MOTION LAB BERLIN

Workshop handout

Introduction to 3-Axis CNC machining

www.motionlab.berlin

HELLO!

In this workshop you will learn how to use the Routermax 1325 CNC milling machine at MotionLab.Berlin. This machine allows you to prototype 2D-3D parts through subtracting material by planing and milling parts of it. By the end of the session, you will have milled a series of parts from MDF that can be assembled.

This handout compiles the most relevant information about CNC milling, as well as some practical instructions on how to use the CNC mill at MotionLab.Berlin. We encourage you to always come back to this material in case you have any questions regarding the use of the technology and the machinery.

YOUR LEARNING OUTCOME

During this workshop you will learn how to:

- Create a CNC-G-Code with Estlcam, and transfer it to the CNC machine
- Use the control software MACH 3
- Operate the Routermax 1325 CNC machine safely

We introduce ourselves

What previous professional experience do you have?

What expectations do you have of this workshop?

Do any of you already have a concrete project?

Should the CNC milling machine be your "main tool" or be part of your manufacturing strategy?

MACHINERY & EQUIPMENT

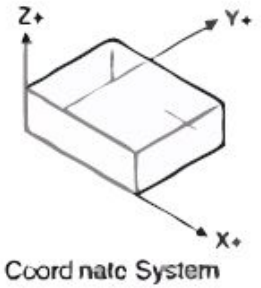
Winter CNC Routermax - Basic 1325 Deluxe

Workspace:
2500 x 1250 mm

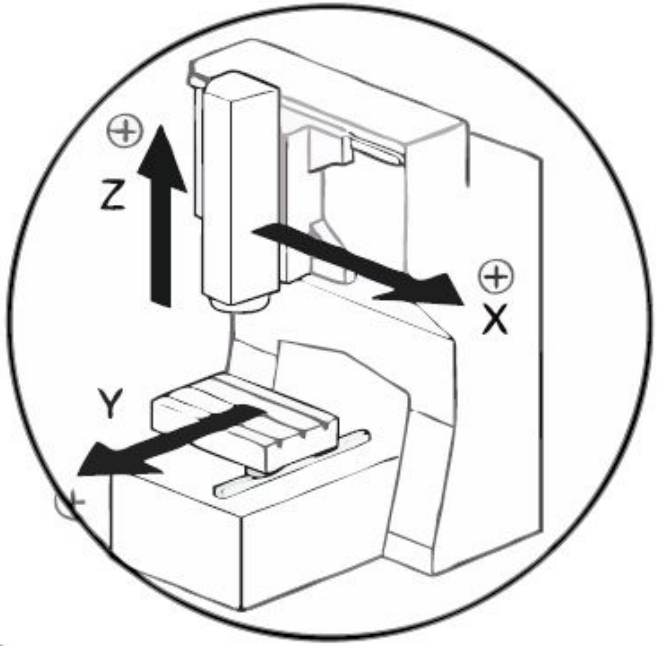
Vacuum pump

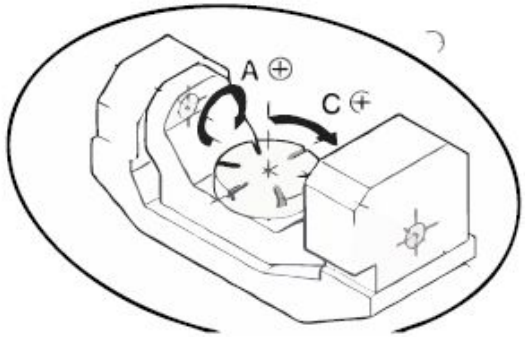
You can use the machines by booking them HERE

3-axis CNC machine, 2,5 milling



Coord nate System

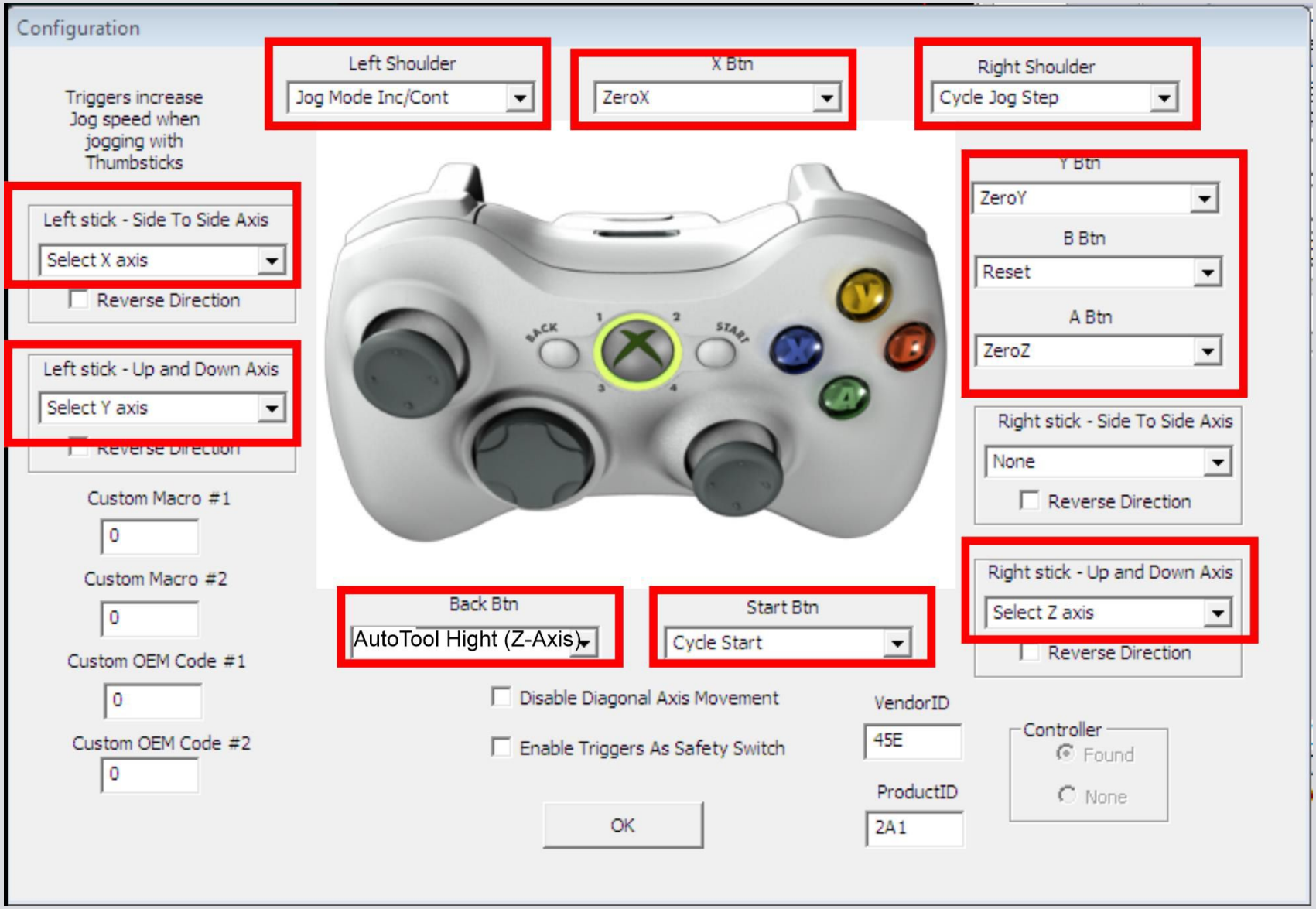




Z Achse

X, Y Achsen

X-Box Controller / Key settings



The journey is the reward.

CAD Software

- Inventor
- Solid works
- Rhino
- Fusion360
- AutoCAD
- Etc.

CAM postprocessing „Translator“

Frässtrategie festlegen
Übergabe an den Postprozessor.

Mach3 (Arc) mill
- Mach3 ATC (Arc) mill
- Estl CAM
- WinPc CNC
- USB - CNC
- Eding CNC
- Linux - CNC
- Many more...

CNC control software MACH3, and/ or others

„Brain“

„Muscles“

Gcode – a machine language

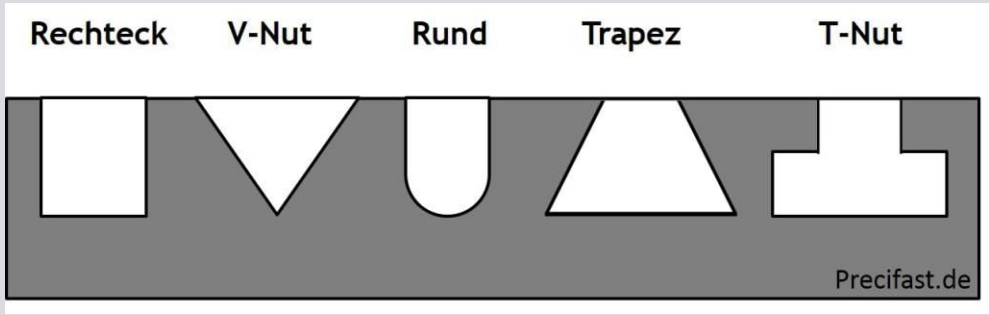
1. (Project square-100x100)
2. (Created by Estlcam version 8 build 8,507)
3. (Machining time about 00:00:20 hours)
4. (Required tools:)
5. (Fraeser 5mm)
6. G90
7. M03 S20000
8. G00 Z5.0000
9. (No. 1: Ausschnitt 1)
10. G00 X27.4935 Y-122.4535
11. G00 Z0.5000
12. G01 Z-1.0000 F900 S20000
13. G01 X27.4943 Y-27.4935 F1500
14. G01 X122.4543 Y-27.4943
15. G01 X122.4535 Y-122.4543
16. G01 X27.4935 Y-122.4535
17. G00 Z5.0000
18. G00 X0.0000 Y0.0000

Gcode	Explanation	Erklärung
G90	Use absolute coordinates	Benutze absolute Koordinaten
F900	Speed: 900	Vorschub: 900
S20000	Spindle RPM: 20000	Spindel U/min = 20.000
G00	Rapid Motion	Eilgang
G01	Cutting Motion	Arbeitsgang
Z5.0000	Move Z to 5 mm height	Fahre Z auf 5mm Höhe

Cutter (Router Bit) - Design - Geometry

Type
- End Mill
- V-bit
- Ball Nose
- Trapeze cutter (dovetail)
- T-slot milling cutter

Cutting geometry
- Up cut
- Down cut
- Combination up/ down cut



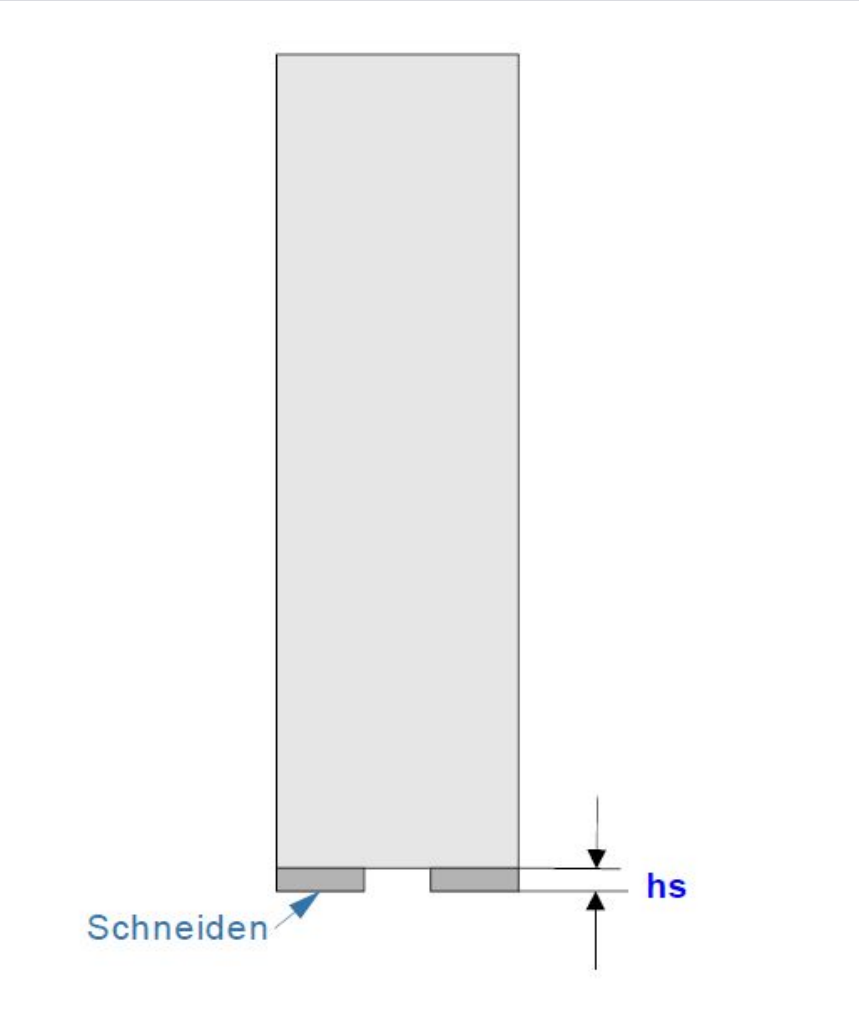
Milling directions:
Counter-face milling (outer contour)

Synchronized milling (inner contour)

"Plunge" of the milling cutter

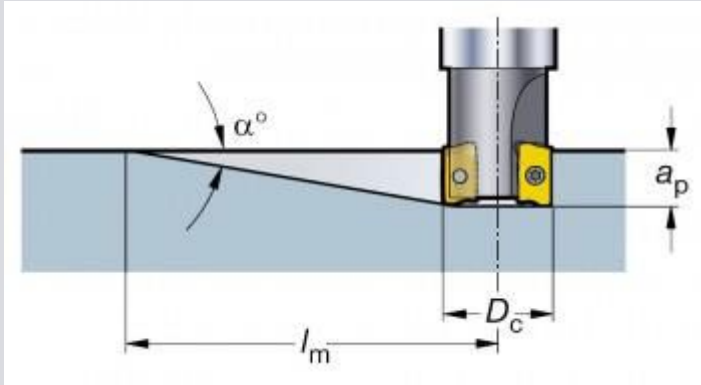
plunge or **"plunge in"**

• only possible up to cutting edge height (hs)



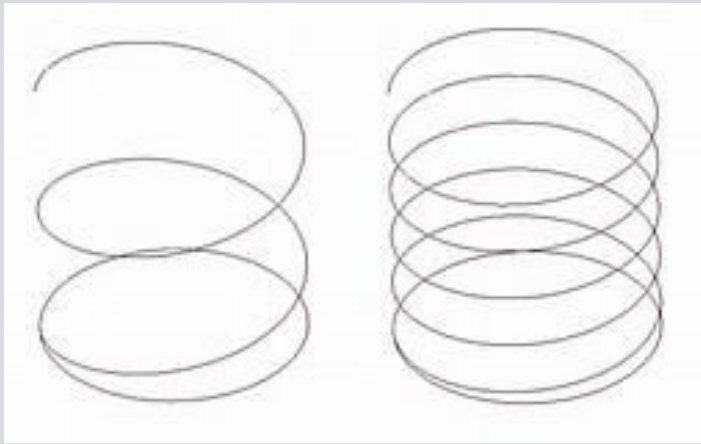
"Plunge" of the milling cutter

Ramp



Helix

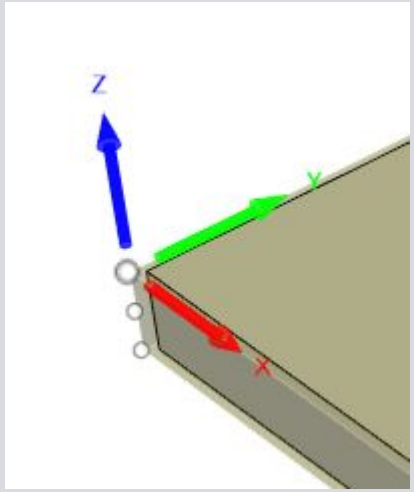
- **Spiral-plunge**



The Z- zero point - alignment

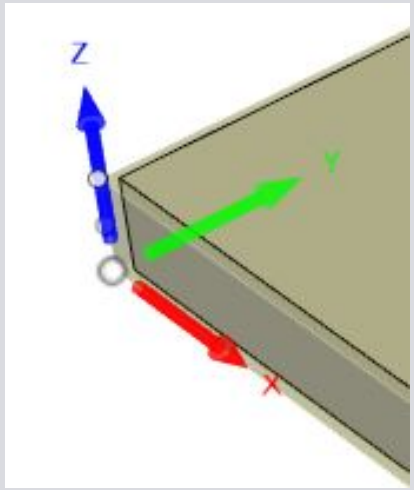
Z- Zero point on workpiece surface:

Depth of a "pocket", blind hole in relation to the workpiece surface

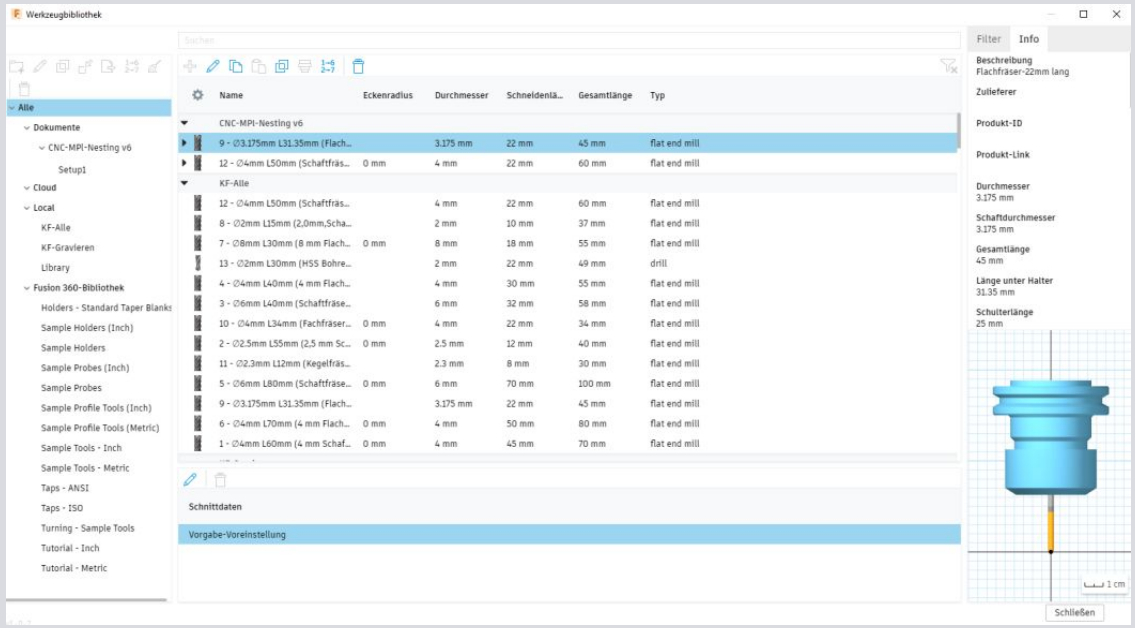


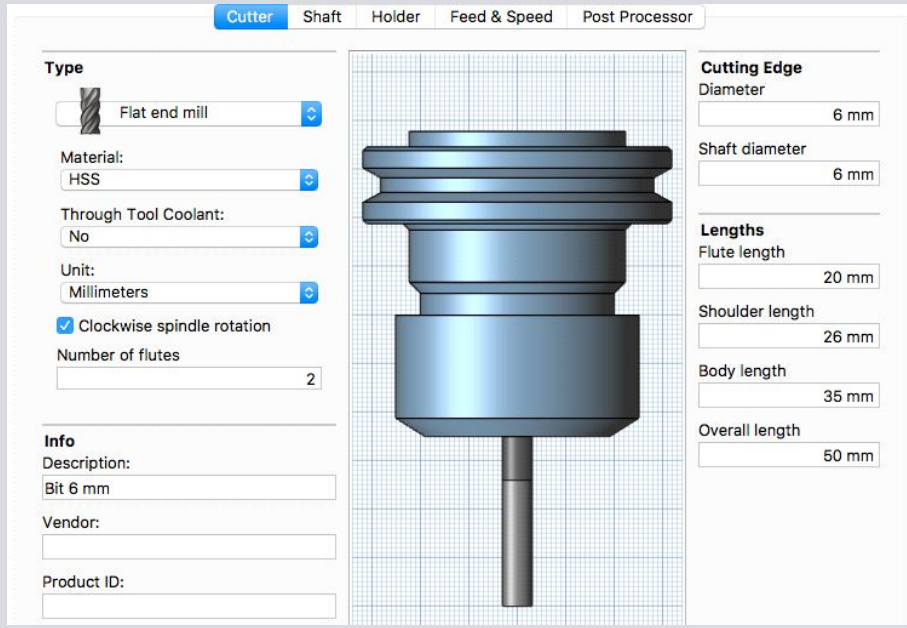
Z- zero point on the machine bed:

“Milling out" the contour of a geometry



Tool library Fusion360





Tool change M6

Assign "unique" number

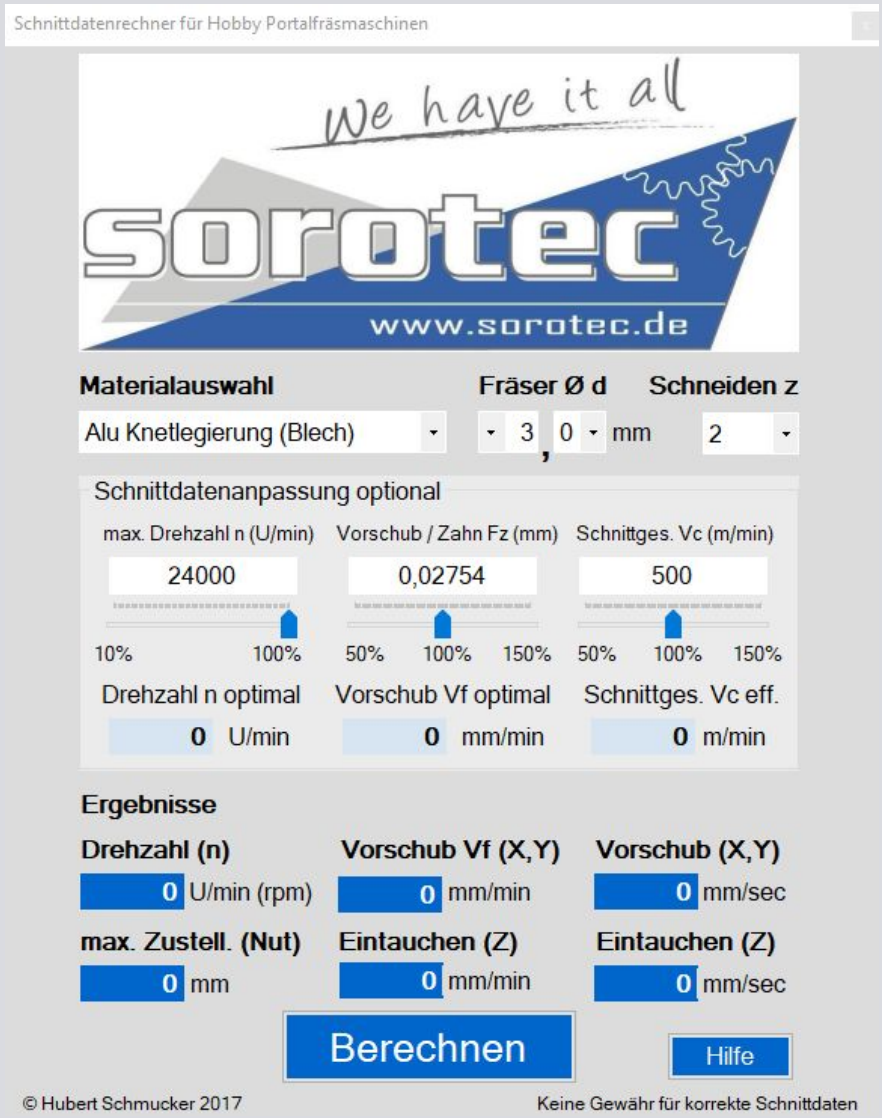
...a little arithmetic is necessary

Richtwerte Fräsparameter										
Materialien	Schnittgeschwindigkeit [m/min] Vc	Duchmesser Fräser								
		Ø 1 mm	Ø 2 mm	Ø 3 mm	Ø 4 mm	Ø 5 mm	Ø 6 mm	Ø 8 mm	Ø 10 mm	Ø 12 mm
		Zahnvorschub (fz) in mm/Zahn/ Umdrehung								
Alu- Druckguss	200	0,01	0,01	0,01	0,015	0,015	0,025	0,03	0,038	0,05
Knetlegierung, Aluminium	500	0,01	0,02	0,025	0,05	0,05	0,05	0,064	0,08	0,1
Weichkunststoff	600	0,025	0,03	0,035	0,045	0,065	0,09	0,1	0,2	0,3
Hartkunststoff	550	0,015	0,02	0,025	0,05	0,06	0,08	0,089	0,1	0,15
Holz hart	450	0,02	0,025	0,03	0,035	0,045	0,055	0,065	0,08	0,09
Holz	500	0,025	0,03	0,035	0,04	0,05	0,06	0,07	0,085	0,1
MDF	450	0,03	0,04	0,045	0,05	0,06	0,07	0,08	0,09	0,11
Messing, Kupfer, Bronze	365	0,015	0,02	0,025	0,025	0,03	0,05	0,056	0,065	0,08
Stahl	90	0,01	0,01	0,012	0,025	0,03	0,038	0,045	0,05	0,08

n - Speed of the milling cutter [1/min]
Vc - Cutting speed [m/min]
Vf - Feed speed [mm/min]
d - Diameter of the milling cutter [mm]
z - Number of teeth (number of cutting edges)
Fz - Tooth feed mm/ tooth/ revolution
n = (Vc * 1000)/ (Pi * d) [1/min]
Vc = (n * Pi * d)/ 1000 [m/min]
Vf = n * z * fz [mm/min]

Immersion depths
- **Aluminum: 0,1- 0,5*d**
- **Wood: 1- 1,5*d**
- **Polyoxymethylene: 0,5- 1*d**
- **Rigid foam 2- 5*d**

The cutting data calculator



Free Download :

- **https://webseite.sorotec.de/service/downloads/**
  Milling parameters
- **„Schnittdatenrechner zur Installation auf dem Pc“**

The dangers of feed speed

Cause	Consequence	How to fix
Feed rate too high	„Singing noise“, to fine chips	Reduce feed rate
Feed too large	Cutter rattles, vibrations, material melts	Reduce feed
Speed too low	Noise	Increase speed
Milling Cutter blunt	Unclean Results	Use sharp, high quality milling cutters
Cutting edge too short	Shaft grinding, smoke development, odor	Use end mills or mills with longer cutting edge
Cutting edge too long	Cutter bends, vibrations	Use shorter milling cutter with sufficient diameter
Cutting edge too hot	Smoke development, milling cutter turns black	Use shorter milling cutter with sufficient diameter
Resin deposition	Cutter turns black	Cleaning the milling cutter
Union nut not sufficiently tightened, collet not fitting	Cutter releases and drills into the workpiece	use exactly fitting collet chuck and tighten union nut with the wrench
Groove plugged with chips	Chips in the groove	Use milling cutter with large flute / suck out flute during milling, whirling
Cutter glued with melted chips	Grinding chips on the milling cutter	Use milling cutter with large flute, more feed, less infeed
Material gets into vibration	Noise emission	Tighten guides sufficiently, set connections, clamp properly, use vacuum table

Workpiece clamping

We always use a "sacrificial plate”!

- Further clamping variants for the workpiece
- Vacuum
- Holding claws
- Screws (Spax)
- Individually designed holding elements

The sacrificial plate serves as a "protective layer" between the workpiece and the machine bed.

If minor inaccuracies occur, not the vacuum bed of the machine but only the sacrificial plate is damaged.

MATERIALS

Which materials can be milled and which not?

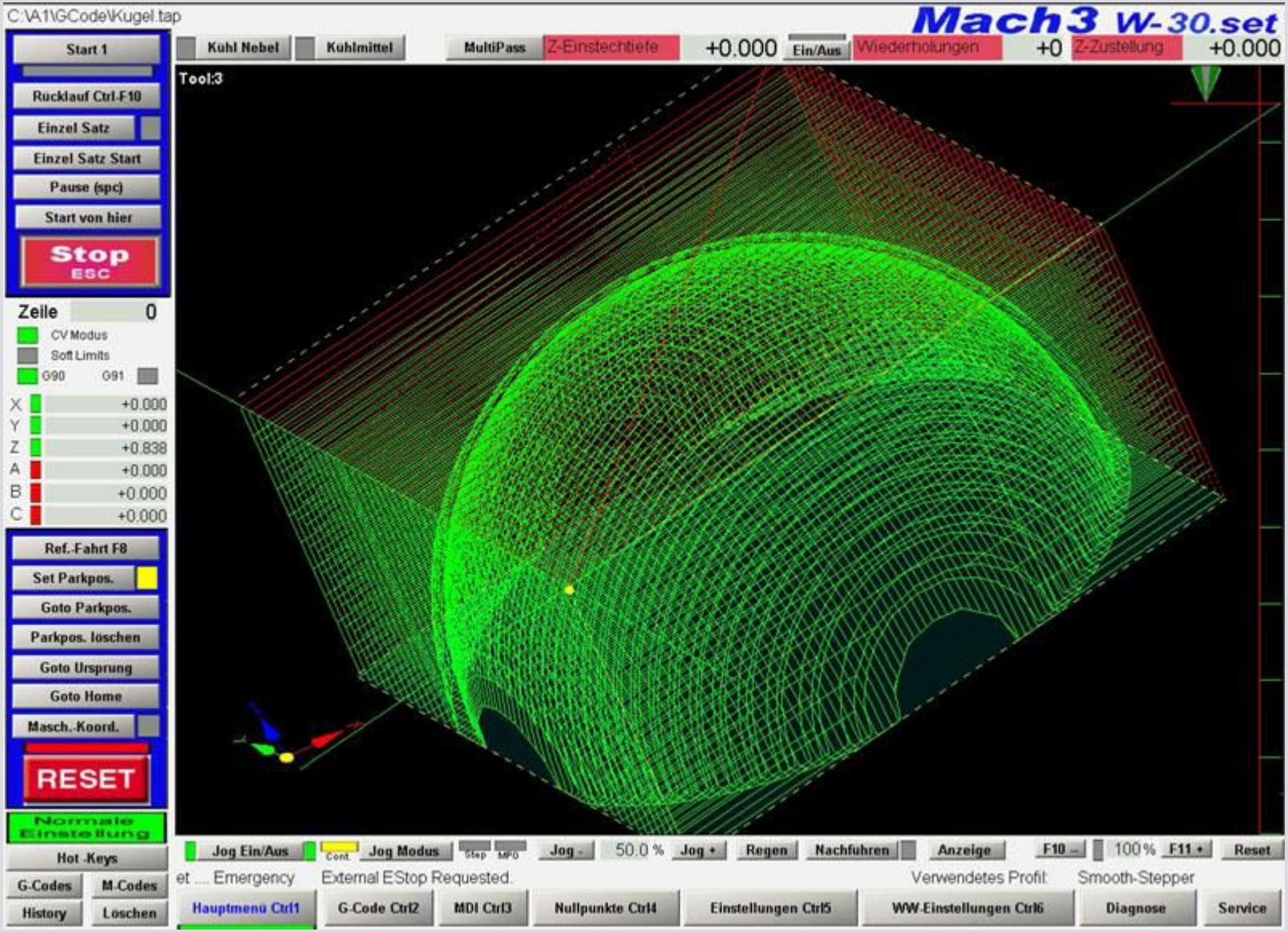
DO

- NE metals (aluminium , brass, bronze, copper)
- Hard/ soft woods
- MDF (Attention: fine dust can be carcinogenic use suction
- Plywood, multiplex
- Plastic (POM, acrylic)
- Rigid foam , polystyrene

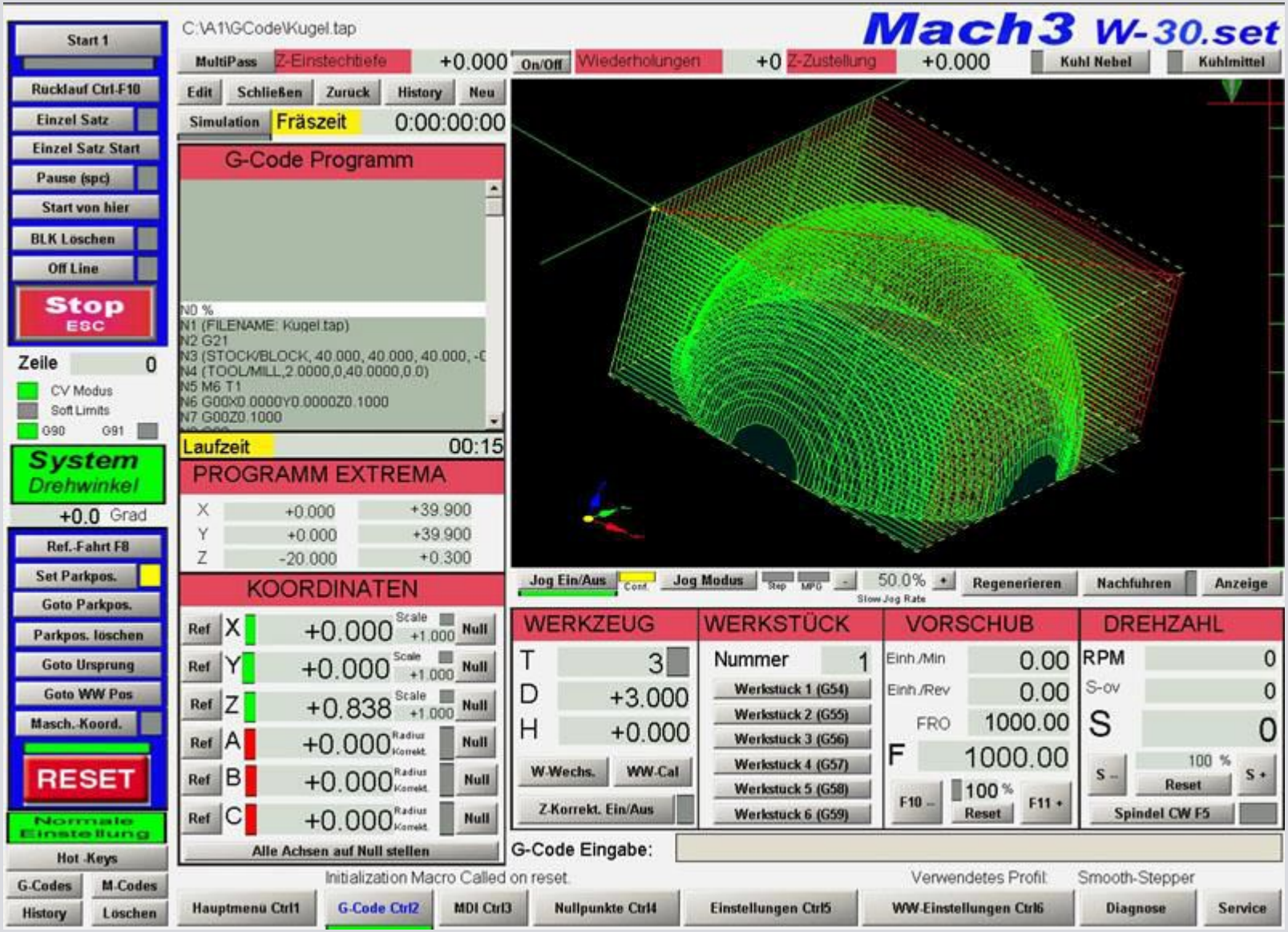
DO NOT

- Steel
- Stone

Mach3 control software - start screen



Mach3 control software - working screen



Work safety and behavior in WoodLab

Industrial safety

- Hearing protection
- Safety goggles
- Face mask - Fine dust (MDF)
- Gloves - special case!!!
- head protection - longhaired "hoggers”
- Tight fitting clothing
- Sturdy shoes

Clean up

- Remove our legacies (swarf) and empty the collection containers
- Return tools and materials to their original location
- Switch off power to machine (milling machine), shut down PC
- "All around" visual inspection
- Light off
- Locking the entrance door

Checklist for working with the CNC

Preparations:

- Book milling machine
- Boot up PC
- Switch on the switch cabinet (green control light)
- Mach3 software:
  - Press reset button
  - Axes X,Y,Z Move limit switch free
  - Homing of all axes : F8 key
  - Load Gcode menu item File)
- Clamp milling cutter (Collet, union nut , insert into spindle)
- Position and clamp the sacrificial plate and raw material
- Working coordinates (X,Y,Z define zero points)
- Move "suction shoe" on/ into position
- Switch on the extraction system
- Start milling program (Gcode)

Rules of conduct:

- Never leave the machine unattended during the milling process!
- Always keep milling paths free of chips!
- Keep checking the workpiece clamping regularly

Postprocessing:

- Wait until the spindle "stops".
- Clamping the milling cutter
- Free movement of workpiece
- Clamping of workpiece and sacrificial plate
- Switch off switch cabinet
- Shut down pc
- Cleaning the machine
- Dispose of material residues
- Clean up workshop, sweep
- Empty chip container (suction system, vacuum cleaner)
- Visual inspection
- Lock the workshop

ALMOST THERE!

NOW, PARTICIPATE FROM THE LIVE WORKSHOP AND START WORKING ON YOUR PROJECTS!

DID YOU LIKE HE CONTENT OF THIS WORKSHOP AND YOU ARE STILL NOT A MEMBER?

Join our ecosystem and make your ideas come to life!

Reach out to our colleague Matthew

Or sign up for our newsletter to learn about the upcoming workshops and events.

Note:
This is a living document, which may experience changes as our labs evolve.
If any of the links don't work, please report it to info@motionlab.berlin

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