pressed. Dragging from left to right will select only those objects which are all included in the selection area. Dragging from right to left will select all objects whose any part will be in the selection area. The dragging rectangle can be combined with the Ctrl key.
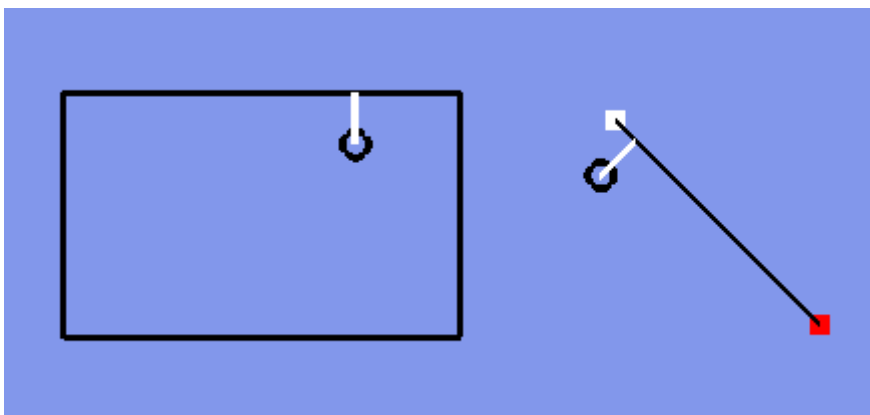
After selecting, when we release the left mouse button, green "+" and red "-" will appear next to the cursor:

Clicking the "+" will set the elements selected as **active** in a given stage.

Clicking the "-" will set the elements selected as **inactive** in a given stage.

5.3.2. Places of entry

The place of entry is set by clicking the left mouse button on the circle at the end of the white line connected with the object and dragging into the desired location.

In case of contours closed, the place of entry sets the beginning of the treatment of such a contour. It is not important on which side of the contour the place of entry is located. When the correction is at the different side than the place of of entry, the program will move the place of entry to the right side.

In case of open objects, the beginning of treatment will be the end from which it will be closer to the place of entry.

The black circle at the end of the white line means that the entry has been locked (set by the operator) and the white circle means an unlocked entry and is set by automatic arranging of entries. You can lock / unlock entries by selecting a command from the context menu of the contour concerned.

5.3.3. List od stages

After going to CAM, the panel changes under the main menu. Instead the properties of objects or the list of layers / drawings we have now **LIST OF STAGES**.

- ⅄ New – adds a New stage at the end of the list
- ⅄ Remove – removes the selected stage from the project
- ⅄ Duplicate - causes duplication of the currently selected stage, the copy appears at the end of the list

Nr.	Description	tool	machining
*1	5mm	T_H	T
*2	10mm	T_H	T
*3	12 mm	T_H	T
*4	13 mm	T_H	T
*5	15 mm	T_H	T
*6	18 mm	T_H	T
*7	20 mm	T_H	T
*8	22 mm	T_H	T
*9	24 mm	T_H	T
*10	25 mm	T_H	T
*11	26 mm	T_H	T
*12	30 mm	T_H	T

The sequence is set by clicking the left mouse button on the stage and dragging it to the indicated place.

Clicking the right mouse button on the icon of the stage tool, we can select another one which is available. Similarly, clicking on the icon of treatment, the available treatments for the selected stage will appear.

Double-clicking with the left mouse button on the number of the stage allows us to establish the option of automatic continuation.

The number of stage with the current path, without continuation

The number of stage whose parameters have been changed and the path is out-of-date, without continuation

The number of stage with the current path and automatic continuation selected. After its performing by the machine, performing the next stage will automatically begin.

The number of stage with the current path and automatic continuation selected requiring confirmation – the machine will stop after finishing this stage and will ask whether to continue operating. After confirmation, the next stage will begin.

In CAM are displayed only contours from the selected drawing or the nested sheet. We make a selection in the options of a given stage in part: "Data Source".

5.3.4. Stage properties

Double-clicking with the left mouse button in the list of stages in the area of any stage will display the edit panel of its properties. This panel occurs in different forms depending on a machine type (Laser, Waterjet, Router), however, it has several common parts.

5.3.4.1 .   "Project parameters" tab

These parameters apply to all stages in the project.

Continuing operation after its completion – allows the execution of the project many times, useful in mass production. We set the number of repetitions and the option that makes it necessary to confirm the start of the treatment of a subsequent element (machine stops after performing treatment, we have time to remove the detail and insert new material, START begins the execution of of the stage / stages) once again.

Confirmation between stages - selecting this option will cause that between all phases of the project in automatic continuation it will be required to confirm the start of treatment, regardless of whether a given stage has the enabled continuation with confirmation or not.

Return to the beginning after completion - after the completion of the last stage, the machine will drive over the base point of the project

Starting always from the first stage - the treatment will always be started from the first stage, regardless of the currently selected

Measuring material after changing sheet – enabling this option will force enabling measuring material in the stage after selecting another sheet in the data source

Measuring material after changing palette – enabling this option will force enabling measuring material in the stage after execution of the palette change – option for the stage of laser cutting and the machine with an automatic pallet changer

5.3.4.2 .   Stage parameters

These parameters apply only to the current stage.

The first value for editing is the name of the stage . The name should be clear to the operator and reflect the work performed in the stage.

To perform the work as in previous versions of the program we leave "Default" "Base of project" for each stage, which guarantees us that the database will always be up to date and exactly in the place where we have set it. However, in version 5 of the PC-CAM we have the ability to perform each step in relation to another base which is useful in performing the same project in a few different fastenings on the work table (e.g. on the two sections of the vacuum table, in several vices mounted side by side on the table)

We can choose:

- Base of project – the project base set by us in the CNC module
- Base of machine – if the machine is equipped with basing pegs, we can choose one or more basing locations defined by these pegs
- Custom bases – Here we can determine the coordinates of the base point, or select a pre-defined base. If we define a few custom bases, then the subsequent base among those defined will be used for each re-execution of the stage.

Without tool change – option for the milling machine to perform the stage with the tool previously used.

Options of the continuation of the stage are displayed the same as those set in the "list of stages". Changes can be made here or in the list of stages.

Always show the path – the option allows you to display the route of a given stage, even if the stage is not selected in the list of stages (useful when processing a complicated detail on a milling machine, the operator can have a preview of all the paths at a time)

Save to NC / Load NC – gives you the ability to import / export G-code paths

Automatic selection of contours – gives you the ability to add contours to the stage from indicated layers

Solid of material – allows you to define the size and location of a solid of material from which we will perform our detail, it allows you to check whether the project fits within the area of the material, as well as allows you to effectively plan the distribution of elements on the material

5.3.4.3 . Buttons

Create – generating a route

Show – displaying the preview window of the G-code of the generated route and manual modifying it as well.
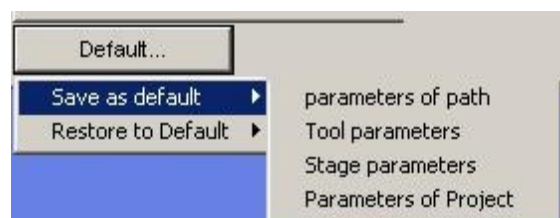
Close – closing the window of the properties of the stage

Default… - saving the current settings of: Tools, Paths, Parameters of the project or the stage parameters as default for a newly created stage and restoring default values

5.3.4.4 . Milling machine parameters

Double-clicking on the name of the stage will open the parameters window. On the left you can select the type of the tool, below the number of the socket of the storage in which the tool is located.

Under the socket number there are parameters describing this tool, different tools will have more or fewer parameters describing (diameter, radius, opening angle, diameter of foo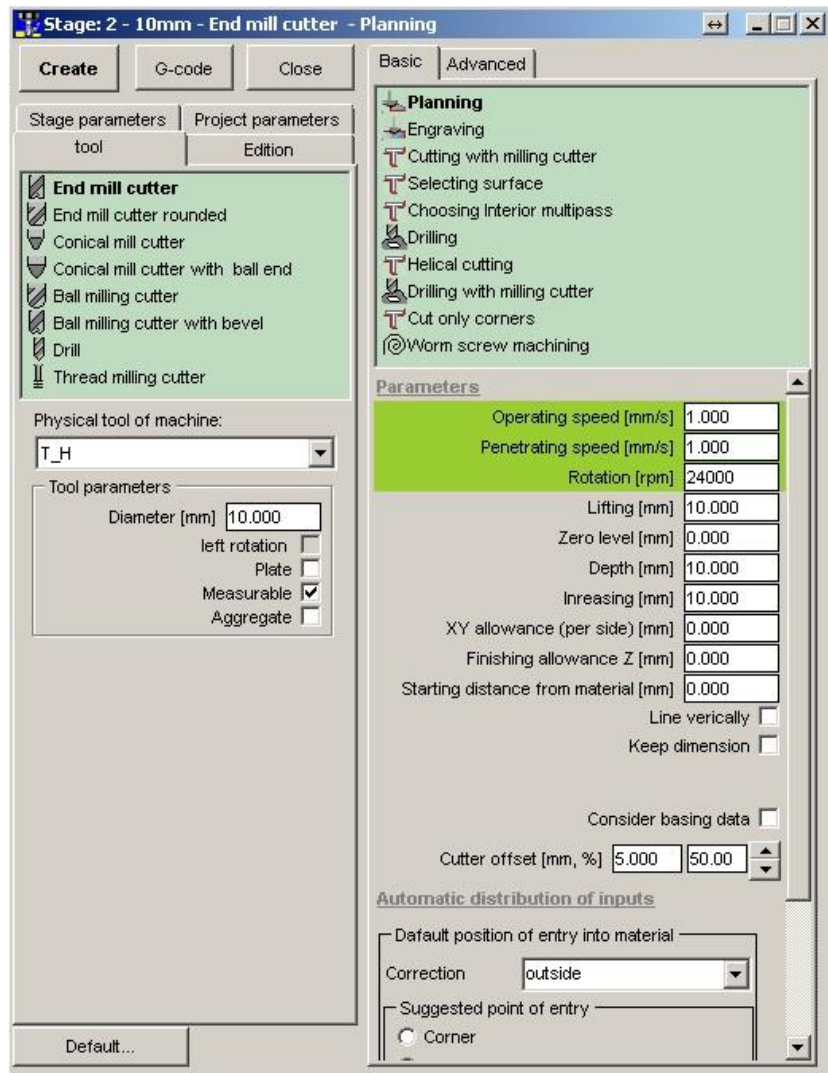ter etc.). Below there are tool options available or not, depending on the machine configuration. The possibility to work on left rotation, setting the tool as an angular aggregate, a plate cutter (without going up after pressing STOP), a fixed-length tool (eg. head).

We select a method of operating with a defined tool in "Basic parameters" on the right.

Tools parameters

- ⚞ Number of the tool
  from storage – the drop-down list allows you to select a tool that will be used.
    - ○ T[01], T[02], … – the number of the tool from the tool storage (option)
    - ○ T_H - the tool fed from hand (if there is no space in the storage or the machine is without the Automatic Tool Changin System)
    - ○ Plotter – the additional, automatically lowered head with a plotter (option)
    - ○ Laser scanner - the scanner which provides scanning the surface (option)
    - ○ Oscillating knife – the automatically lowered or manually mounted head with an active knife
- ⚞ Diameter - the diameter of the working part of the tool
- ⚞ Left rotation – when the tool needs left rotation to work properly (option related to the type of the spindle)
- ⚞ Aggregate - the tool of the angular aggregate type, automatically selects the option Plate
- ⚞ Plate – it blocks automatic vertical drive after interruption of work for plate tools and / or angular aggregates
- ⚞ Measurable - the tool can be measured with the tool length sensora

Common operating parameters for most types of treatment

- ⚞ Operating speed – the value given in [mm / s] specifies the feed of the tool in the material. Over the material, that is, in approaching movements, the machine will be moving at its maximum speed. It should be remembered that the master controller of the speed in the machine is the potentiometer on the control panel labeled as "Operating spee" or "Feed"
- ⚞ Deepening speed – the value given in [mm / s] specifies the speed of deepening the cutter into the material. This value can be scaled with the potentiometer "Operating speed" ("Feed")
- ⚞ Rotation - the value given in [rpm] specifying the spindle rotations in a given stage

- Zero level - it means the level counting from the Z base, from which we begin to count the depeening. This option is useful for millings and drillings in previously selected pockets. It allows to skip movements that would be performed in the air. You can enter positive and negative values. For the level of the base, we enter "0" by default..
- Lifting – the height in Z axis counted from the zero level, on which the end of the tool will rise at approaching movements
- Depth – the value at which the milling cutter will maximally descend in a given stage, is counted from the zero level
- Increasing – indicates the material thickness which the tool is able to process at a time. If it is less than the material depth, the treatment will be carried out in several passes. If it is greater, the tool will descend only to the value of the depth.
- Finishing allowance XY – allows you to enter the value of allowance that will be left on the sides of the detail after processing the current stage
- Finishing allowance Z - allows you to enter the value of allowance which will be left at the bottom of the detail after processing the current stage
- Take measurement data into account – if the machine is equipped with a scanner and the surface which will be treated is not flat, after scanning this surface, the correction of deepening based on the measured data can be applied. For example, you can engrave a caption on the convex element with fixed deepening from the surface.
- Type of deepening – defines the way the pass will take place between subsequent increasings
  - Vertically – default depeening, vertical descent in the indicated place
  - Ramp – depening along the ramp to achieve increasing (or depth)
  - Zigzag – similar to the ramp but the direction of deepening changes in the middle

5.3.4.5 . Piercing strategies

The strategies are a definable way of the entry of the tool into the material (the shape of piercing distance) and the exit after cutting. We have the possibility to detefine the length, the angle, radius, an additional pass along the contour or an overcut (negative pass). Piercing strategies can be defined globally for the stage, then they will be considered for each performed contour during the generation of the path, or we can define individual values of the strategy parameters by selecting a specific contour.

NOTE. Changing any parameter of the global strategies will automatically delete the strategies of individual contours.

The strategy parameters are defined for several cases:
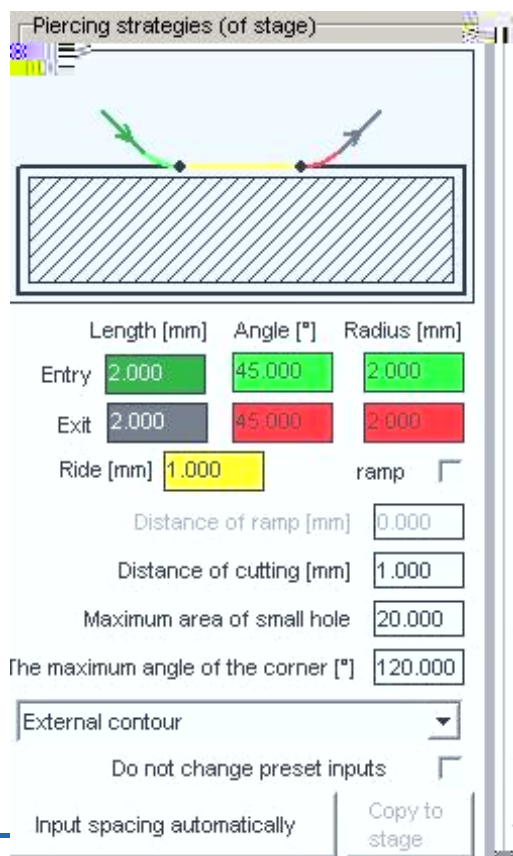
- External contour – for contours from which move away outside
- Internal contour – for contours from which move away inside
  - External corner
  - Internal corner
  - Small hole
  - Open contour
  - Contour without correction

For entry and exit in each case we can change the values:

- Length – that is piercing distance in fact
- Angle – the default is 90 °, which is perpendicular to the contour, whereas reducing the angle, the entry / exit will be softer
- Radius – entering the values will result in rounding the entry / exit line

An additional value for some cases is Pass_ by default set to 0, which means the place of entry and exit overlap. Entering the value less than zero will cause that the material may remain overcut, greater than zero - the doubled pass along some initial segment. The place of

entry is always at the indicated point, the place of exit depends on the entered value of the pass.

<u>Ramp</u> – for a milling machine the entry can be made additionally along the ramp

<u>Distance of the ramp</u> – distance through which the milling machine will perform the entry into the material along the ramp

<u>Distance of cutting</u> This is a distance performed at the end of the contour at a constant speed specified by the parameter: The speed at the end - the parameter for the stage of cutting with water

<u>Maximum field of a small hole</u> – the value below which the strategy of "Small hole" will be used in objects

<u>Spacing of entry automatically</u> – allows you to space the places of piercing in default locations after they have been changed manually

<u>Do not change preset entries</u> – spacing the places of piercing automatically, we can skip those ones we have set manually

<u>Copy to the stage</u> – if we modify the strategy of a particular contour, we can copy this strategy to the stage strategy by clicking this button

### 5.3.4.6 .   Type of treatment

Planing

Aligning selected contours with lining to achieve the ideal plane. The path is generated with an allowance of at least 50% of the tool diameter so that to plane all selected contours. The correction is automatically selected as an internal one for active contours which are not nested within other closed contours.

- ⮝   <u>Offset (% of cutter)</u> – the percent of the tool diameter of which the milling cutter will move
- ⮝   <u>Starting distance from material</u> – As the entry into the material is always performed vertically, in this case it is possible to define an offset of the place of the entry into the material, so as to deepen vertically but on the side of the material, thus in fact the milling cutter starts working with its side and not with its face.
- ⮝   <u>Line vertically</u> – The default direction of planing is the horizontal direction (along X), this option allows you to change the direction into vertical (along the Y axis)
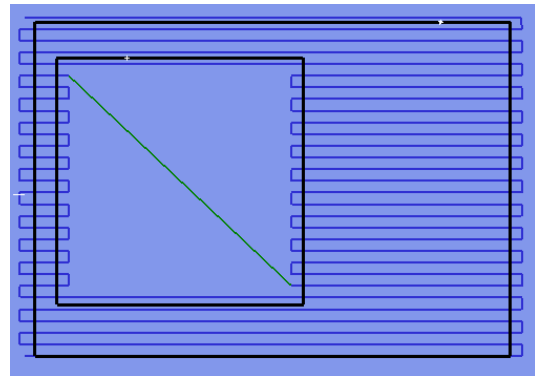
Engraving

The drawn contours will be the tool path (work without correction). Engraving e.g. captions.
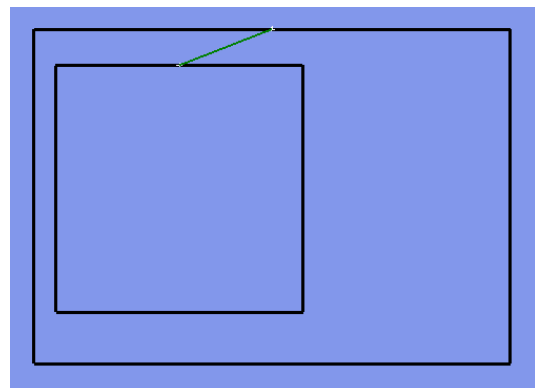
Cutting with milling cutter

Cutting details with milling cutter.

- ⮝   <u>Common cut</u> – if the project includes two objects (e.g. rectangles) separated from each other by the width of the tool. Selecting this option will cause that the overlapping path between them will be executed only once.
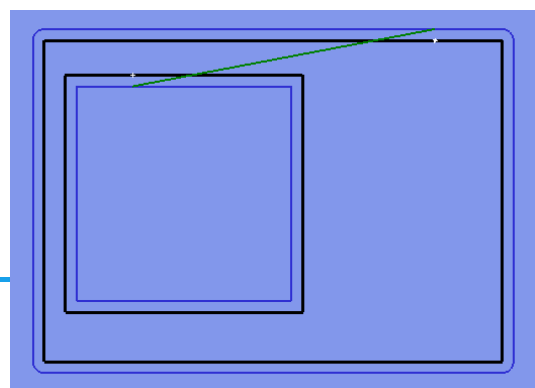
⋏ Correction side - it is possible to select the correction side of the outermost objects, the objects which are deepened will have a reversible correction with each level of containing contours in contours. With this algorithm, it is possible to cut a frame in a frame in a single stage of the project.

⋏ Direction of movement – In case of applying the internal / external correction, it is important to be able to define the concurrent / countercurrent movement direction because the direction of movement can affect the quality of the processed surface.

Helical cutting

Allows you to cut parts through at once but constantly deepening, so there is no need to make exits. The options are the same as in "Cutting with milling cutter"

Pocket machining

Allows you to make a pocket with offset algorithms, the path does not exceed active contours

⋏ Maximum number of offsets – defines the number of offsets that will be generated. Too low value can cause leaving the area which is not machined in the middle of the pocket. Excessive paths are removed automatically.

⋏ Angle of the wall – the program allows you to define the inclination of the pocket walls. Normally it is 90 degrees, entering a higher value allows for the consideration of the assumed inclination of the wall.

⋏ Insert cuttings – pocket machining the interior with the high value of offset can cause the formation of triangular areas at the corners that will be skipped when pocket machining the interior. Selecting this option causes inserting lines into the path (at the corners) that are to prevent this.

⋏ Minimum angle of sharp corner – defines the value of the angle of the corner in the path from which the cutting will be inserted.

⋏ Connecting contours – defines the way of connecting lines of successive offsets
  ⋏ Line – a standard way, a straight line
  ⋏ S – the pass is made in the shape of the letter "S", two semicircles connected with each other form a smooth pass
  ⋏ Wave – the pass smoother than wave and S, is formed with two quadrants of the circle
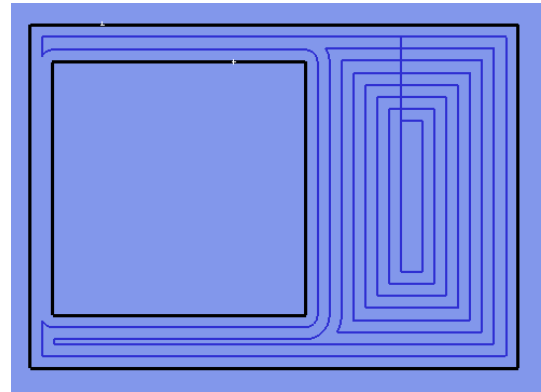
Lining

Allows you to make a pocket with the lining algorithm. The algorithm has the same options as planing, but the path does not go beyond contours. At first, lining of the interior of objects with allowance is performed and then there is the pass collecting the allowance and smoothing walls.
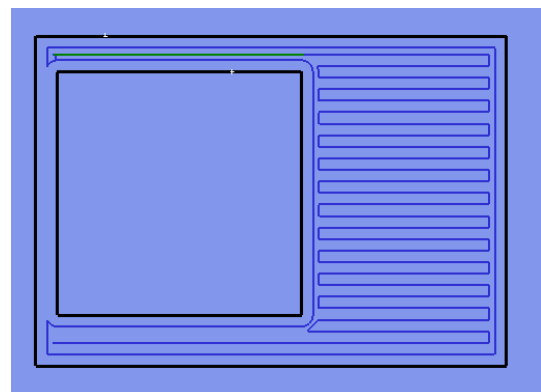
Drilling with cutter

Helical drilling with a cutter allows you to make holes with a cutter with diameters: from the tool diameter up to the double diameter of the tool.

- ⚲ Drilling place
  - ⚲ In the middle of objects – each center of the active contour will be the place of drilling
  - ⚲ In the start place – drilling is performed in the point where the line of entry connects with the contour
  - ⚲ In corners – drilling will be performed in corners, as well as on the beginnings and ends of open objects
- ⚲ Diameter of hole – determines the diameter of the hole to be made, the value must be higher than the tool diameter entered. It is also recommended that the value is not higher than the double diameter of the tool, because if it is higher, in the middle of the hole there remains the roller which can damage the tool
- ⚲ Depth of hole – the depth at which the hole diameter will be made
- ⚲ Diameter of deepening – there is a possibility of making deepening under the screw head in one stage, to perform deepening, the value must be higher than the diameter of the hole
- ⚲ Depth of deepening - the depth at which the diameter of deepening will be made
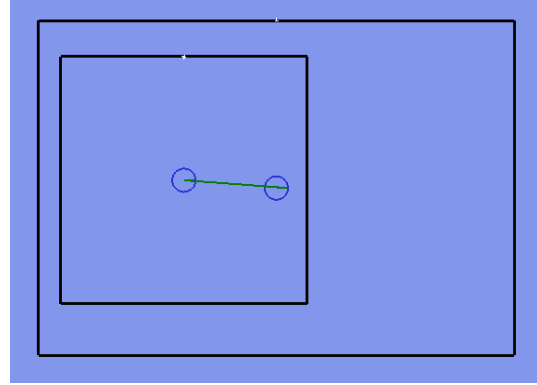
Cutting corners

When using conical milling cutters, engraving can be optimized to achieve sharp corners. To achieve a sharp corner, upon having reached the acute angle of the object, the machine moves diagonally toward the surface of the material.

- ⚲ Minimum angle of sharp corner - determines from which value of the angle of the corner in the path cutting will be performed.
- ⚲ Increasing of cutting - indicates the material thickness which the tool is able to cut at a time. If it is less than the depth, cutting will be carried out in several passes. If it is higher, the tool will descend only to the value of the depth.
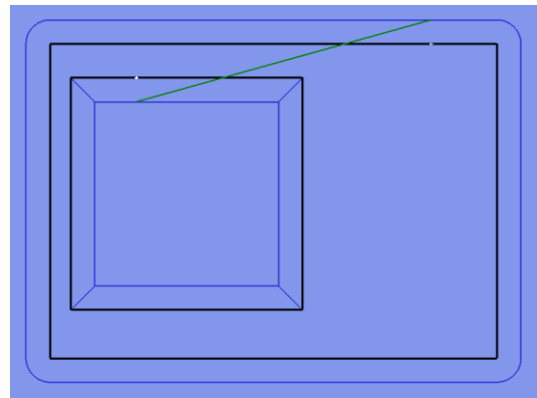
Chamfering

It is possible to chamfer the top edge of the detail with conical cutters.

- ⚲ Phase width – determines the size of the phase, the value refers to the view from the top
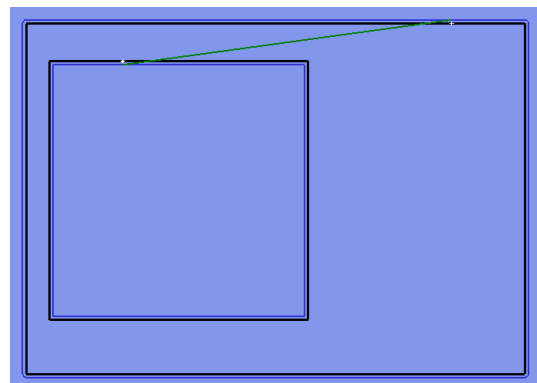
Rounding

Ball end milling cutters can be used to round the top edge of a workpiece. A ball end milling cutter of any possible diameter can be used for any rounding.

- ⚑ <u>Rounding radius</u> – specifies the radius on which the rounding is to be made
- ⚑ <u>Angular increasing</u> – specifies the accuracy of the rounding, the higher the value the more accurate rounding

Drilling

Drilling with drills.

- ⚑ <u>Speed of first deepening</u> – for the first deepening (entry into the material) it is possible to reduce the speed of deepening
- ⚑ <u>Drilling method</u>
    - ⚑ <u>With throw</u> – after each deepening for increasing, the drill will be hovered above the material to remove the chips from the hole. The exit and return to the previous depth will take place at the approaching speed.
    - ⚑ <u>With stop</u> – after each deepening for increasing, the machine will be waiting in place for the time specified in the window <u>Stop time</u>
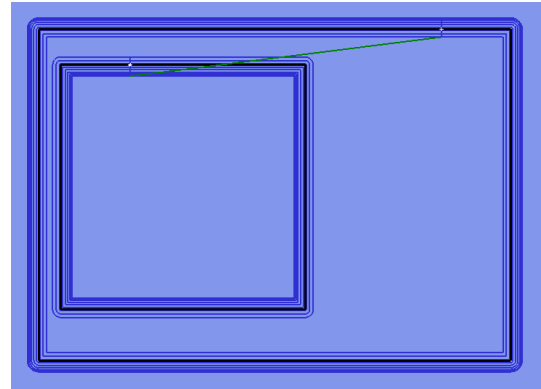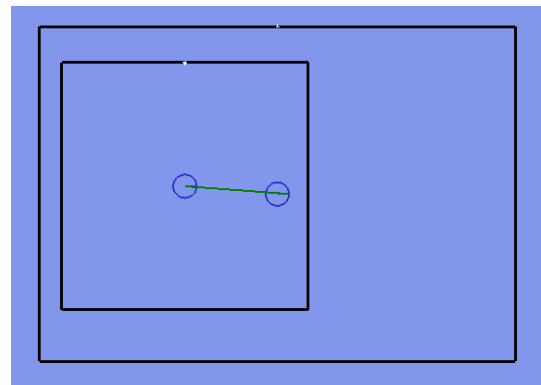
Threading

<u>Threading is possible only with threading cutters</u>. You cannot work with manual or machine screw taps, it is threaten with damage to the tool and / or to the material.

- ⚑ External thread – The threads made by default are internal threads, selecting this option switches over to external threads so you can make the thread on the roller
- ⚑ Concurrent direction – By default, the thread is made in the countercurrent direction, which in case of right-handed thread causes that the machine makes the thread from the top to the bottom. If you select this option, the right-handed thread will be executed from the bottom up, that is, the cutter will return to the full depth and then gets to the wall and starts thread milling on the wall. Such execution of a thread is not recommended, especially with milling cutters with more than one "coil" thread.
- ⚑ Left-handed thread - selecting this option will cause that the thread will be executed as left-handed. By default, threads are executed as right-handed
- ⚑ Thread parameters – the external diameter and the pitch, as well as the tool diameter for standard threads are selected from the table. However, if, for example, the diameter of the tool in the table is different than the installed tool, or we want to make a fine thread which is not in the table, the parameters must be given.
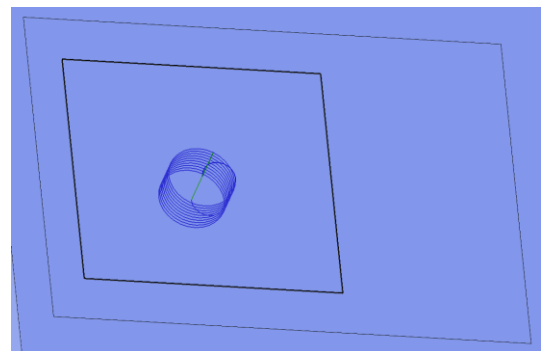
Cutting with saw

If the machine has an axis "C" which is the controller of angular aggregates, it is possible to cut with an appropriate aggregate with an installed circular saw.

Writing

Writing with an additional print head.

Cutting with controlled knife

The contours will be the tool path (work without correction), unless you set the value of the Eccentric and the correction side will be selected .

If the blade is wide and you need to eliminate cuts in sharp corners, it is important to specify the Length of the front and back calculated from the axis of rotation of the knife accordingly to the geometry of the knife.

Length of the turn says how long before the mild angle the knife starts to set onto the correct angle.

Perforating - it is possible to execute the selected contours as perforated (cutting - break - cutting) despite the fact that the contours are continuous. Perforation options are available in the Advanced tab
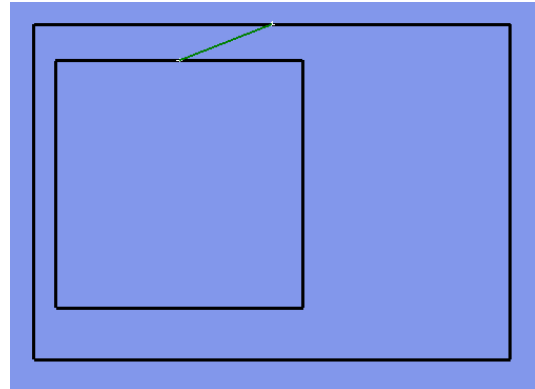
Operating with angular aggregate (Symmetry axis)

 Operating with the angular aggregate with setting "Axis of symmetry" requires the determining three-axis machining (eg. drilling or milling), and then defining the axis of symmetry or the axis around which the rotation of the generated toolpath occurs.

Being in the editing stage we select the segment which gives us the axis of symmetry, e.g. the edge of the drawn door, we right-click and select "Convert to (not) constructional." The line changes into the constructional one (dashed).

We exit the editing and being in the CAM we have to assign to the stage a tool from the storage which is Aggregate or T_H as a tool / aggregate fed from hand. After this operation the constructional lines will become visible. The line should be selected , we have to right-click and select "Set being the axis of symmetry". We click Create route.

Selecting the option Aggregate, the option Plate is automatically selected, which blocks the driving up after pressing STOP during operation. Otherwise, after stopping with the STOP, driving up will take place, which may damage the tool, the material and even the aggregate and / or the spindle. The option Plate should always be selected during operation with the aggregate.

The tool path is being generated and always refers to the spindle axis, so we need to add the offset by entering an appropriate value "Agr. - Distance from the axis " in the parameters of the tool, otherwise the aggregate will collide with the machined material.

By pressing CTRL + Mouse Wheel and while moving the mouse, we can change the perspective to view the generated path.

The option „Agr. – Tool angle" in the mechanical parameters tab determines the deviation of the aggregate tool from the 0Z axis. For fixed aggregates the value of 90 should always be entered there, for angular aggregates the value should be changed according to the angle set in the aggregate.

The option „Agr. – position" at which side (when the axis C = 0) the tool is. This is particularly important for double or quadruple aggregates.

If the line being the axis of symmetry is vertical and has its beginning at the bottom and its end at the top, the method of determining the symmetry axis refers to the operation at the the right side of this axis. If we wanted to set the operation with an aggregate at the left side, the axis of symmetry should start at the top of the line.

Obviously, we can determine the symmetry axis on lines which do not overlap with X and Y axes. The side of the appointed line on which the aggregate will operate depends on the order of selecting nodes.
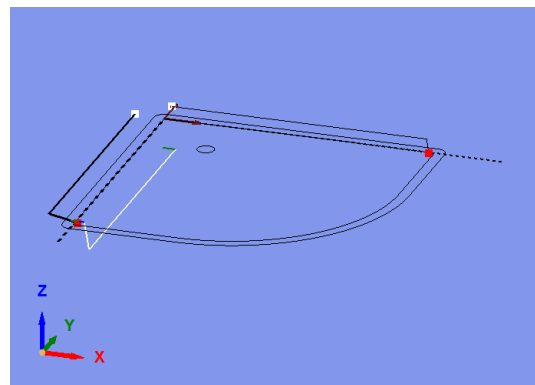
To return to three-axis machining without aggregate, you should right-click in CAM on the constructional line and select "Delete being the axis of symmetry," or choose a tool which is not an angular aggregate.

Horizontal cutting with angular aggregate

The other way to use an angular aggregate does not require determining the axis of symmetry.

Consists in the fact that with a constant <u>Depth</u> of Z-axis, the C-axis is set in the direction tangential to active contours. The <u>Depth</u> value determines the position of the tool axis in the aggregate, in relation to the surface of the material. The value of the <u>horizontal Depth</u> specifies how deep the tool will be deepened into the side walls.

In the adjacent figure, the route of the end of the tool is marked with white colour and the route of the spindle axis (incomplete) with yellow).
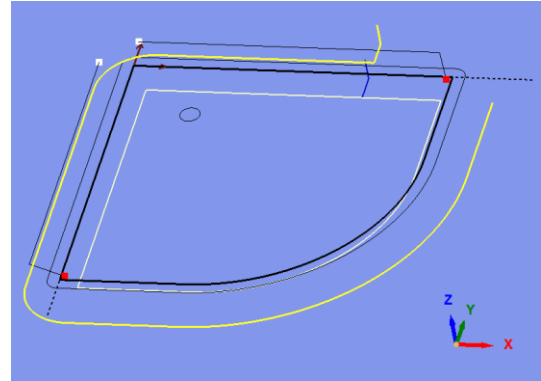
For this type of work an important step is to correctly set the location and the type of entry.

The vertical entry in this case refers to the Z-axis, so its effect will be the vertical furrow in the wall, to avoid this you must define the entry (and exit) <u>from the side</u>:

without a radius with the <u>angle of entry / exit</u> 90 degrees and with the appropriate <u>length</u>.

KiMLA

5.4. CNC

5.4.1. Machine control panel

After clicking the "**CNC**" button or pressing the **F1** key, the "**CNC controller**", which is visible in the figure, appears. The functions in the control panel allow manual movements of the machine, accessing the tool exchanger (optional), controlling the feed rate of the machine and operating with a scanner (optional). Depending on the number axes, the panel may be slightly different in appearance.

In the box "**Manual Control**" we have the ability to move the spindle head position using the arrow keys. We move the head along the X axis with the ← → arrows and along the Y axis with the ↑ ↓ arrows. Using the "**Page Up**", "**Page Down**" buttons we adjust the head height above the table (Z-axis). The "**Home**" and "**End**" buttons cause movement / rotation of the next axis, the "**Insert**" and "**Delete**" buttons cause movement / rotation of the next axis. Depending on the configuration of the machine there may be additional axes A, B, C, T (rotating storage), N (rotation of oscillating knife).

Although the machine can be controlled before initiating, it is recommended to find a reference point of the the machine by clicking the button FIND REF. .

The speed of movement of the machine depends on the parameters set in the "**Machine Settings**" panel and the position of the potentiometer. Pressing the "**Shift**" key, "**Ctrl**" or tilde "**~**" key while pressing an arrow key moves the machine with a different speed.

When the machine is not initialized, the speed of the machine in manual movements is limited.

It is also possible to move the machine in a step mode. In this mode, the machine does not move with a preset speed, but onto a preset distance.

By clicking the icon ▣ Or pressing the „**S**" key you switch between manual control modes: continuous and stepwise. The table below shows the control values for continuous and step modes, the step mode values are constant, the continuous mode values can be changed.

In the manual control box the appropriate value is displayed in white depending on pressing an additional key.
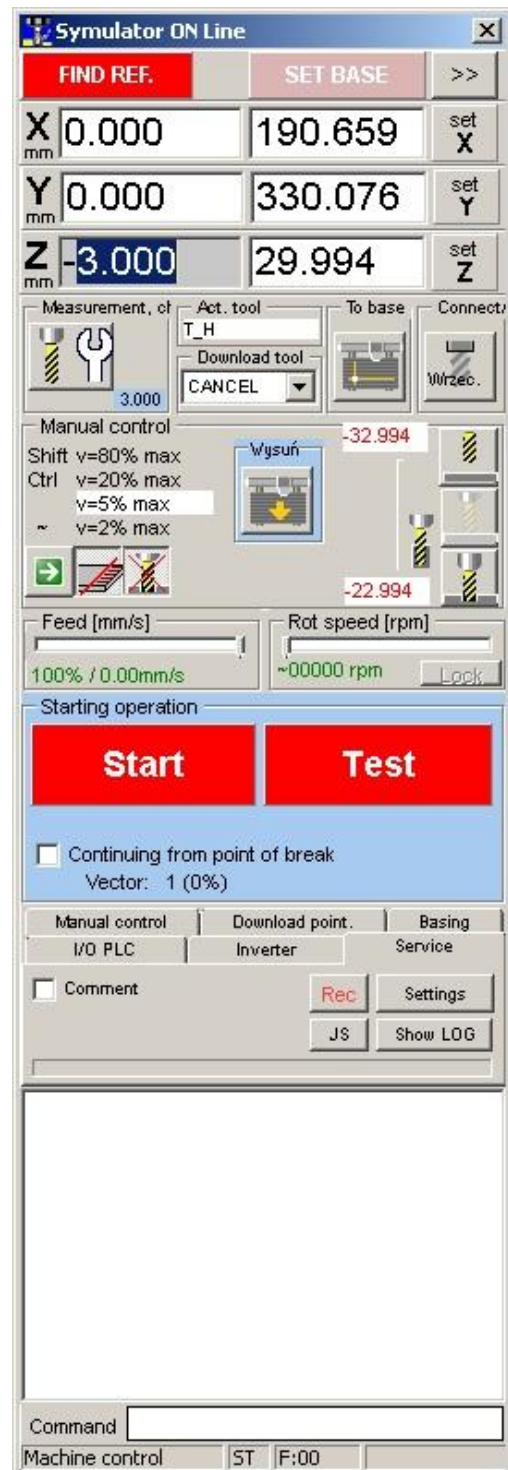
	Movement- step mode	Movement – continuous mode
Move in a given axis + Shift	10 mm or 10°	100% max speed of the machine
Move In a given axis + Ctrl	1 mm or 1°	20% max speed of the machine
Move in a given axis	0.1 mm or 0.1°	5% max speed of the machine
Move in a given axis + ~	0.01 mm or 0.01°	2% max speed of the machine

Note !!!

The speed and smoothness of the movement of the manually controlled machine depend on the operating system settings associated with the operation of the keyboard, such as repetition delay and next character repetition rate.

The buttons ![icon] ![icon] ![icon] successively cause: the head approaches the lifting height, the height of the material and the height of deepening

Note !!!

Before you use any of these functions, make sure you have set the base and it is valid for a given time. For example, we set the base, we change the tool for a longer one, without pressing the Measurement / Change, we press approaching to the lift height - because the length of the tool is outdated, the head enters the material, which may result in damage to the material / head.

The button ![icon] allows you to enable the spindle manually, e.g. to warm up the spindle bearings.

In the changing tool panel we are able to install the new tool before treatment well as during a break in treatment. After pressing the „Measurement, Change" button ![icon], the machine will move the head over the tool length sensor and will wait for the replacement. After making and confirming the replacement, the tool length will be measured and saved.

For example, before processing we measure the tool length. During machining the cutter is damaged, we break operation of the machine by pressing the "Esc" key or click the red "STOP" button on the control panel of the machine, we perform the tool changing procedure. After measuring the length by the machine, the new value will be saved and you can continue operating.

The „To base" button ![icon] causes that the machine approaches the the beginning of the drawing, which is the place set and saved by the "Set base" button.

The „Move away" button ![icon] moves the tabletop to allow easier access to the material..

5.4.2. Setting the base point of the project.

The beginning of the drawing is marked with the sign of crosshair. Adjusting the beginning of the drawing takes place by pressing the button ![SET BASE].

Then, the point at which the spindle is currently located is considered to be the beginning of the drawing (axes X, Y, Z point 0,0,0) . This operation is very important and should be performed each time after:

loading a new drawing,

changing the material being processed,

changing the tool without measuring the length.

In order to improve setting the base, the following buttons allowing you to change a single coordinate are available.

    ⌖   Download base from file.

    ⌖   Setting X component of base

    ⌖   Setting Y component of base

    ⌖   Setting Z component of base

Clicking on the "Download base from file" button opens the list of previously defined bases.

Clicking on either item on the list is equivalent to reaching a defined place with the machine and clicking "Set base", and what goes with it, we lose the currently set base.

The file with saved coordinates of basis points (bazy.ini) is located in the config directory of the program. It has the following structure:

[Bazy]   - file header (required)

B1_opis=Baza pokazowa - verbal description of base B1 (will be displayed in the program)

B1_X=100.000   - X coordinate of base B1

B1_Y=100.000   - Y coordinate of base B1

B1_Z=100.000   - Z coordinate of base B1

To add your own base, you must add four lines describing the new base.

Assign the sequence number to the entries of the base e.g.B2 (base number cannot be repeated).

Assign the name to the base (B2_opis) that it could be easily identified.

Manually enter the coordinates X, Y, Z (B2_X, B2_Y, B2_Z) of the base remembering that the decimal separator is a dot.

Write the file bazy.ini

The entry of the new base should look like e.g.:

B2_opis=BAZA NOWA

B2_X=58.452

B2_Y=256.991

B2_Z=11.801

In the panel "Start work" we can start milling with the button , and perform the test with the button . The test is performed 1 mm above the base with the head off. It allows us to determine if the performed tool path is consistent with the expected one.

Note !!!

Before pressing START or TEST, make sure that you have set the base and is up to date .

After pressing "START", "TEST" the panel is displayed as shown below.

You can see the number of the executed vector, the total number of vectors, and the current number of repetitions of the execution of the project.

The progress of operation can be broken by the red "STOP" button on the control panel, with the button in the program or by pressing the "Esc" key on your keyboard. We then have the ability to break the operation with the button or its continuation with the button . You can also continue operating from any selected vector. To do this,

you have to enter the number of the vector in the "**Vector**" box and press "**Continue**", and the machine will start to execute this vector as the beginning of work.

Note !!!

Changing the value to a larger one will cause continuation of operating with omitting a few vectors. If the sequence of performing work is important, it may cause damage to the material or the tool .

At the time of stopping, closing the machine control window is not possible. We can choose only [Stop] or [Continue].

5.4.3. Diagnostics of limit switches, buttons, and the tool length sensor.

If you suspect that one of the limit switches, the scanner or the tool length sensor does not work, you can check it in the control panel. Click on the "I / O PLC" tab.

When you press any of limit switches in the line "Limit Switches", on the line will appear the name of the axis on which the limit switch has been placed. If you press the tool length sensor, the field "TOOL" will be highlighted, and if you press the scanner, the field "Scanner" will be highlighted (if the machine does not have a scanner, the field is constantly highlighted). Similarly, by pressing the "Start" and "Stop" buttons on the control panel of the machine, we will cause highlighting the corresponding fields. The "PLC" button opens a diagnostic window of the machine signals.

5.4.4. Tool changing automatics panel.

Some machines are equipped with spindles with an automatic tool changing system. In the project panel you can define for each stage, which tool will be required to execute this stage. During the project implementation, at the beginning of each stage, the machine wil put aside the previous tool and will download another one.

When you manually control the machine, it is possible to put aside and download any tool. Additionally, you can turn off the mode of the tool control automatics and manually remove the tool. Available options are active when you select "Manual Control " in the automatics panel, shown in the figure.

Note !!!

During manual control, pressing the button "Open jaws" immediately opens the jaws. If there is a cone installed in the spindle, it will fall out at once, the machine will not drive to the tool change point. If we are not ready for it, we can damage the tool, the material,the table or even the cone.

Note !!!

Selecting the tool "Cutting blade controlled" in machines with automatic lowering of the blade will result in putting the tool aside and the knife will slide out

5.5. Quick start

We turn on the power using the main switch on the side of the machine. The computer starts up automatically. Then we run the PC-CAM program. If there appears an error message in the communication, we should check if the emergency button is not pressed (indicated by the green LED that is off in the control panel) and if Ethernet cables are correctly inserted in sockets. You should check if the IP address settings and subnet masks are consistent with the manufacturer's recommendations.

We open the previously prepared project file (extension *.PCPR) in the control program. If the file has not been prepared in advance, you should perform Figure in the CAD module of the program or import the file in one of the supported formats (e.g. DXF).Po wczytaniu pliku mamy wciśnięty przycisk CAD ![CAD], czyli jesteśmy w module do projektowania elementów, zaznaczamy interesujące nas elementy i klikamy „Stwórz obrysy" ![icon]. The selected elements form closed contours. Then we press the CAM ![CAM] and we select contours with the mouse or we select all CTRL + A, after selecting we select the green "+" to set the elements as active. We enter the stage settings, and we use a built-in calculator to determine the cutting speed. Then we press the CNC button ![CNC] (or the F1 key on the keyboard) to establish communication with the machine and control it. The machine control window "CNC controller"should be displayed.

Press the button ![FIND REF.] in the upper part of the CNC controller panel. The Z axis should rise up to the maximum, then the machine should drive to the lower left corner of the table. The zero point of the Cartesian system is located in the lower left corner of the work table, if we look down on the machine. The machine is ready for operation.

Using the arrow keys and Shift, Ctrl and ~ we drive with the head to the place where we want to set the base. This point is the lower left corner of the material by default unless in it is set differently the project. Driving down slowly with the Z axis, we set the head approx. 1mm above the surface of the material, and then we press the key ![SET BASE]. It is recommended that the last few centimeters to the base should be performed in the step mode ![icon], to prevent accidental damage to the tool.

We press the button ![TEST]. The machine should perform work with the tool lifted to the height of about 1mm above the set base (approximately 2mm above the material).

This option is used to check whether the cut object will fit onto the material. After a possible correction of parameters, we press the green "START" button on the control panel or the button ![START] in the program and after starting the pump the machine performs cutting. The progress of the work can be broken by the red "STOP" button on the control panel, the button ![STOP] in the program or by pressing the "Esc" key on your keyboard. After stopping the machine, we can do the following:

![BREAK] stop operating – operating stops and the head drives onto the lifting height,

 change the number of the current vector

![CONTINUE] continue operating – machine will be performing the rest of the drawing,

The current head coordinates are displayed in the upper part of the screen. In addition, the percentage progress of work is displayed in the form of the bar of progress in the bottom of the control window.

After finishing work, the Z axis will drive up and the message "Operation completed successfully" will appear..

5.6. Generator of stages

Generator of stages is functionality that allows automatic preparation of stages based on the drawing. Each contour which is a part of the drawing is assigned to a layer. You can associate any number of CAM templates with each of the layers. Then, automatic generating stages is possible with appropriate templates.
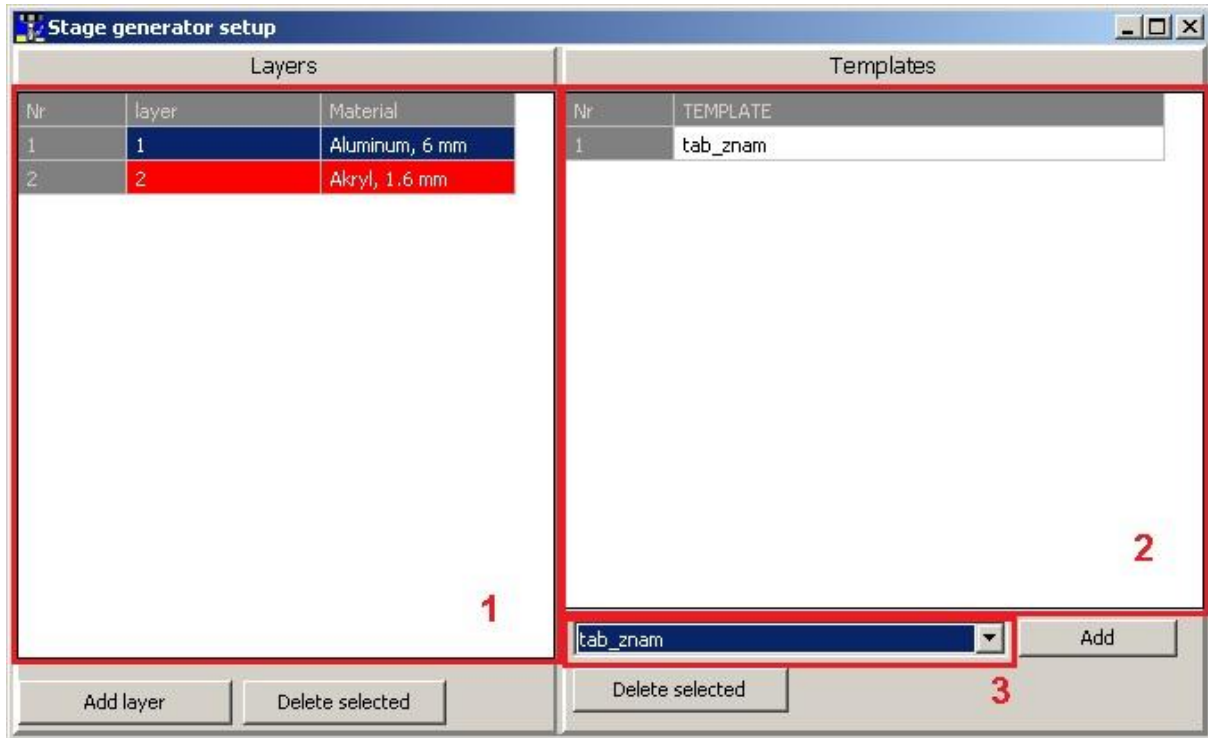
In the configuration of the generator stages window it is possible to determine for which layers the specific templates will be applied to. The list of layers is on the list **1**. Adding a layer is possible by pressing the **Add Layer** button. After writing the layer name, it will be added to the list. To remove layers from the generator of stages, you have to select them and press the **Delete Selected** button. Selecting layers in the list **1** results in displaying templates associated with the layer in the list **2**. To add a template association with the layer, you have to select a template from the list **3** and then click the **Add** button. Removing associations of templates with the layer can be achieved by selecting the templates in the list **2** and clicking **Delete Selected** button**.**

You should pay attention to the order of defining layers and templates (the order may be changed by dragging individual items with the mouse). Stages will be generated in the order of appearance of layers and templates in the configuration window.

After configuring the generator, it is possible to automatically create stages while loading DXF files or on demand. To automatically generate stages based on the configured associations, you should select the option **automatically generate stages** in the DXF import window.
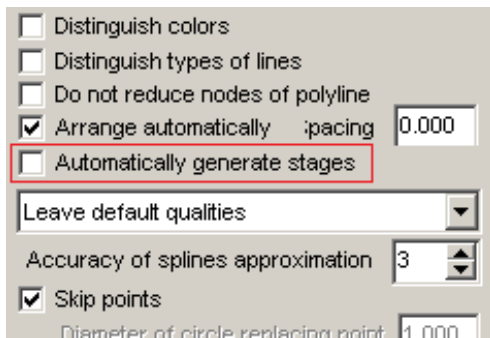
To generate stages from the already existing drawing, you need to press the **Generate stages** button located on the top bar and is available in the CAD mode. Stages will be generated for the currently selected drawing.

If a current drawing contains objects whose layers do not have defined templates, a warning will be displayed.
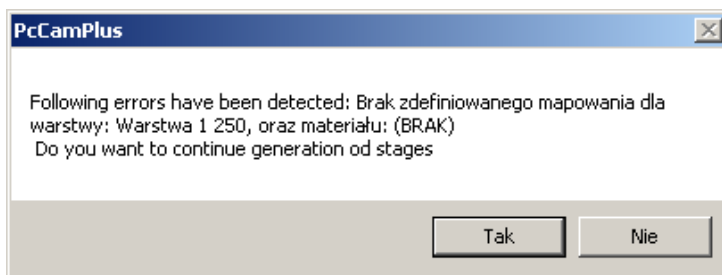
Clicking **yes** will generate stages without layers, for which there is no mapping. If you click **no** the generation of stages will be broken.

Configuration of mapping is stored in the file **layer2template.datx**, which is located in the directory with the program.

Program control keys and mouse functions:

Key	Function
Esc	Quit / Close CNC controller panel (sterowania maszyną)
F1	Display CNC controller panel (sterowania maszyną)
F2	Displays CAD panel
F3	Displays CAM panel
F5	Update tool path of the selected stage
Ctrl + F5	Update tool path of the all stages
F9	Centers view at cursor
F11	Centers view at cursor and zooms out
F12	Centers view at cursor and zooms in
Ctrl + G	Create contours from selected objects
Ctrl + U	Separate selected groups, contours
Ctrl + C	Copy selected elements to clipboard
Ctrl + V	Paste selected elements from clipboard, with an offset of 10mm up and 10mm right
Ctrl + A	Select all
Delete	Delete selected
x2	zoom on the whole drawing
(rotation of scroll wheel)	Decrease / Increase drawing scale
CTRL + mouse move	Rotate drawing in area
Ctrl+X	Protection form collision with the material enabled/disabled
Ctrl+S	Saves the project to the hard drive
S	Switches the machine into continuous / step operation mode
When active CNC controller	
Klawisze strzałek	When CNC controller active, machine movement at X and Y axes
Page up	Raises Z axis
Page down	Lowers Z axis
Insert	Rotate next axis (eg. N)
Delete	Rotate next axis (eg. N) in the opposite direction
Home	Rotate next axis (eg. B)
End	Rotate next axis (eg. B) in the opposite direction

6. Appendix A

6.1. NC code record format accepted by PC-CAM software

NC code reading in the PC-Cam software has been prepared in order to identify a maximum number of postprocessors that are included in CAM software.

Note !!!

IT IS NOT POSSIBLE TO PROVIDE COMPATIBILITY OF READING FILES FROM ALL POSTPROCESSORS AND ALL CAD SOFTWARE

Taking into account the development of engineering software and increasing requirements of accuracy and complexity of processing, the main emphasis has been placed on the lack of limits on the length of the code loaded.

The files that contain the machine code should have NCC or NC extension. PC-CAM also recognizes files with HNC extension, but their structure is different.

Note !!!

Performing paths saved in the NC code requires the PC-CAM software in 3D

6.2. Characters recognized in the code

1. ***** character of the beginning of the line with the comment
2. **;** character of the beginning of the line with the comment
3. **_** character of the beginning of the line with the comment
4. **O** character of the beginning of the line with the comment
5. **(** the beginning of the comment
6. **)** the end of the comment
7. **G** preparatory function followed by a one or two-digit code
8. **F** feed speed control function
9. **S** rotational speed control function
10. **T** tool changing
11. **X,Y,Z** final coordinates of the straight line or the arc
12. **CC** circular interpolation in files with HNC extension
13. **D** direction of circular interpolation in files with HNC extension
14. **L** function representing the linear interpolation in files with HNC extension
15. **M** auxiliary function followed by a one or two-digit number
16. **N** the line numbering

6.3. Initial coordinates

> **Note !!!**
>
> **If in the NC code in the first line with the coordinates of the beginning of the file or in the first line with the coordinates after the tool changing (T) the coordinates of all the available axes are not given, the value of 0.0 will be adopted for axes which we have not taken into account**

e.g.

T8 – tool exchange

C180 – approaching X0 Y0 Z0 C180 coordinates

6.4. Comments

The following signs indicate starting the line with the comment: *, O, _ , ; (semicolon).

If the interpreter detects one of these characters, it goes automatically to loading the next line of the code. This means ignoring all the characters to the end of the line. To place a comment you can also use characters ( ) - parentheses. In this case the comment is placed inside the parenthesis; the characters outside the parenthesis will be interpreted.

Examples of using comments:

* It is a comment...
X10 Y20 *It is a comment...
(It is a comment...) X30 Y40

6.5. Feed Speed control

The **F** character is followed immediately by a number greater than zero indicating the machine feed speed in mm/min. This speed is compared with a maximum speed of the machine and is entered as the speed of cutting moves of linear and circular interpolation, starting with a given line to cancelling with another **F** instruction.

6.6. Rotational Speed control

The **S** character is followed by a number greater than zero indicating the rotational speed of the tool. This number is compared with the minimum and maximum rotational speed and saved as the current speed for a given tool (stage). The rotational speed control is possible only by machines with the appropriate communicating module located in the frequency inverter.

6.7. Line numbering

The line numbering is not obligatory. However, you can save the existing tool path by adding the line numbers to it. In this case the lines will be numbered using the **N** character and the number identifying the next line in the code.

6.8. Coordinates dimensioning

The functions **G90** and **G91** determine the way of the coordinates dimensioning. In the case of **G90** we have absolute coordinates, in the case of **G91** the coordinates are incremental. The record in the absolute coordinates means the feed of the machine to a specified point, the record in incremental coordinates - the feed by the value preset. The following examples illustrate two ways of dimensioning.
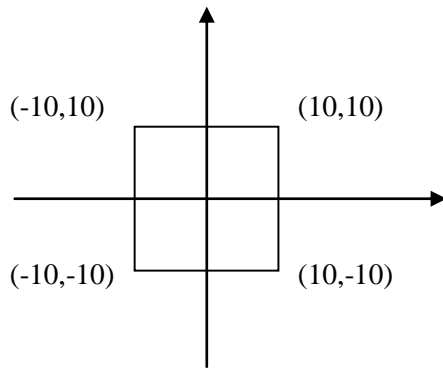
Figure 13 Absolute dimensioning

```
G90

G0 X10 Y10

G1 X-10

Y-10

X 10

Y10
```
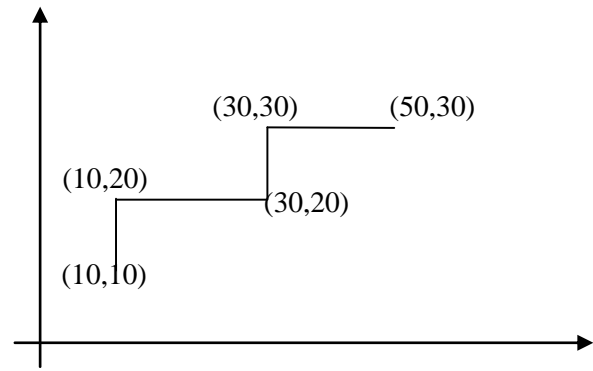

Figure 14 Incremental dimensioning

```
G91

G0 X10 Y10

G1 Y10

X20

Y10

X20
```

The default value which is valid from the start of the program is **G90**. If the entire code is given in absolute terms, there is no need to call the **G90** instruction. When all values are given in incremental coordinates (**G91** at the beginning of the code), the default starting point is X = 0 Y = 0 Z = 0.

6.9. Coordinates dimensioning units

The functions **G70** and **G71** change dimensioning units of coordinates. G70 means dimensioning in millimeters, **G70** in inches. The default unit valid from the start of the code are millimeters. If the entire saved code is given in millimeters, there is no obligation to give **G71**.

6.10. Approaching motion (G0)

Calling this function causes the motion of the machine to the destination point specified by the XYZ coordinates at a maximum speed of the machine. This speed is set in the Options menu -> Machine Settings separately for the X,Y axes and the Z axis.

Note! The value of the maximum speed should not be increased without consulting the manufacturer. Approaching speed is regulated by the knob on the control panel in the range from zero to 145% without the possibility of exceeding the maximum speed. The G0 instruction is performed until it is cancelled by the **G1**, **G2** or **G3** instructions.

6.11. Linear interpolation (G1, G01)

Calling the G1 function causes the movement of the machine along a straight line to the destination point specified by the coordinates XYZ. This movement takes place with a operating speed specified by the the F parameter, for example:

```
G1 X10 Y20 Z30 F300
```

means the movement along a straight line to the point (10,20,30) with the speed of 300 m/min. If in a given line the speed is not specified, the previous value of speed is assumed. It is similar in the case of any value of the feed, for example:

```
G1 X10 Y20 Z30 F300
X50
```

means the movement along a straight line to the value (10,20,30), and then to the value (50,20,30). The operating feed (G1) applies to all lines until it is canceled by G0, G2 or G3 instructions. The value of

KIMLA

the feed speed can be adjusted from 0-145% with the knob on the control panel. Operating speed cannot be greater than the maximum speed of the machine specified in the Options menu -> Machine Settings.

6.12. Circular interpolation (G2, G3)

The G2 or G02 function means the feed along the arc in the clockwise direction to the destination point. The G3 or G03 function means the counterclockwise movement . You can place the arc on the XY, XZ or YZ planes. There are two ways to write circular interpolation.
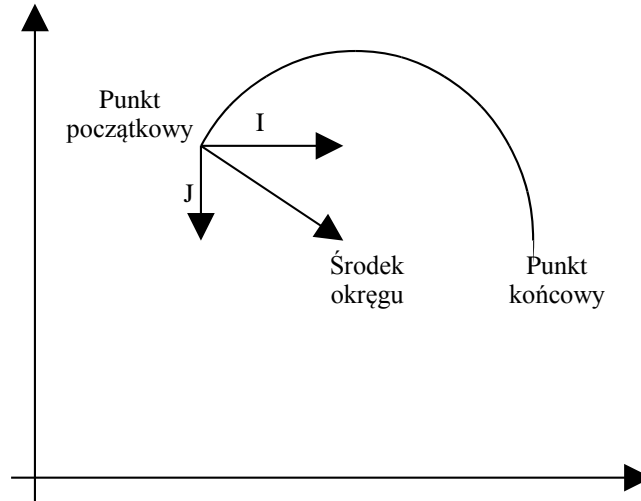
Figure 15 Circular interpolation with J,I,K parameters

The I, J, K coordinates are the values of the displacement of the point of the beginning of the arc to the centre of the arc.

1. I - X component of the displacement
2. J - Y component of the displacement
3. K - Z component of the displacement

If the arc is located on the XY plane, the K component is set to zero automatically. If the end point will coincide with the end point, the full circle will be made.

An example record of circular interpolation:

```
G0 X50 Y50
G2 X50 Y60 I0 J5
```
means approaching the point (50.50), and next the feed along the semi-circle from the start point to the end point. Coordinates of the arc centre are (55.50) (X coordinate of the start point plus I and Y coordinate of the start point plus J). Approaching will take place in the clockwise direction.

The G2 instruction sets the clockwise direction, instruction G3 means the feed goes in the counterclockwise direction. The R (or U) parameter means the value of the radius of the arc appointed by the following rules:

• If the length value is preceded by - (minus), the central angle of the arc is greater than 180 degrees.

• If the length value is not preceded by any character, the central angle of the arc is less than or equal to 180 degrees.

6.13. Feed on the helical path

The feed on the helical path is possible only in the XY plane. To perform this feed we declare simultaneously all the three parameters of the position of the destination point and the parameter defining the movement along the arc G2 or G3. For example:

```
G0 X10 Y0 Z0
G2 X-10 Y0 Z-5 I-10 J0
G3 X10 Y0 Z-10 I10 J0
G2 X-10 Y0 Z-15 I-10 J0
G3 X10 Y0 Z-20 I10 J0
```

means approaching the point (0,0,0), and next plunging on the helical path to the depth of -5 and further successively to the depth of -10, -15 and -20. At each plunging the machining direction is changed.

6.14. The choice of the machining plane

The preparatory functions G17, G18, G19 are used to select the machining plane.

If you do not declare any value, the G17 value is assumed as default. The plane selection is important in circular interpolation.

G17 – XY-plane of processing,

G18 – ZX-plane of processing,

G19 – YZ-plane of processing,

Note !!!

In the case of the helical path motion the machining plane is always G17.
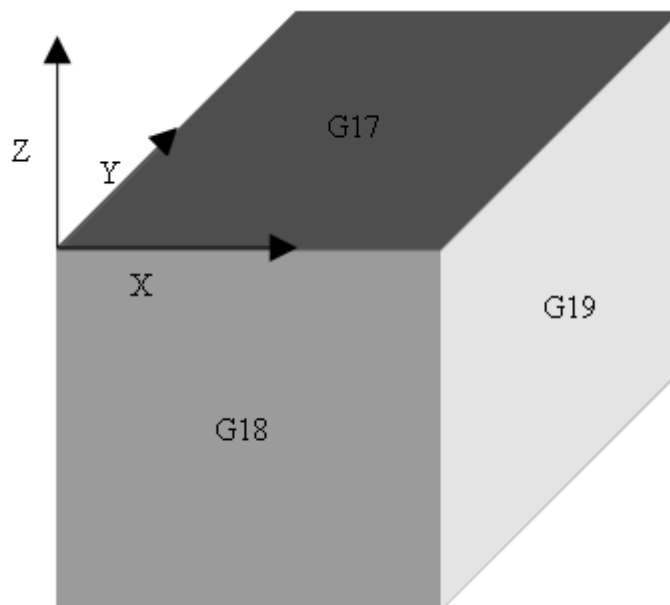
Figure 16 shows the arrangement of planes selected with G17, G18, G19 functions

 Example of machining on the plane other than default one:

```
G0 X0 Y0 Z0

G18

G3 X10 Y0 Z0 I5 K0
```

```
G1 Y5
```

```
G2 X0 Y5 Z0 I-5 K0
```

The above statement should be understood as follows: approaching the point (0,0,0); switching the machining to the XZ plane; the movement along the arc to the point (10,0,0); the movement along a straight line to (10,5,0) and the return arc (0,5,0). In machining on the XZ plane the displacement parameter of the arc centre along the Y-axis - J has been replaced by the K - displacement parameter of the arc along the Z-axis.

```
G1 Y5
```

```
G2 X0 Y5 Z0 I-5 K0
```

The above statement should be understood as follows: approaching the point (0,0,0); switching the machining to the XZ plane; the movement along the arc to the point (10,0,0); the movement along a straight line to (10,5,0) and the return arc (0,5,0). In machining on the XZ plane the displacement parameter of the arc centre along the Y-axis - J has been replaced by the K - displacement parameter of the arc along the Z-axis.

7. Appendix B

Parametry techniczne maszyny

Voltage	400 V
Maximum power consumption	6500 W
Maximum spindle speed	50000 rpm
Working table area	X-1700, Y-3100 mm
Spindle holder	ISO 30
Number of places in the storage	16
Minimum air pressure	8 bar
Number of the machine	2017
Year of production	2015
Total weight	2800 kg

8. Appendix C

Electrical documentation of the machine

8. Appendix C

9. Appendix D

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```
=========================================================
```
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```
                ===========================================================
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