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# BRIGHT

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## BOOSTING THE SCIENTIFIC EXCELLENCE AND INNOVATION CAPACITY OF 3D PRINTING METHODS IN PANDEMIC PERIOD

# e -TOOLKIT 3
# FIXATOR MADE BY STEREOLITHOGRAPH (Digital light processing method)

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| **Project Title** | **Boosting the scientific excellence and innovation capacity of 3D printing methods in pandemic period 2020-1-RO01-KA226-HE-095517** |
| **Output** | **O2 – BRIGHT e-toolkit manual for digital learning in producing medical parts by 3D printing methods in the context of the pandemic** |
| **Toolkit** | **e-Toolkit 3<br>Fixator made by Stereolithography<br>(Digital light processing method)** |
| **Date of Delivery** | **November 2021** |
| **Authors** | **Aleksandar Miltenović, Milan Banić, Nikola Vitković, Miloš Simonović** |
| **Version** | **Final variant** |

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## Content



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## 1 Introduction

In orthopedic surgery, it is vital to use proper fixation techniques to treat various medical conditions. Here is a requirement to provide the best possible medical treatment to a patient with a bone fracture. Surgeons use internal and external fixation techniques to treat bone fractures.

Nowadays, one of two types of plates and their variants are commonly used for bone fixation is Locking Compression Plates (LCP). These fixation systems are standardly anatomically shaped, and they provide angular stability to the bone.

In this toolkit will be shown printing process with all necessary pre- and postprocessing steps as well as machine settings for successful printing of the part – Locking Compression Plates which fixation plate.

## 2. Stereolithography Process

Stereolithography, as 3D printing technology, has following steps in the

- Selection of technology and machine
- Generating 3D model in a software for 3D modelling
- Generating STL file
- Defining parameter of machine for printing (at first use)
- Optional correction of object geometry
- Object positioning
- Generating support
- Distribution of model with support at platform for printing
- 3D printing
- Postprocessing

In a similar way, the steps required for modelling of the medical part is going to be presented. Details presented must be just enough for the readers so they can also replicate it at their home institution following the procedure described in the toolkit manual.

Standard for 3D printing is STL file that needs to be generated. Most of used CAD software (Solidworks, Catia, Inventor) has number of restrictions in work with STL files and therefor is

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necessary using of specialized software for STL file processing. One of those software that can be used for stereolithography is Materialise Magics.

Options that are important for conversion are related for resolution. Most of software are giving button option with high, medium and low resolution as well as options that user can enter his tolerances. As the user want higher resolution and better surfaces, he should choose lower tolerances for possible deviations. This is especially important for the partswith surfaces that are not plane and under angle. As the tolerances are lower the final STLfile will be higher. Also, in the cases when printing resolution is low, high STL file resolution isnot going to get any result. Therefor is important to know the resolution of the printer. For example, Envisiontec Ultra 3SP has the maximal resolution of 0.025 mm in z direction.

Material consumption is an important issue for parts made by Stereolithography printing process. If the functionality of the part as well as strength is less important, there should be less used material. In that case for stereolithography is important to define the model as hollow and to define technological holes if this is necessary. Preprocessing can be done in 3D modeling software that can be, is some cases, easier comparing with software for manipulation with STL file.

## *3.* Generating geometry and preparation for printing

Part that need to be printed has to be made in some of CAD software for 3D modeling. After the modeling is finished is necessary to convert part into STL file. Today all the software has possibility to convert file into STL (Figure 3. 1 – Autodesk Inventor).

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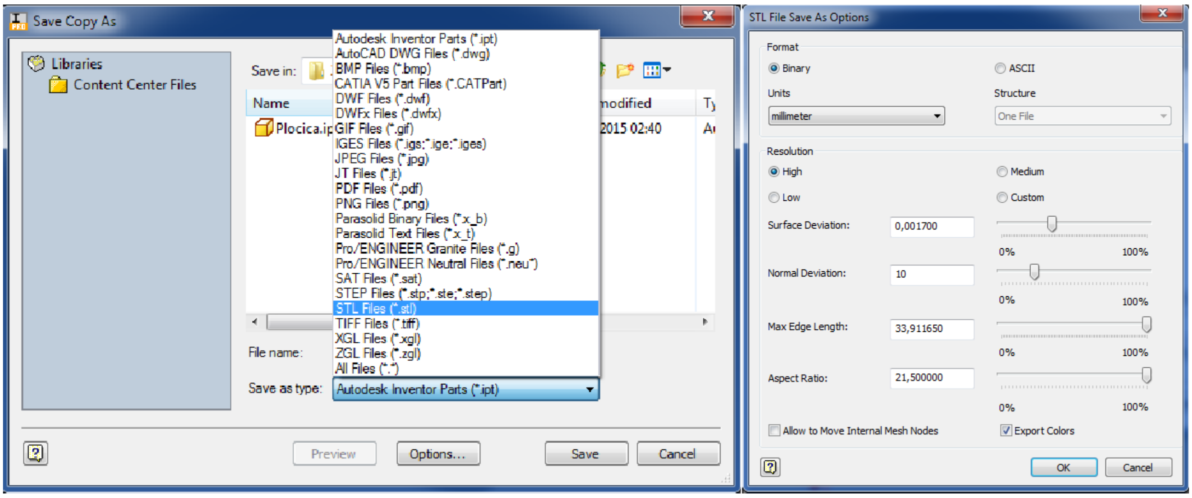


Figure 3.1. Autodesk Inventor windows for converting in STL with possible options

Wall thickness is important for printing process while if the wall dimension is too small there is dangerous that during printing or in postprocessing phase wall can have or got cracks. Some tips for wall thickness is to be at least 1 mm but results will be better if it is 2 mm. Also here should be taken into account the size of the wall and is edge of surface with thickend or not.

Technological holes should be defined for leakage of liquid material. The tip is that the smallest diameter of hole should be 2 mm, but it  would be better to have more holes and that diameter is 3 mm. For this is important also to define the logical position of the hole at the part. Position should be at surface that is not important for the part functionality and that will allow liquid material to leak out (Figure 3.2, 3.3, 3.4).

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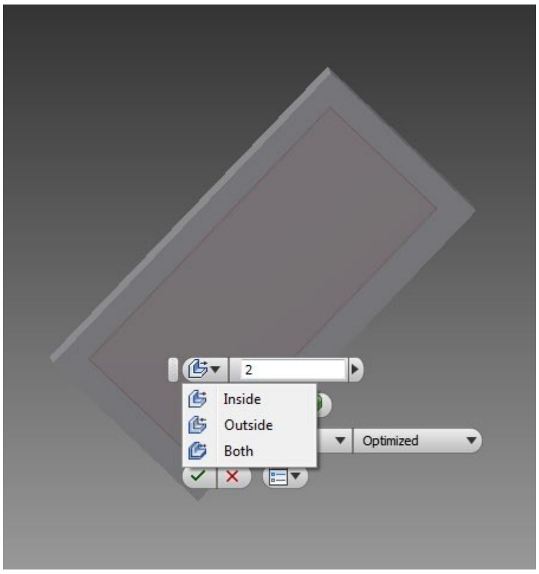


Figure 3.2. Defining hollow and position for technological hole

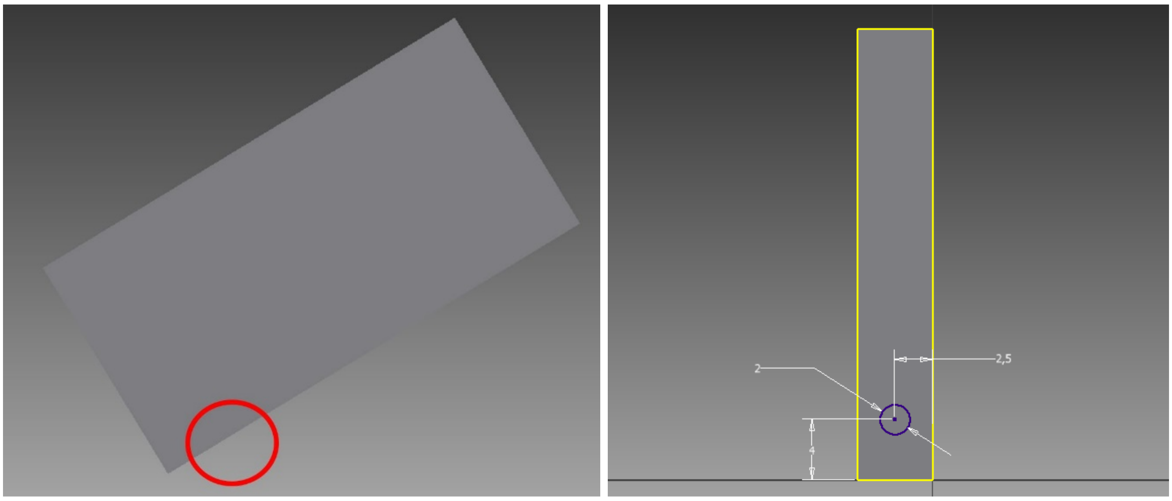


Figure 3.3. Position for technological hole

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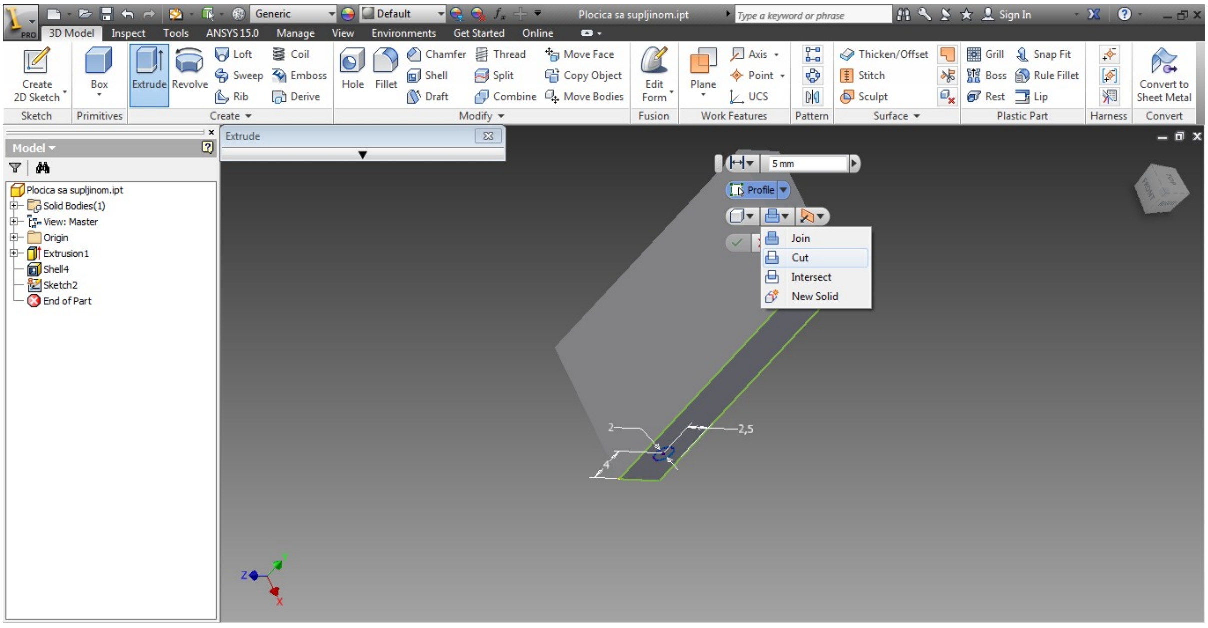


Figure 3.4. Definition of technological hole in CAD software

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## *4.* Materialise Magics

For the good printing of the part is important to define the machine settings. Materialise Magics offers a lot of parameters that need to be defined in order to have good print. Therefor in Figures 4.5 - 4.43 is going to be presenting defining settings step by step. This isespecially important for support settings that enables the good connection to basic platform from one side and to the printed part on other side. This gives smooth postprocessing in which part with support structure need to be separated from platform as well separation of printed part from support.

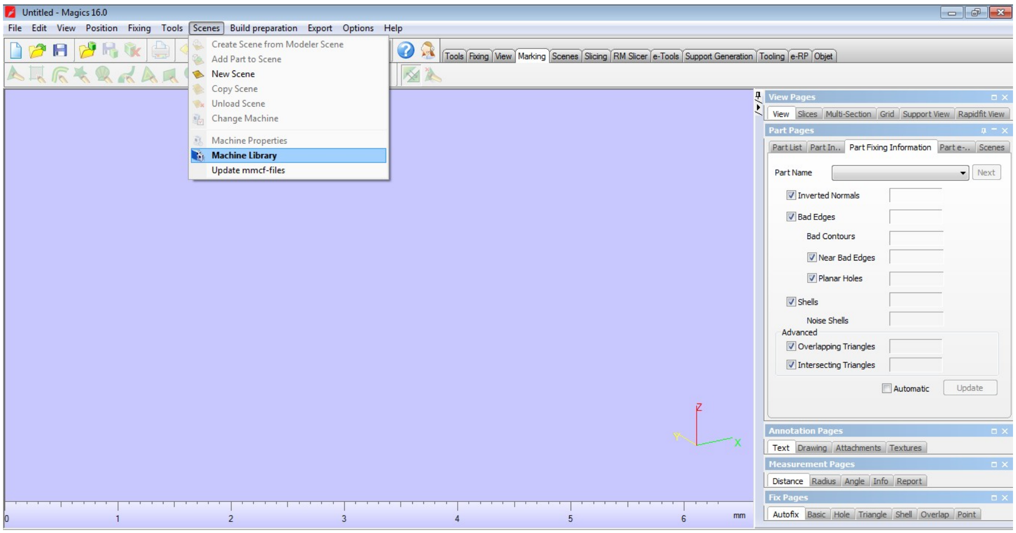


Figure 4.5 Surrounding in Materialise Magics

Figure 4.5 represent Surrounding in Materialise Magics. To access Machine Library is necessary to use card Scenes. After clicking Machine Library is necessary to use Envisiontec Prefactory as it is shown at Figure 4.7.

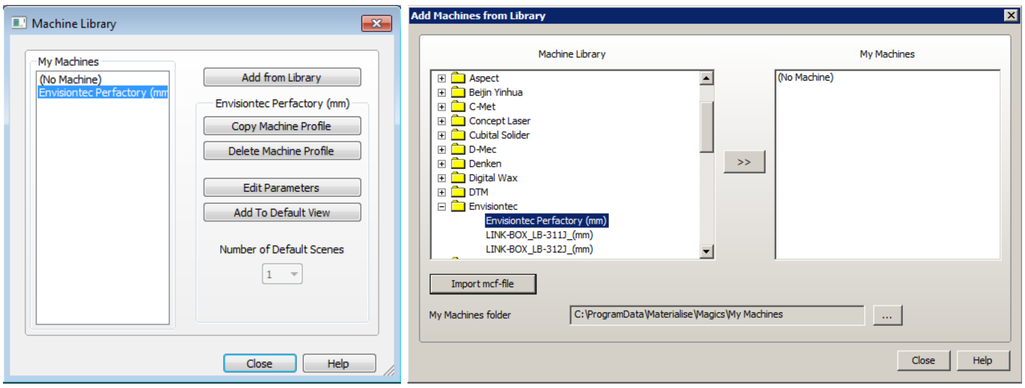


Figure 4.6. Introduction of Envisiontec Prefactory

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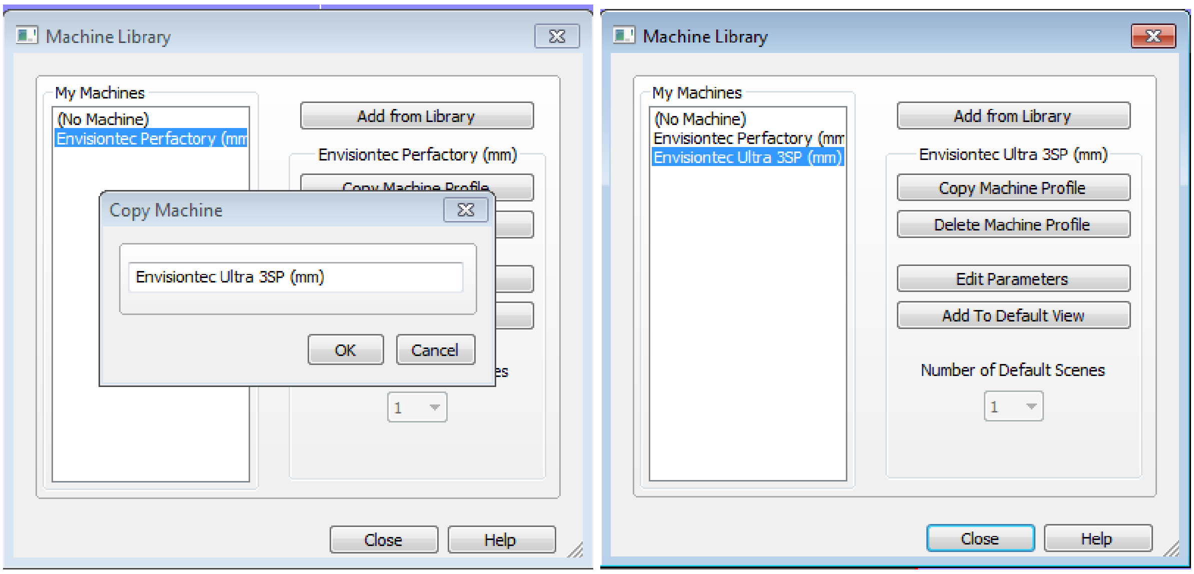


Figure 4.7. Defining 3D printer into Materilise Magics

In Figure 4.7 is shown procedure in which is copied "Evisiontec Perfactory" and changed in the name of 3D printer that is used for printing. In this case is 3D printer "Envisiontec Ultra 3SP" and that is the name used for defining work enviroment. In Figure 4.8 is given introducing field for Envisiontec Ultra 3SP enviroment.

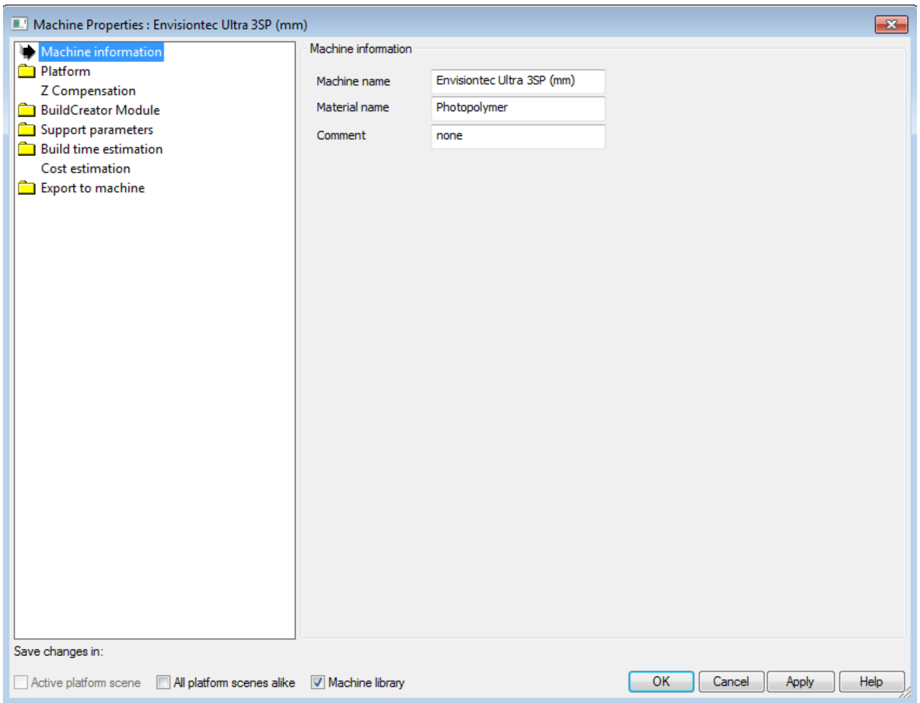


Figure 4.8. Introducing machine settings – machine information

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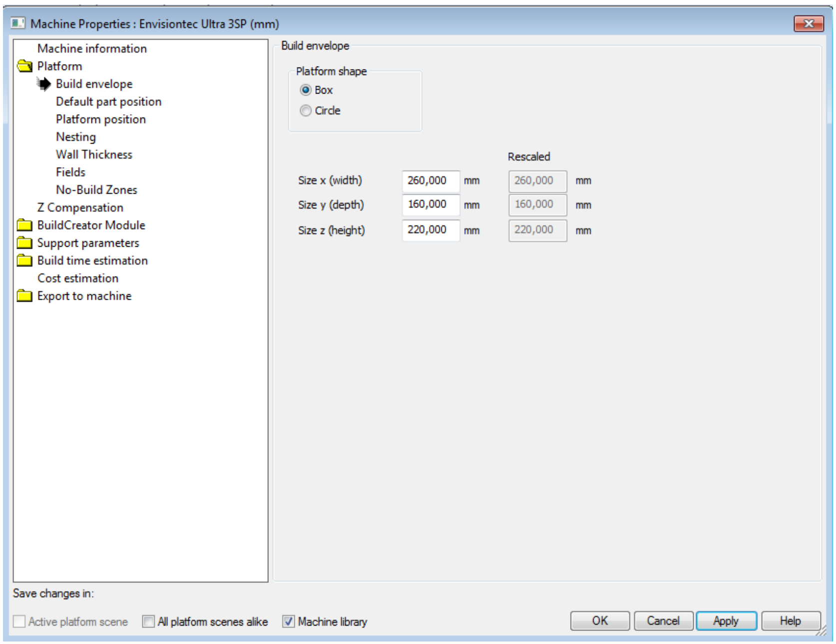


Figure 4.9. Introducing machine settings – platform

In Figure 4.9 are given machine settings for the platform. It has box shape with size 260x160x220mm. In Figure 4.10 is defined default part position for the position of the printingpart on platform.

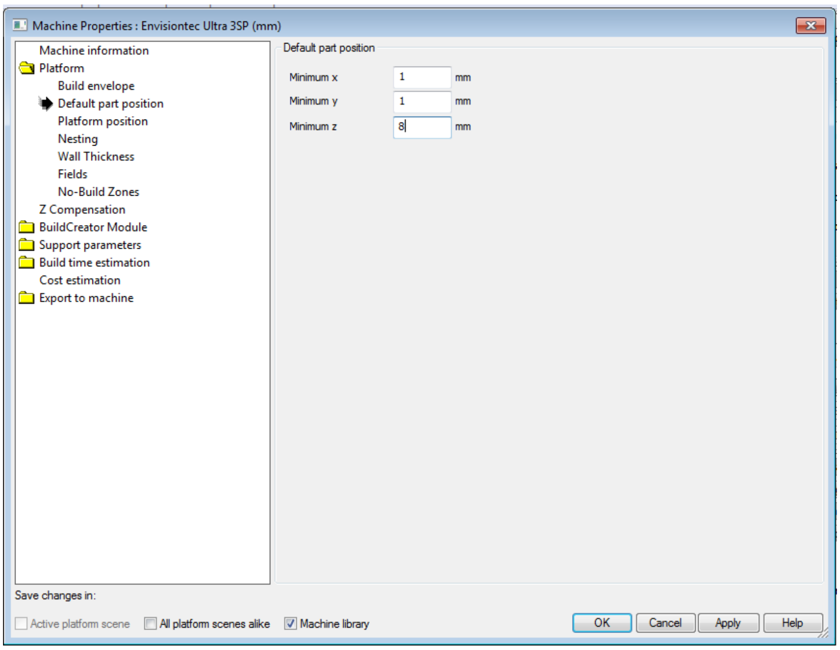


Figure 4.10. Introducing machine settings – default position

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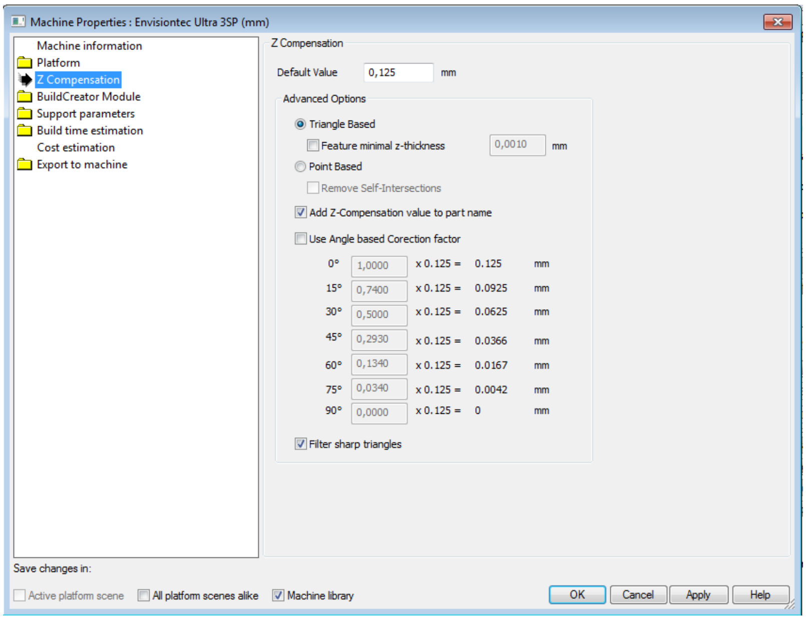


Figure 4.11. Introducing machine settings – platform, z Compensation

In Figure 4.11 is defined z-compensation for the platform – 0.125mm. In Figure 4.12 is defined support format that can be the same as printing part or different. For the successful printing is necessary that the printing part and support has to be entered as two files but with same names.

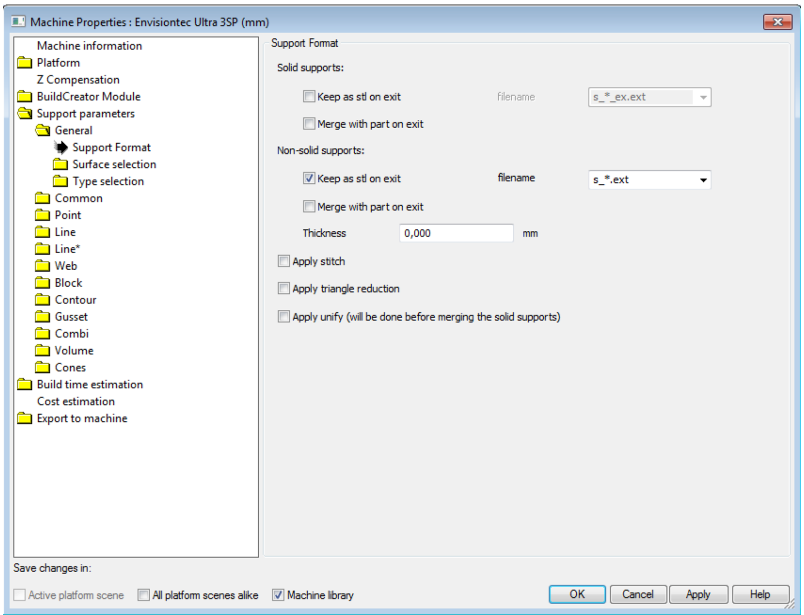


Figure 4.12. Introducing machine settings – support format

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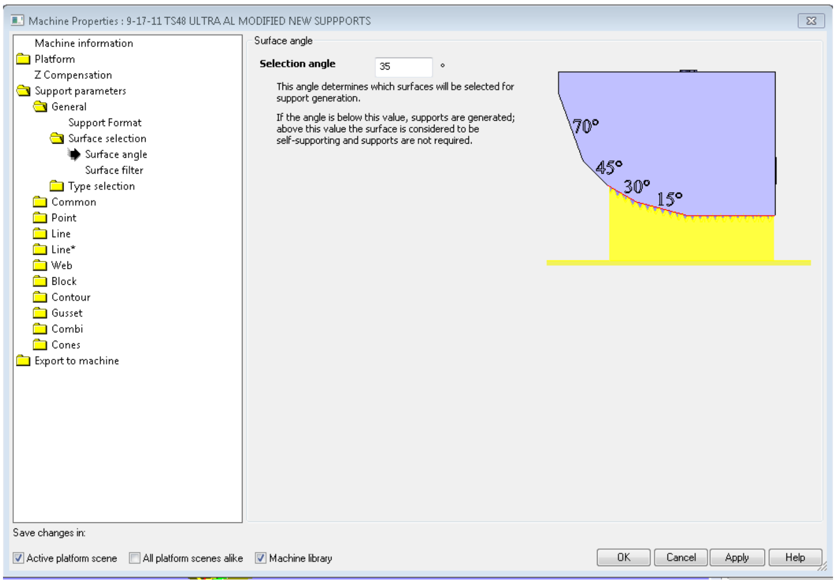


Figure 4.13. Introducing machine settings – surface angle

In Figure 4.13 is defined surface angle in which support will be generated on the part.
In this case will be used 35 degrees. In Figure 4.14 is defined surface filter and surface angle.

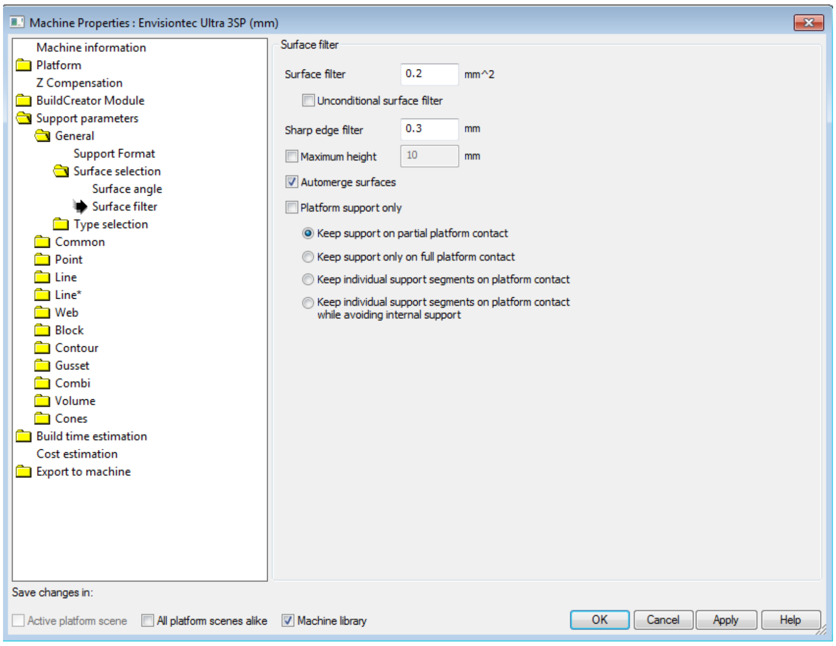


Figure 4.14. Introducing machine settings – surface filter

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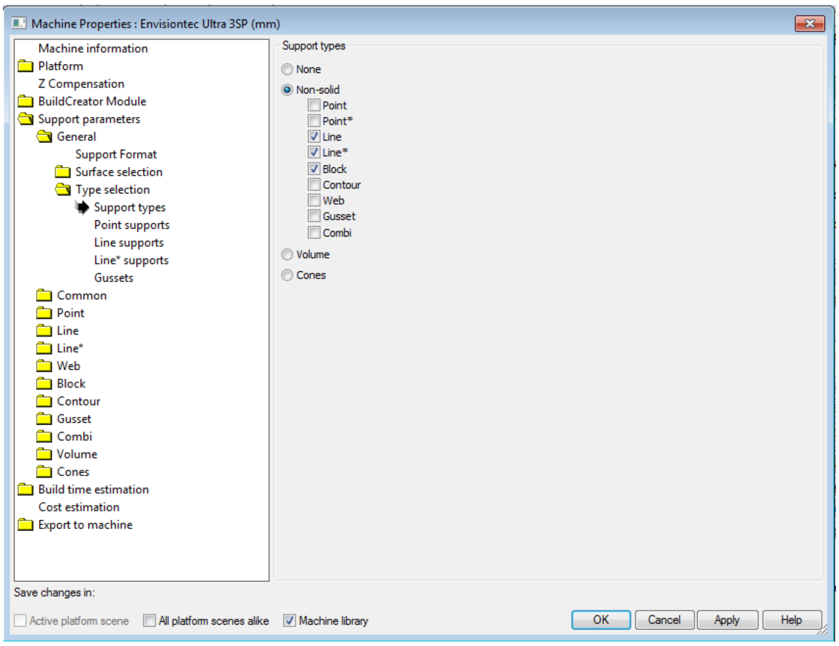


Figure 4.15. Introducing machine settings – support types

In Figure 4.15 is defined surface angle in which support type. In Figure 4.16 is definedbasic parameter for support – gusset.

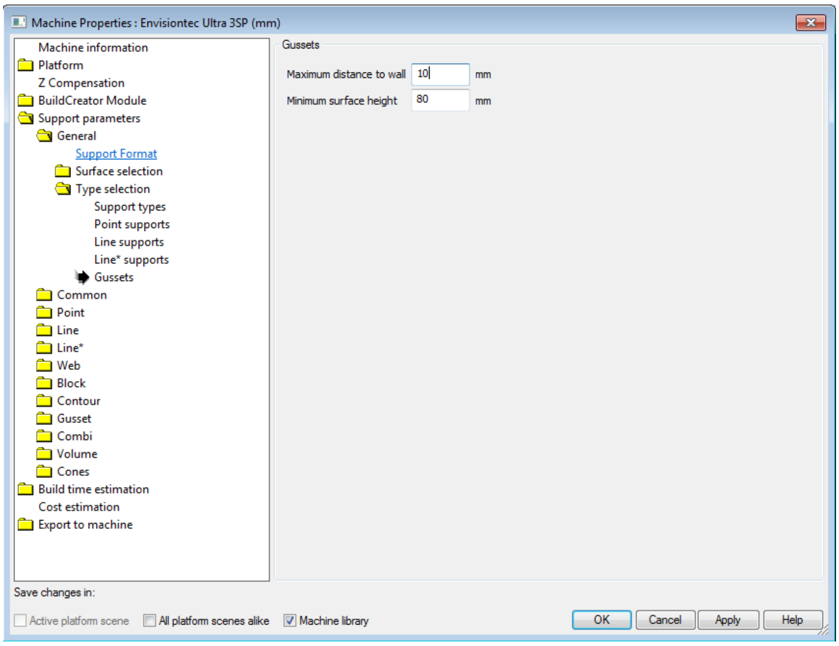


Figure 4.16. Introducing machine settings – gussets

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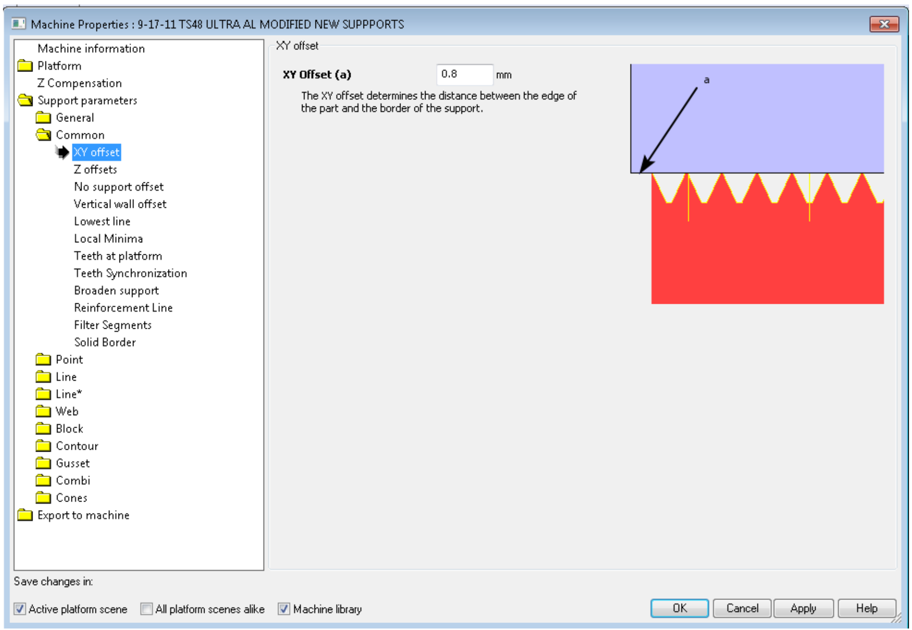


Figure 4.17. Introducing machine settings – XY offset

In Figure 4.17 is defined xy offset for generation of support structure. In Figure 4.18 isdefined z offset parameter that has upper and lower value.

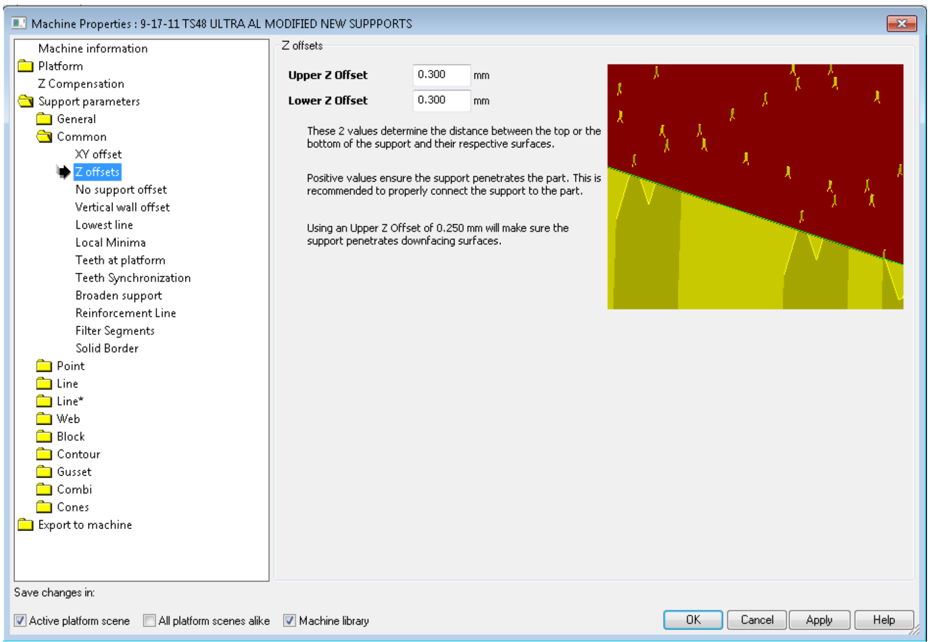


Figure 4.18. Introducing machine settings – Z offset

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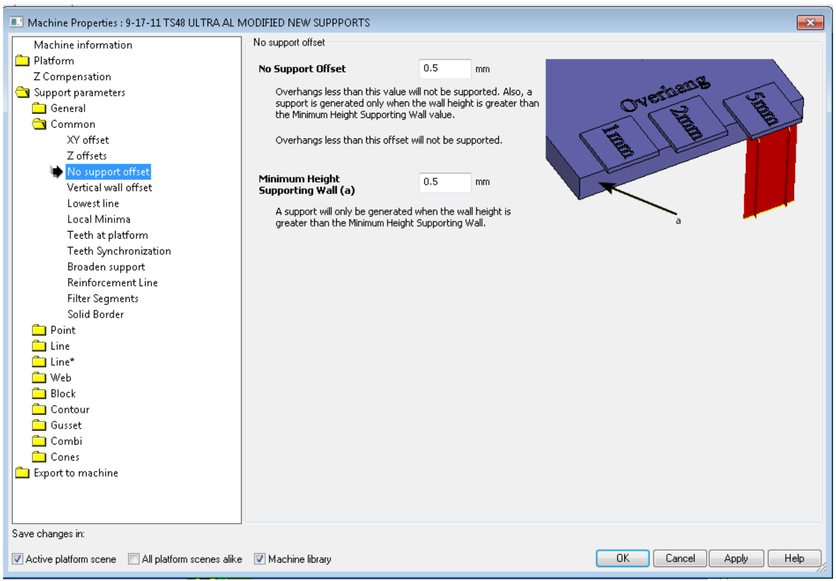


Figure 4.19. Introducing machine settings – No support offset

In Figure 4.19 is defined no support offset with minimum height supporting wall value.

In Figure 4.20 is defined vertical wall offset value.

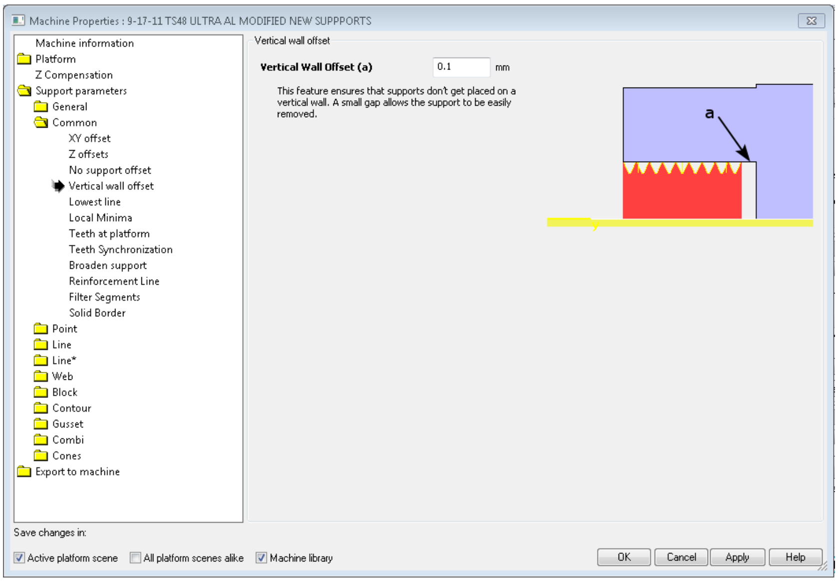


Figure 4.20. Introducing machine settings – Vertical wall offset

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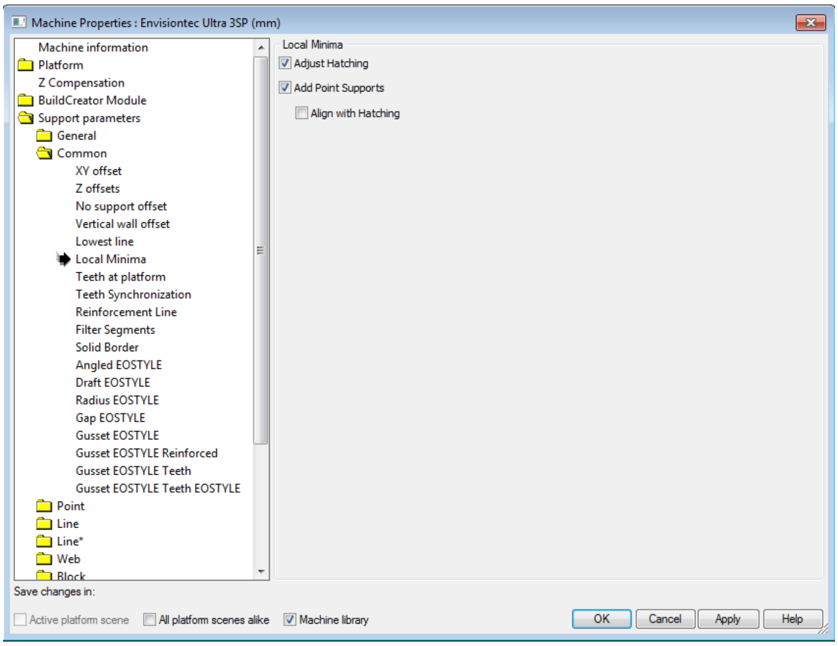


Figure 4.21. Introducing machine settings – local minima

In Figure 4.21 is defined local minima for support. In Figure 4.22 is defined teeth atplatform that can go directly of platform or it can be defined with some value.

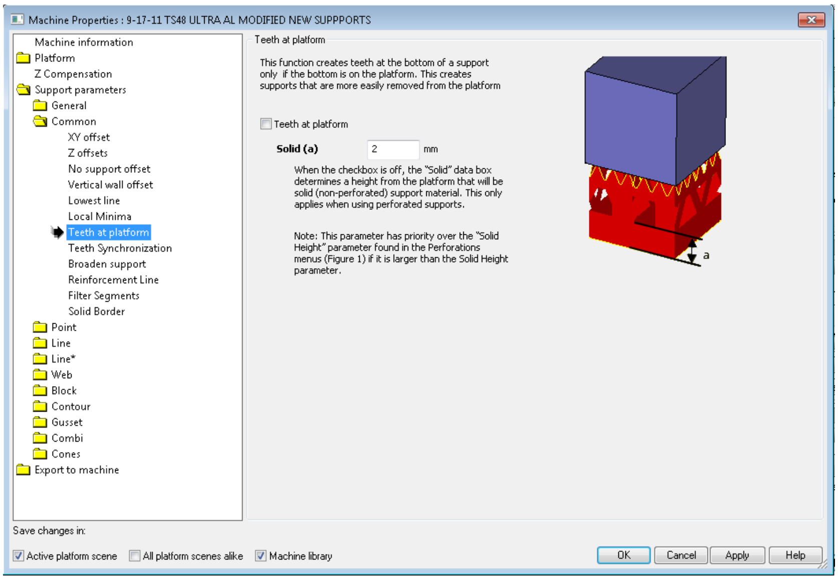


Figure 4.22. Introducing machine settings – Teeth at platform

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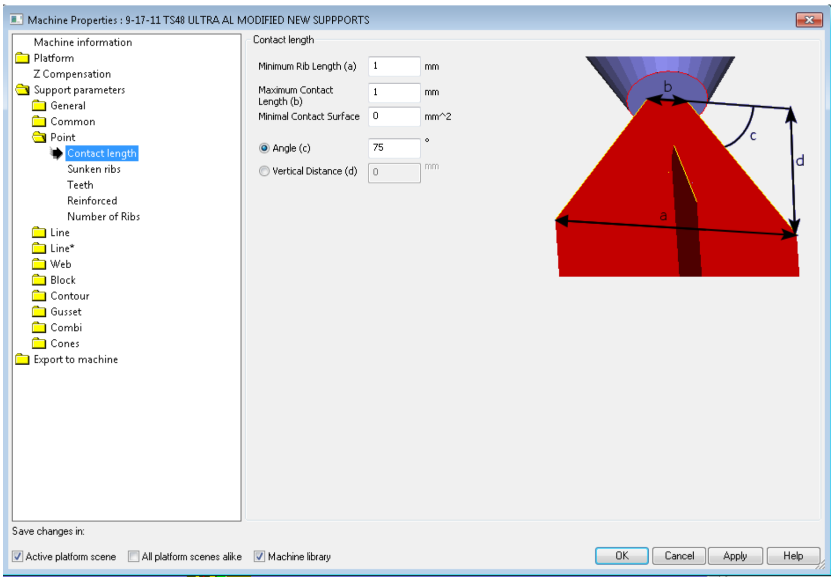


Figure 4.23. Introducing machine settings – Contact length

In Figure 4.23 is defined contact length of support structure. In Figure 4.24 is definedbasic parameter for support – gusset.

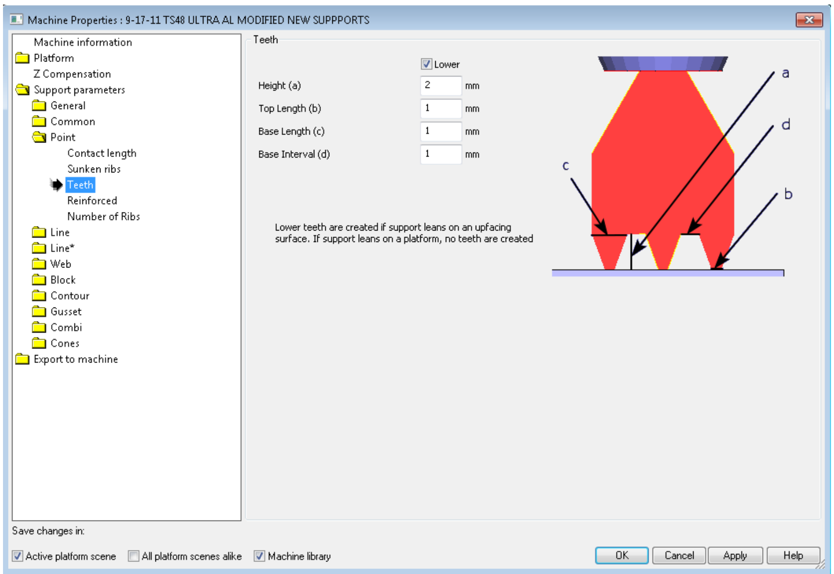


Figure 4.24. Introducing machine settings – Teeth

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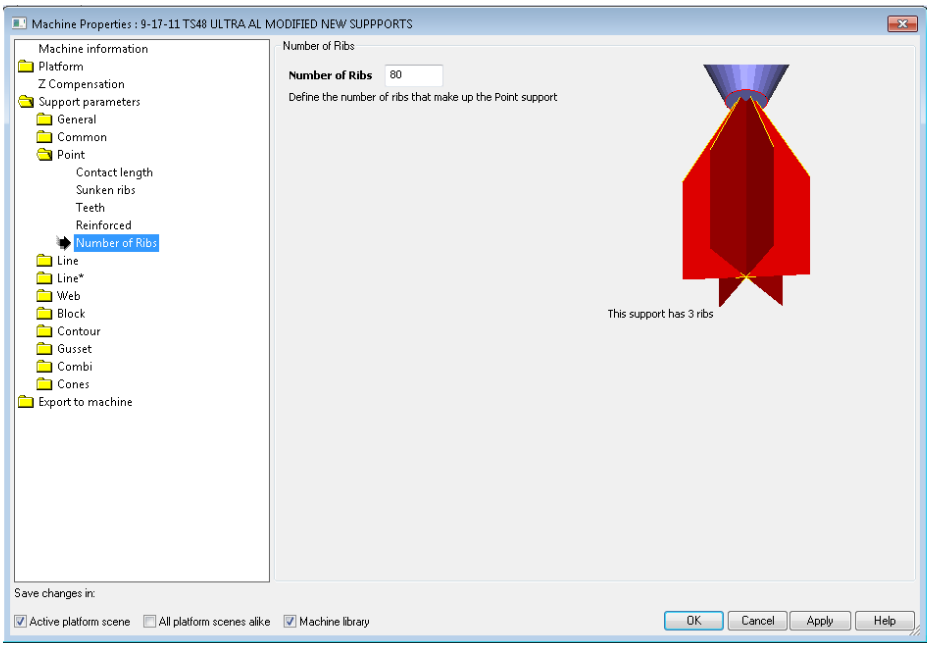


Figure 4.25. Introducing machine settings – number of ribs

In Figure 4.25 is defined number of ribs that are generated on support structure. In Figure 4.26 is defined minimum rib length and maximum contact length.

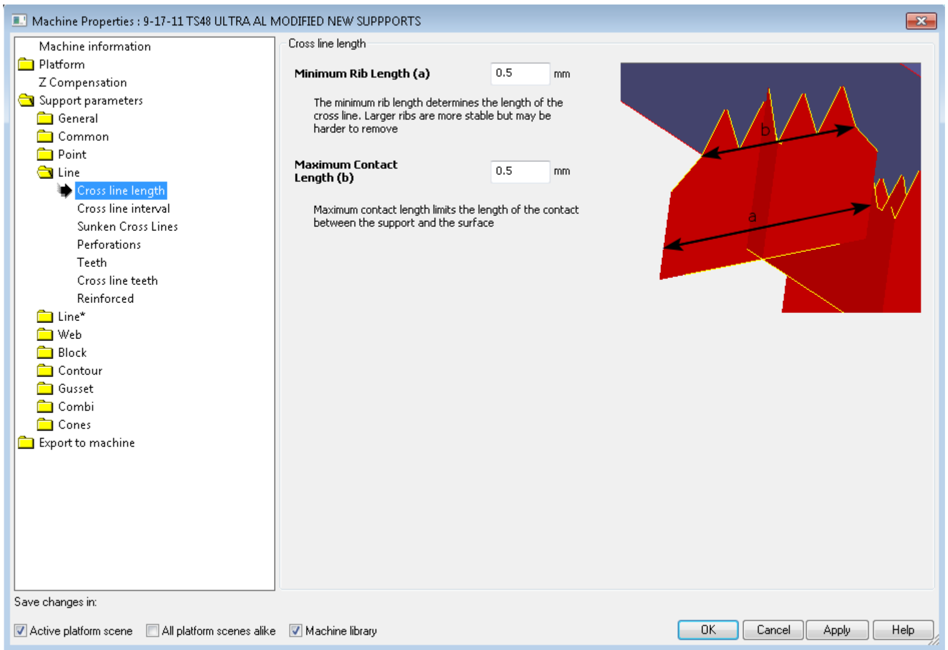


Figure 4.26. Introducing machine settings – cross line length

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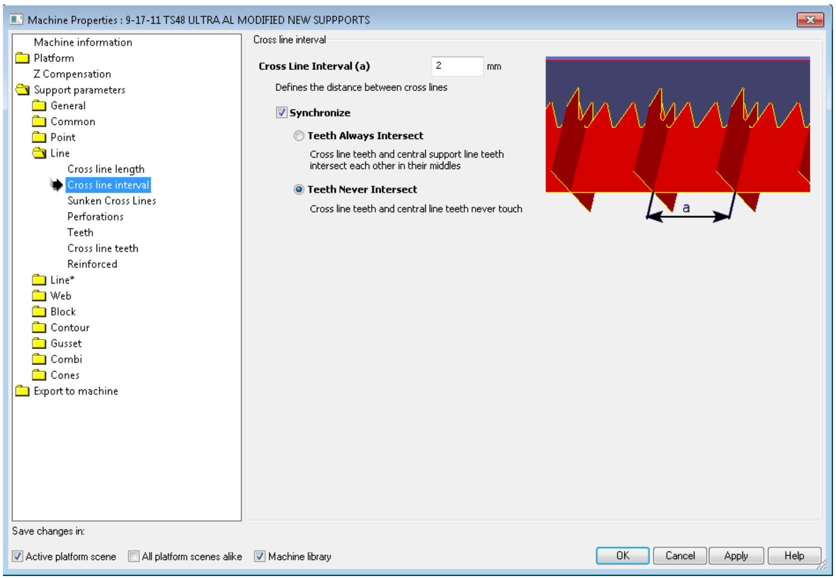


Figure 4.27. Introducing machine settings – Cross line interval

In Figure 4.27 is defined cross line interval. In Figure 4.28 is defined sink cross lines withdistance.

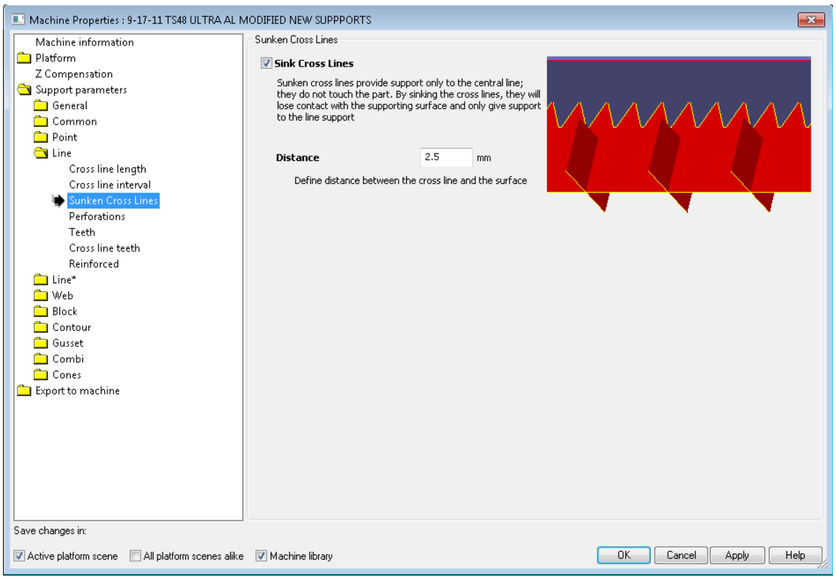


Figure 4.28. Introducing machine settings – sunken cross lines

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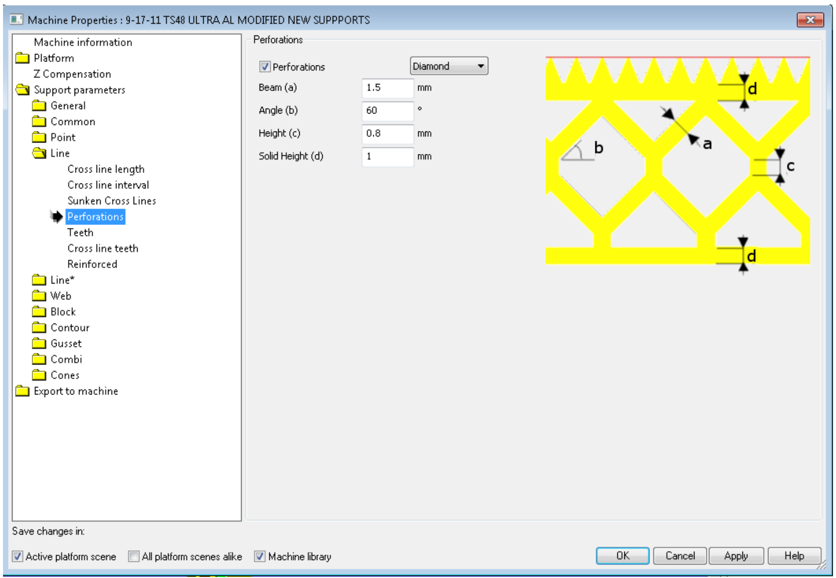


Figure 4.29. Introducing machine settings – perforations

In Figure 4.29 is defined dimensions for perforations. In Figure 4.30 is defined dimensionsfor teeth.

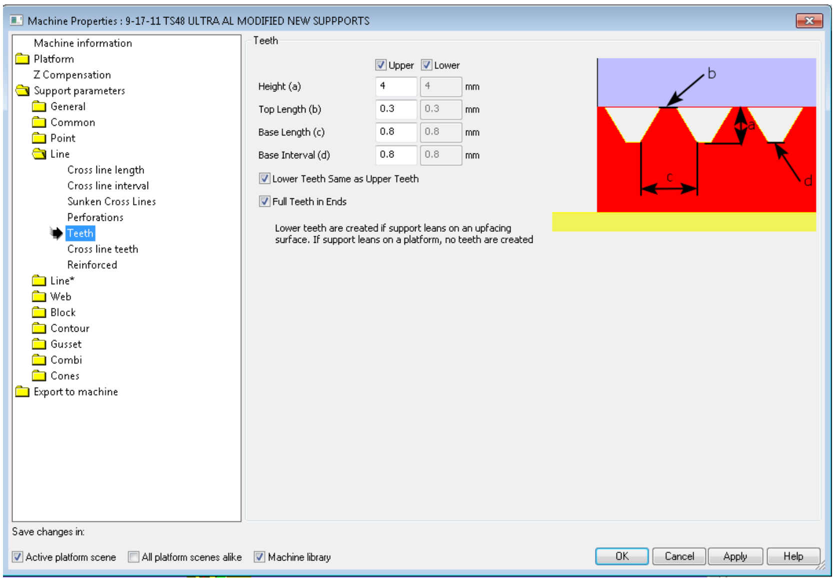


Figure 4.30. Introducing machine settings – line teeth

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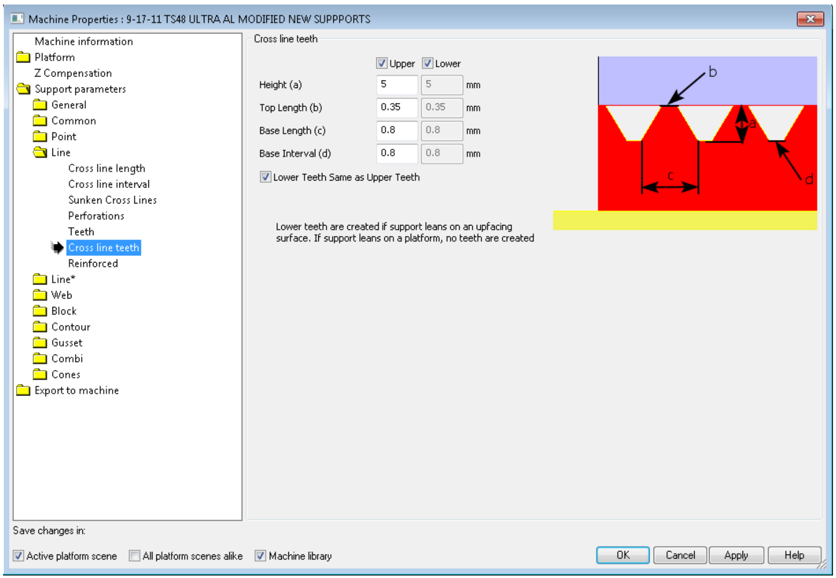


Figure 4.31. Introducing machine settings – cross line teeth

In Figure 4.31 is defined dimensions for cross line teeth. In Figure 4.32 is defined reinforced for line support.

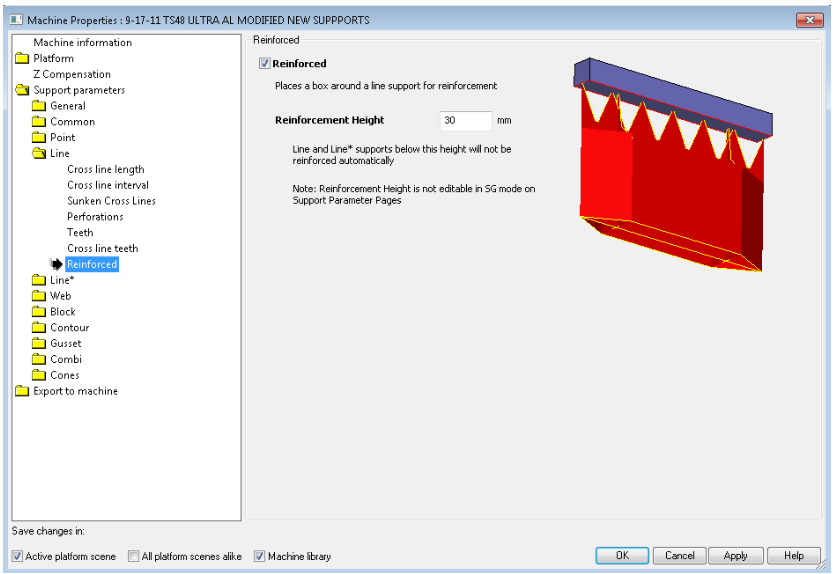


Figure 4.32. Introducing machine settings – reinforced

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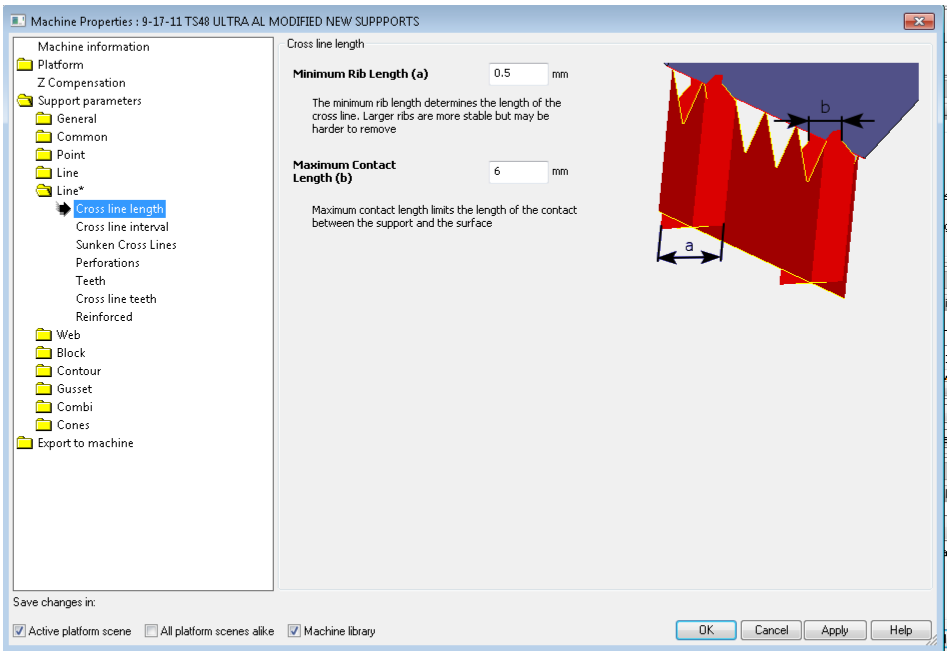


Figure 4.33. Introducing machine settings – cross line length

In Figure 33 is defined cross line length for support. In Figure 4.34 is defined cross line interval for line support structure.

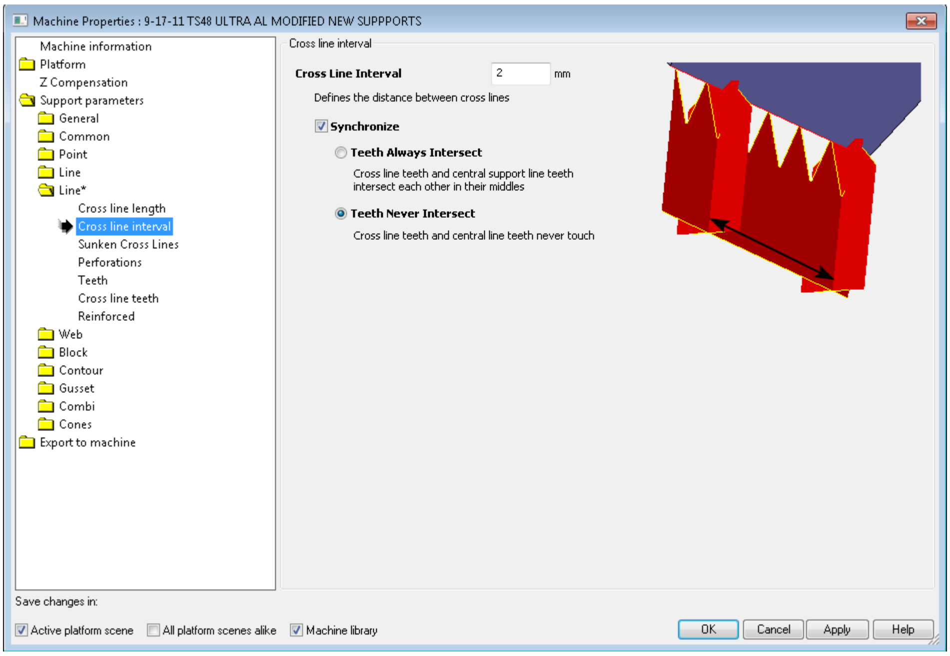


Figure 4.34. Introducing machine settings – cross line interval

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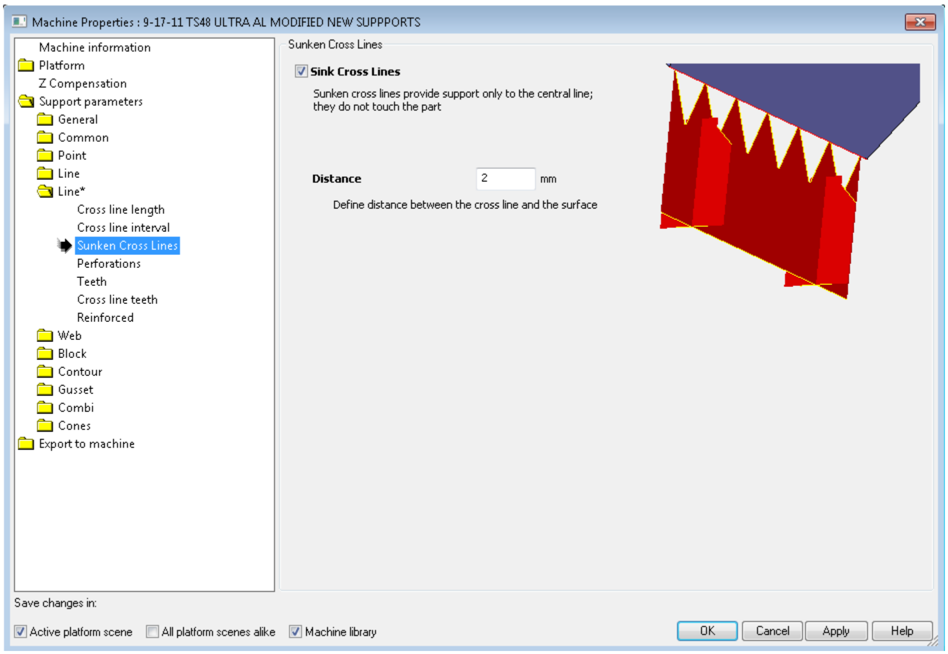


Figure 4.35. Introducing machine settings – sunken cross lines

In Figure 4 . 35 is defined sunken cross lines. In Figure 4 . 36 is defined dimensions forperforations.

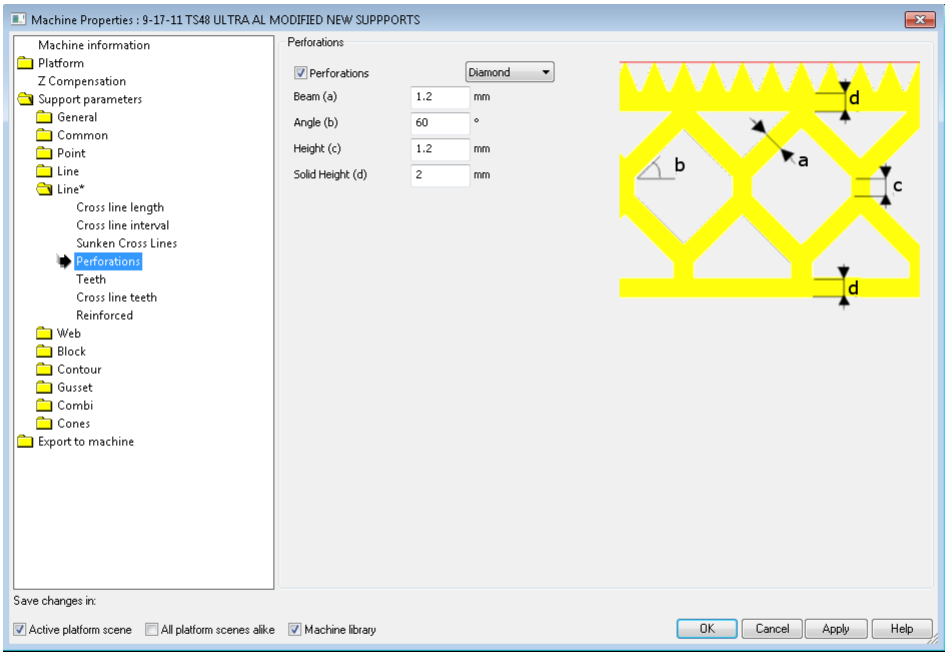


Figure 4.36. Introducing machine settings – perforations

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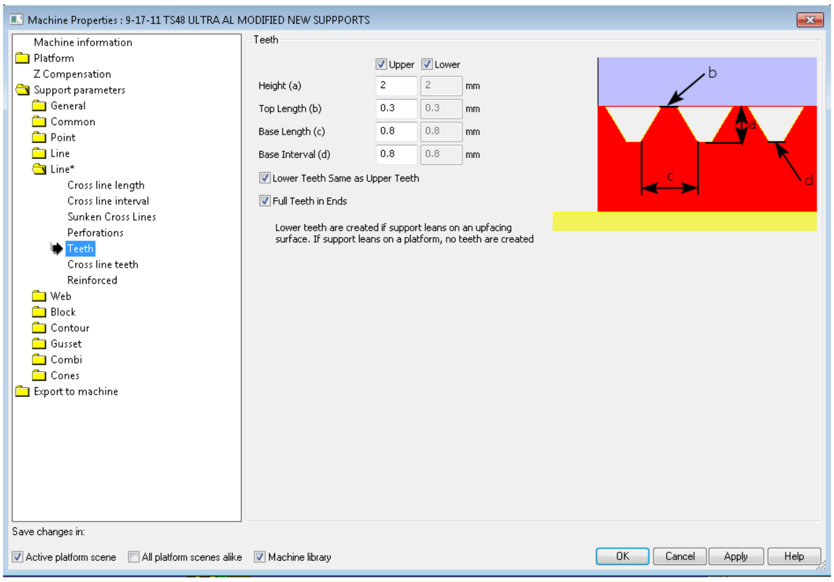


Figure 4.37. Introducing machine settings – teeth

In Figure 4.37 is defined dimensions for teeth. In Figure 4.38 is defined dimensions forcross line teeth.

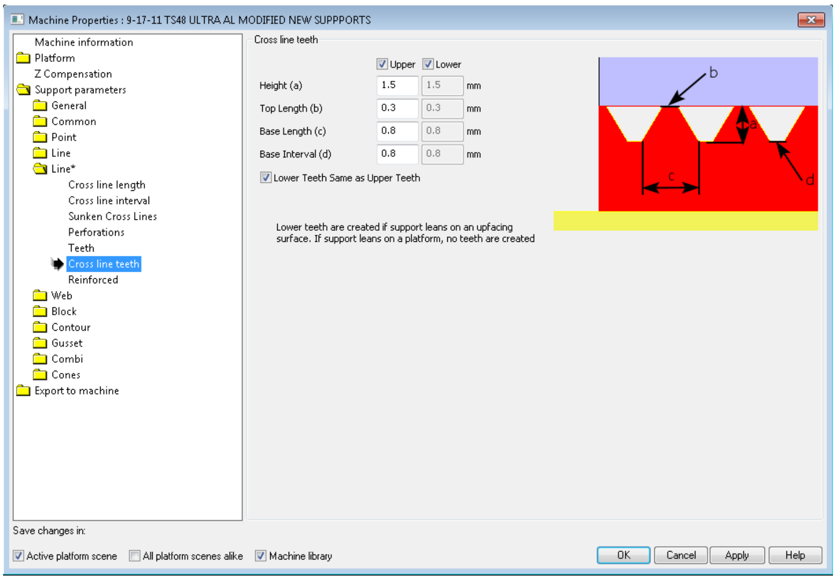


Figure 4.38. Introducing machine settings – cross line teeth

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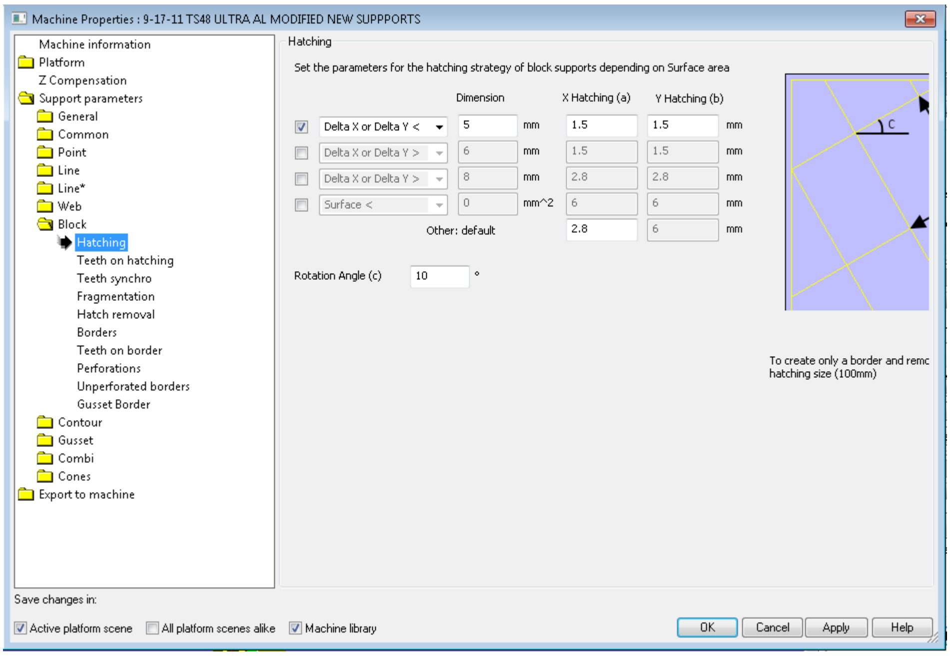


Figure 4.39. Introducing machine settings – hatching

In Figure 4 . 39 is defined dimensions for hatching as blocks of support structure. InFigure 4.40 is defined dimensions for teeth on hatching.

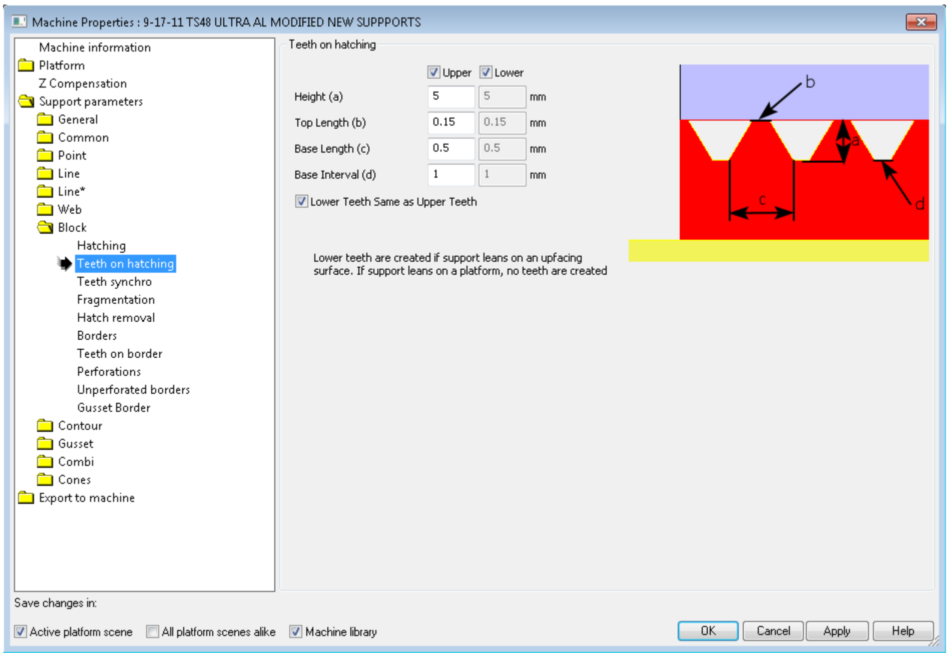


Figure 4.40. Introducing machine settings – teeth on hatching

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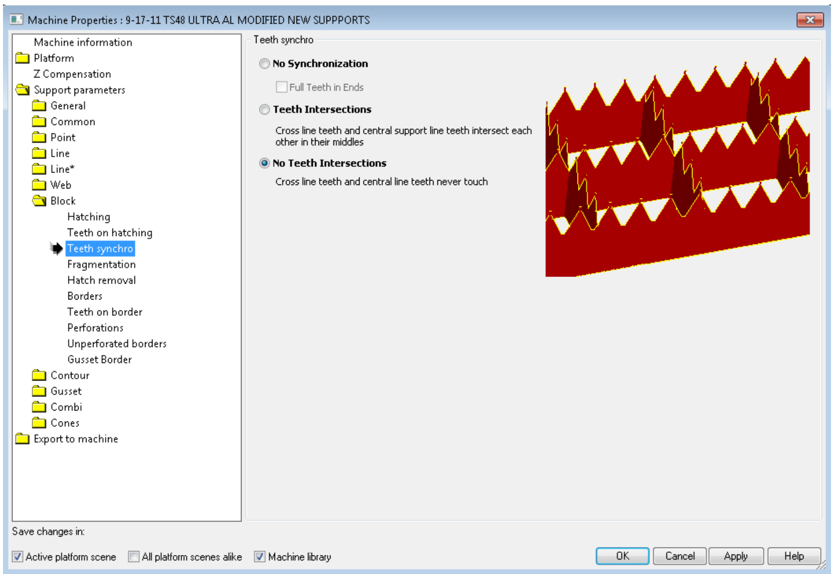


Figure 4.41. Introducing machine settings – teeth synchro

In Figure 4.41 is defined teeth synchro. In Figure 4.42 is defined dimensions for fragmentation.

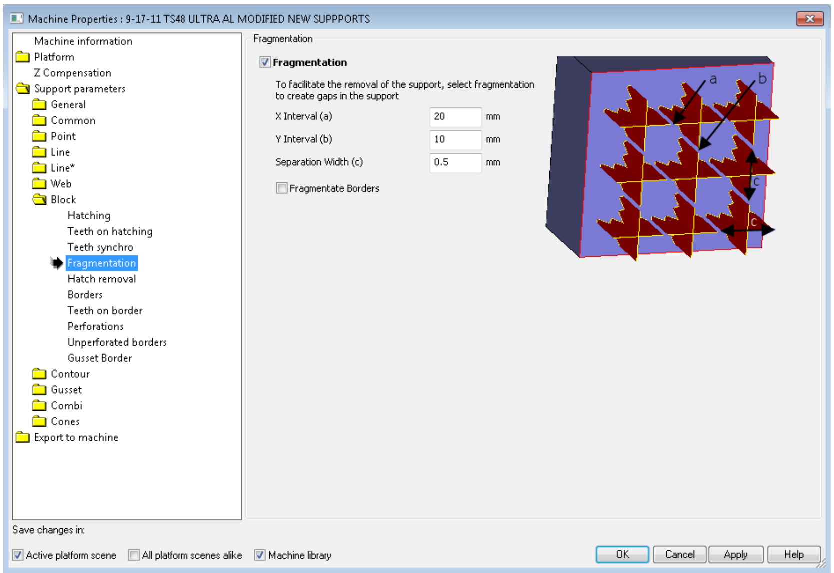


Figure 4.42. Introducing machine settings – fragmentation

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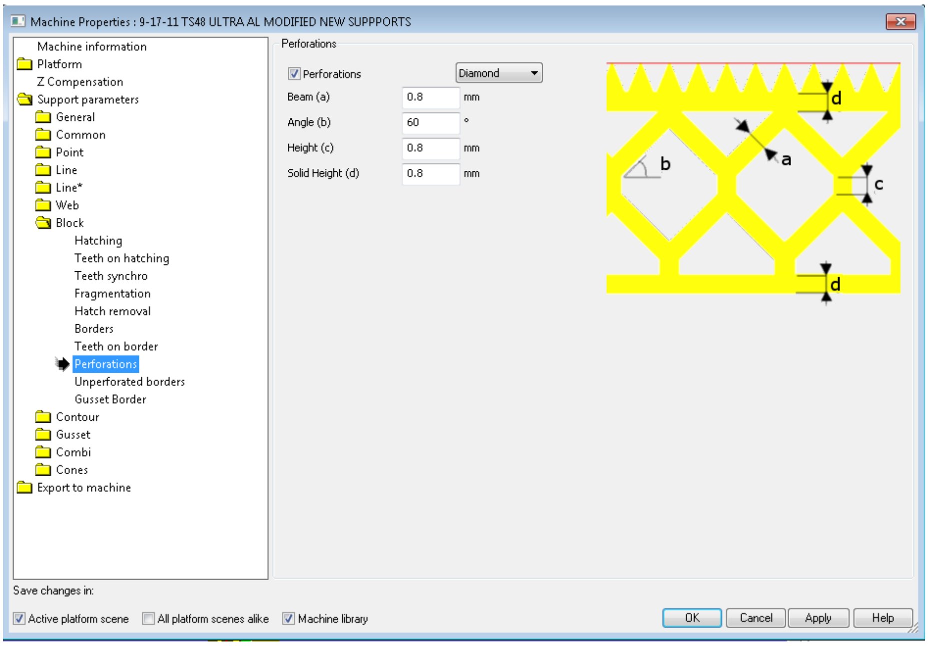


Figure 4.43. Introducing machine settings – block perforations

In Figure 4.43 is defined dimensions for block perforations. In Figure 4.44 is introducingnew scene in the software by using card Scenes.

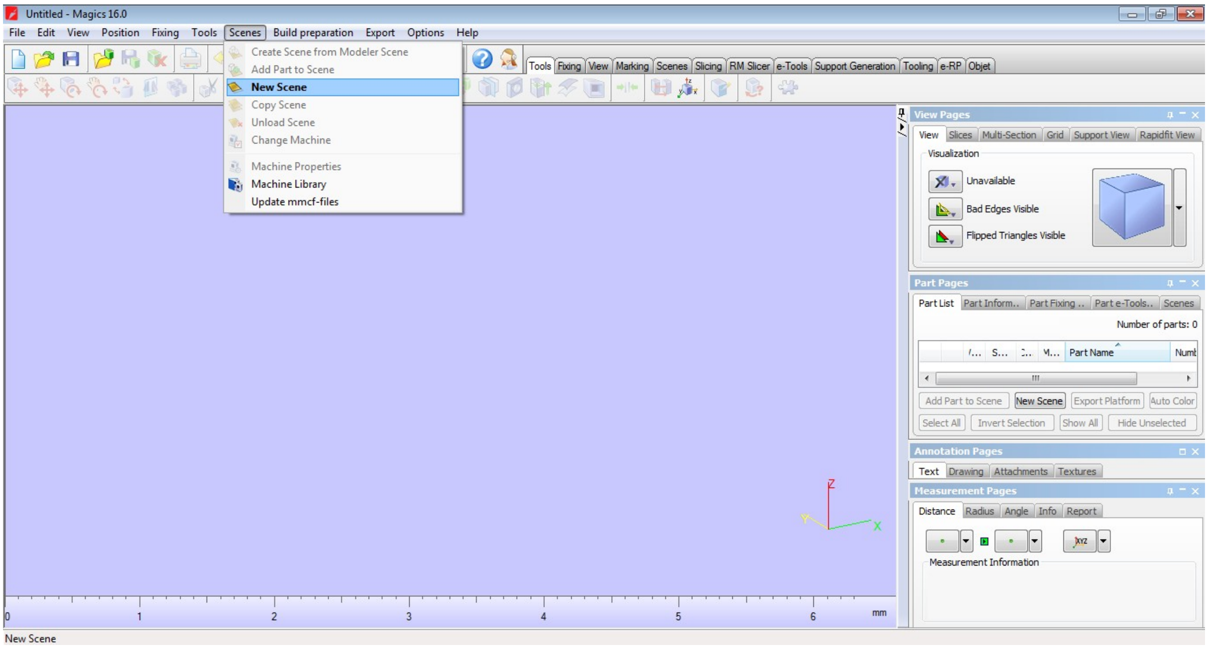


Figure 4.44. New scene

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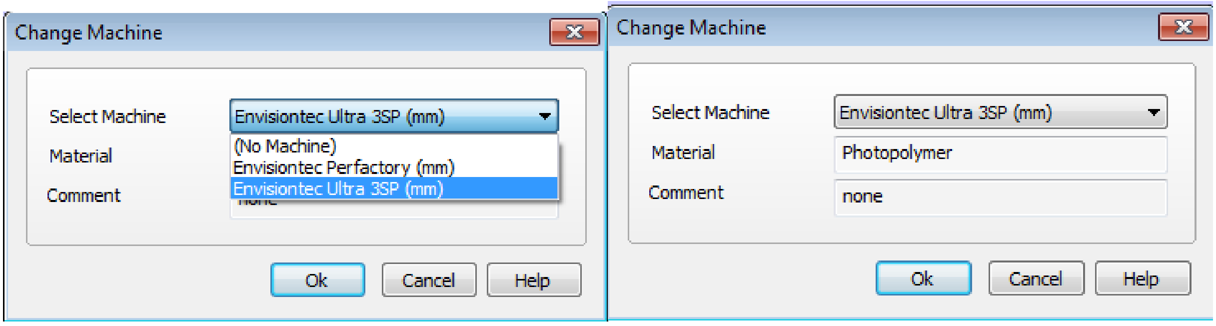


Figure 4.45. Introducing machine settings at new scene

In Figure 4.45 are chosen defined “Envisiontec Ultra 3SP” machine. After the definition of machine setting is finished and this needs to be done only once, is possible to continue work with part. Therefor in Figures 4.46 - 4.48 is shown the position and support structure by selection “block” support parameter.

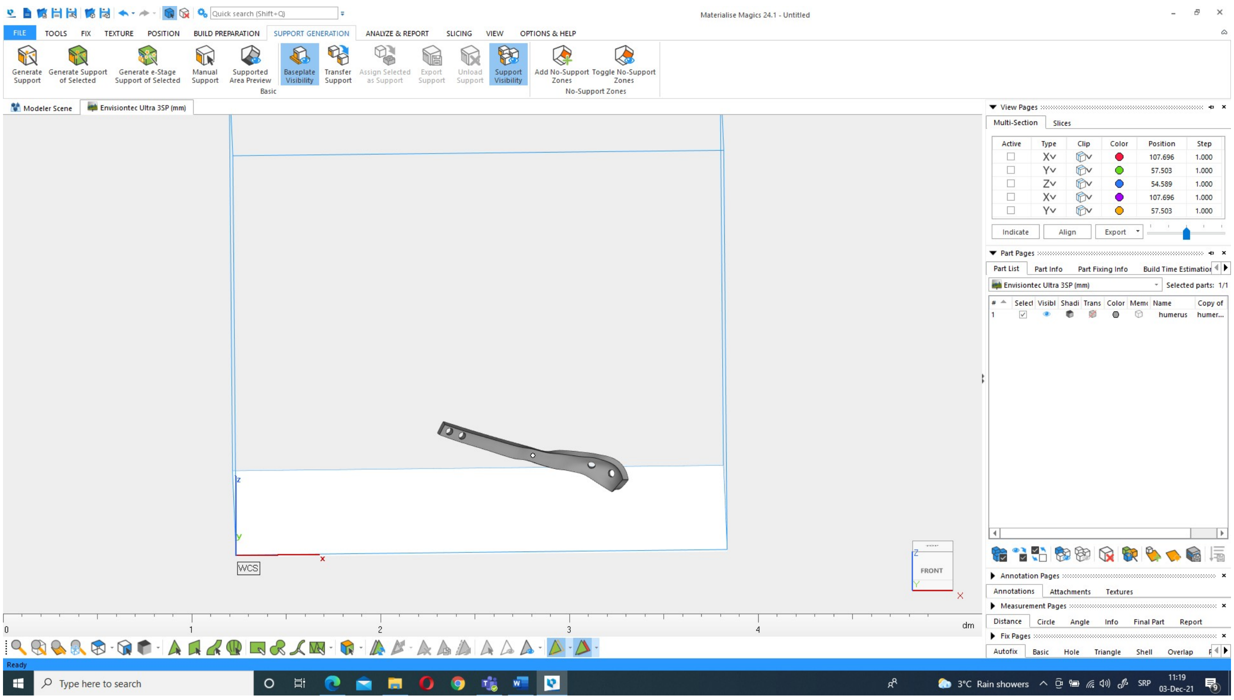


Figure 4.46. Importing part into Material Magics

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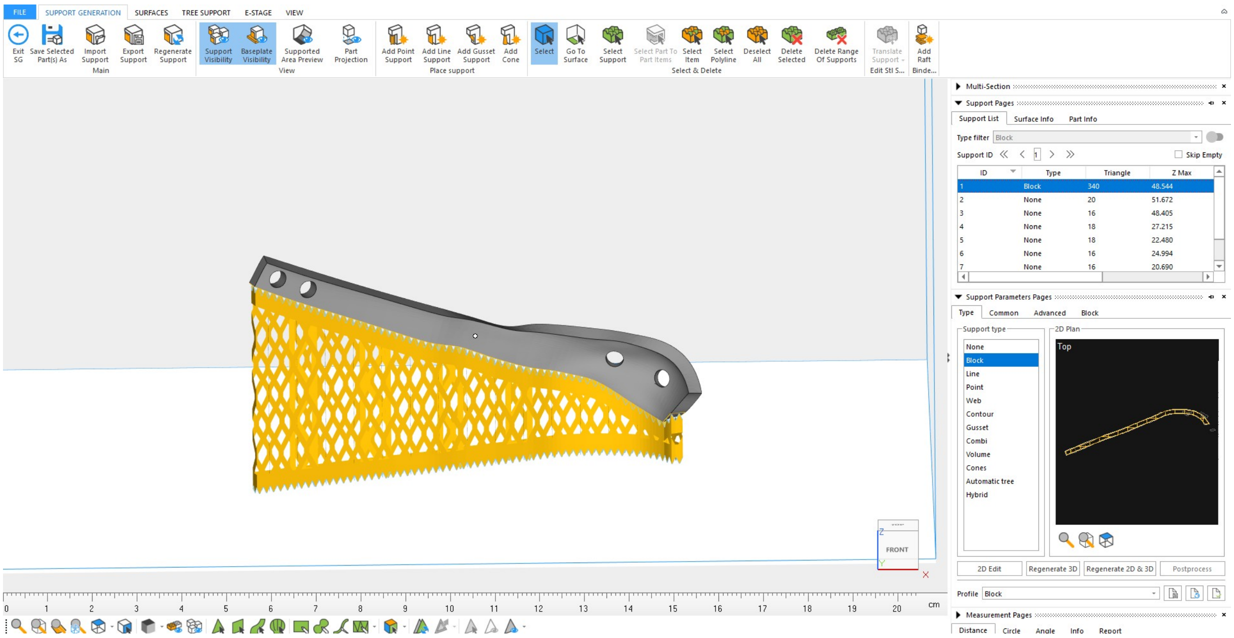

Figure 4.47. Defining support structure

In Figure 4.47 is shown part with, in previous steps, defined support structure. For this support structure is used block support. In Figure 4.48 is shown position of the part with support structure on the platform.

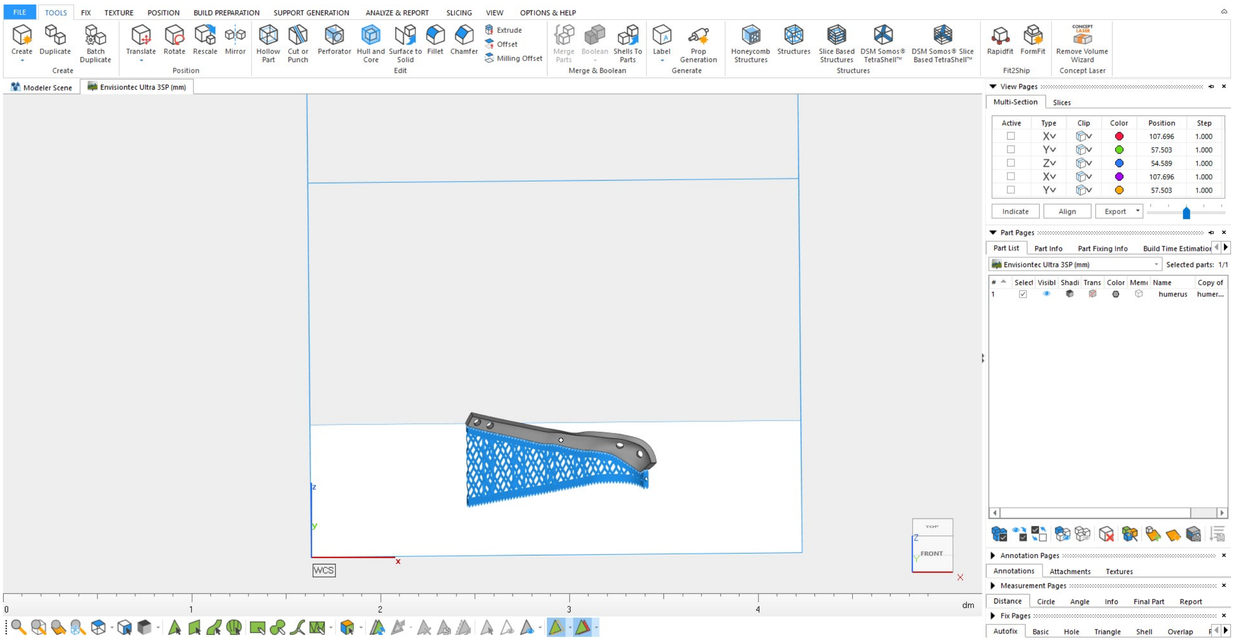

Figure 4.48. Part with support

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## *5.* Printing of part

The printing process for this part was around 7 hours long. Influence on printing speed is very small comparing to the FDM printing process. Printing process is defined by speed of laser per layer in which there is small difference between big and small image. The most important way to influence the printing speed is the have position of the part has less layers.

Figure 5.49. shows the laser that is on the top over the tank with resin material. Laser ismoving left and right and every time makes solidification of one layer. During the printing process, printed part cannot be seen since it is immersed in the tank full of resign. The whole size of printed part is limited with the size of the tank in this architecture of stereolithography printers.

Figure 5.49 Printing of part in the 3D printer

In Figure 5.50 is shows how printed part appears after the printing is finished.

For the postprocessing is important to know that not solidification resign is hazardous and all the operation need to be done so that human skin do not have contact with resign. At Figure 5.51. is shown separation of part with support structure from theplatform and in this process is important to use skin protecting gloves. After the part is separated from the platform is very important to clean part as well as platform since for the next printing is important not to contaminate resign in the tank where platform is going tobe immersed.

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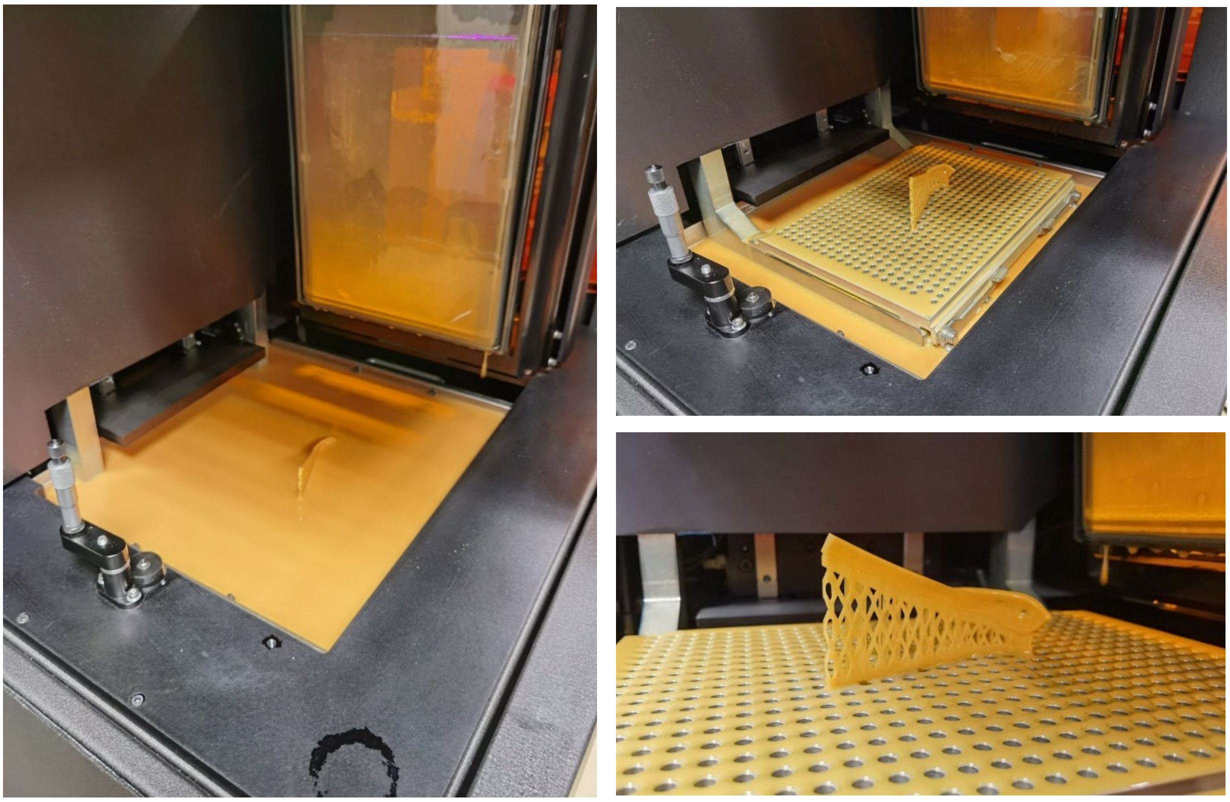

Figure 5.50 Finishing of printing of the part

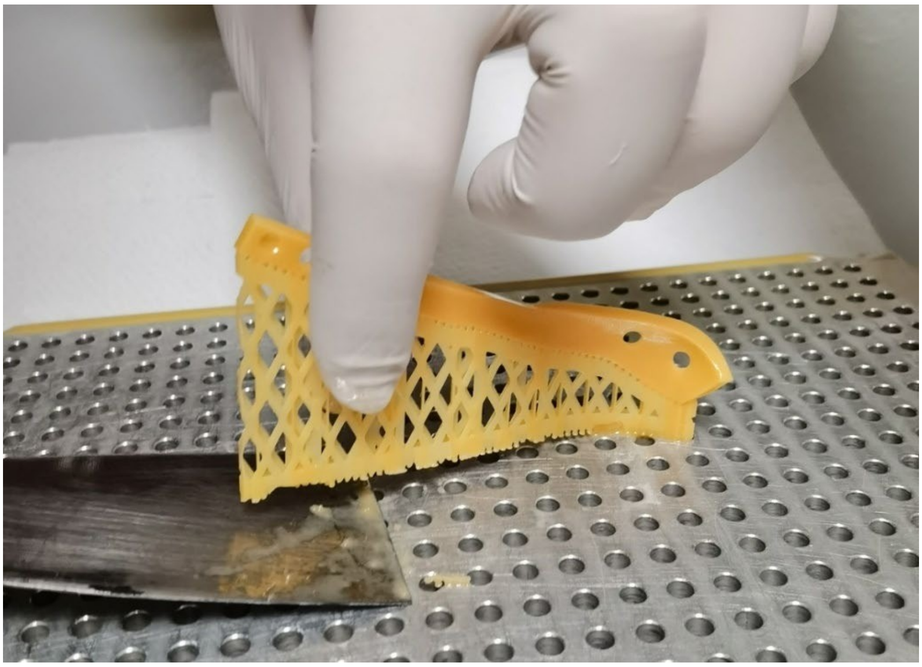

Figure 5.51. Separation of printed part from platform

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In Figure 5.51 is shown removing of part with support structure from platform by using a spatula. After the part is removed it is necessary to wash it with isopropyl alcohol and it is advised it to put it in some bowl filled with isopropyl alcohol and to wash it and clean with brush.

Figure 5.52. Washing of part in isopropyl alcohol

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## *6.* Postprocessing

In the Figure 6.53 is shown process of separating support structure from part. If the machine settings are good introduced as it is shown in part 4 this is not going to be problem and there is no dangerous to damage printing part.

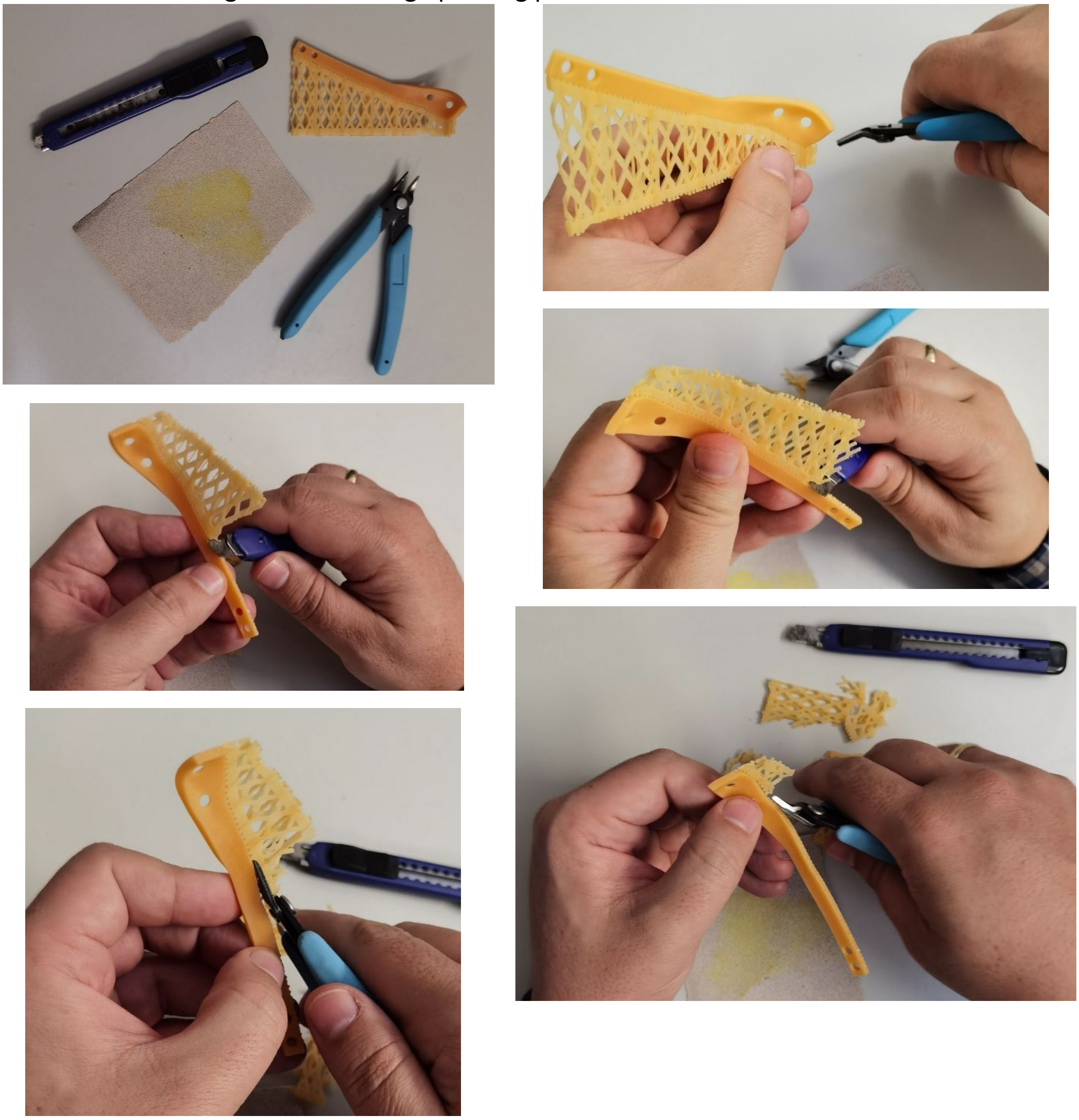

Figure 6.53. Postprocessing of 3D printed part

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Figure 6.54. Postprocessing of 3D printed part

After separating part from support need to be used sandpaper to make smooth surface where it was connected to the support structure (Figure 6.54).

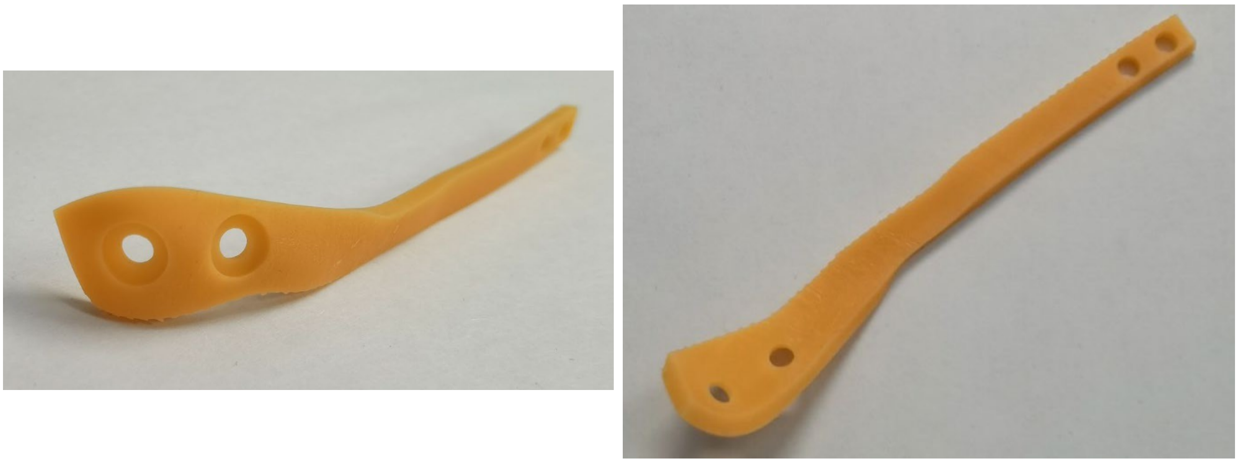

Figure 6.55. Printed part

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In the Figures 6.55 is shown finished and postprocessed printed part. In Figure .56 is given SLA and FDM printed parts for comparison. Surfaces of SLA printed parts are much finer.

Figure 6.56. Printed part by FDM (up) and Stereolithography (down)

## *7.* Conclusions

In this toolkit is presented printing process with all necessary pre- and postprocessing step as well as machine settings for successful printing of the part – Locking Compression Plates which is used in surgery.

The printing process was done with Envisiontec Ultra 3SP. For the slicer is used Materialise Magics. In this software need to be imported STL file that can be done in almost any CAD software. For Materialise Magics was shown the whole process of machine setting that is important for fine printing and especially for the creating good support structure. In Materialise Magics is done slicing of the part and choosing the support structure as well as positioning the part on the platform.

After the printing process is finished is important to have smooth separation of part from the printing platform as well as support structure from the printed part.

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