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BRIGHT

Erasmus+ strategic partnership for Higher Education

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

TOOLKIT 3

FIXATOR MADE BY STEREOLITHOGRAPHY

Project Title	**Boosting the scientific excellence and innovation capacity of 3D printing methods in pandemic period 2020-1-RO01-KA226-HE-095517**
Output	**IO2 – BRIGHT e-toolkit manual for digital learning in producing medical parts by 3D printing methods in the context of the pandemic**
Toolkit	**Toolkit 3 Stereolithography (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 step 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 need 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 parts with surfaces that are not plane and under angle. As the tolerances are lower the final STL file will be higher. Also, in the cases when printing resolution is low, high STL file resolution is not 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 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 1 – Autodesk Inventor).

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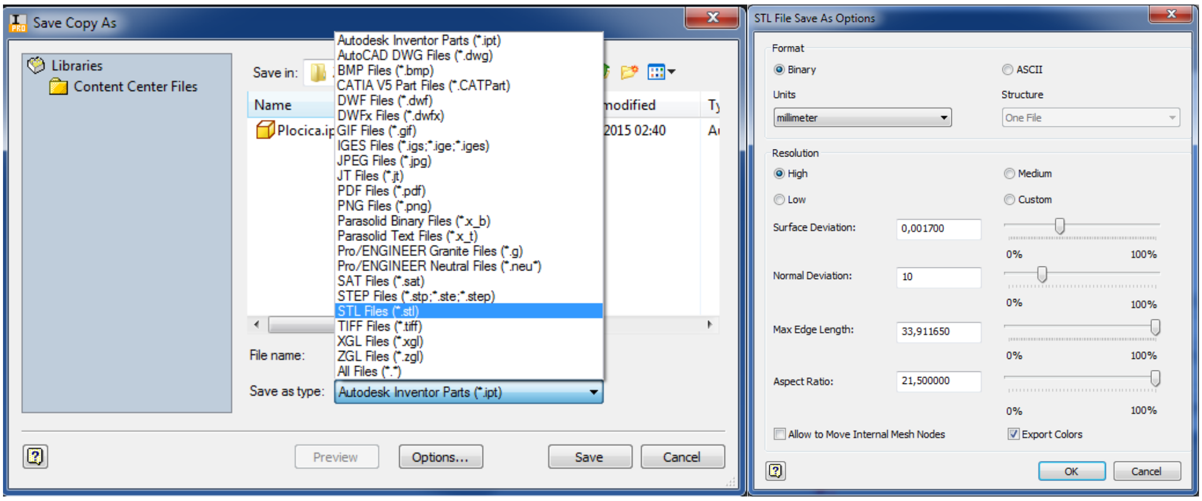

Figure 1. Autodesk Inventor windows for converting in STL with possible options

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. 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 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.

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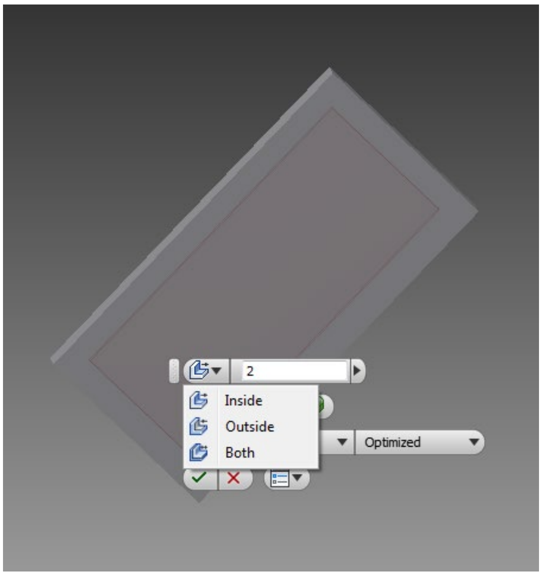

Figure 2 Defining hollow and position for technological hole

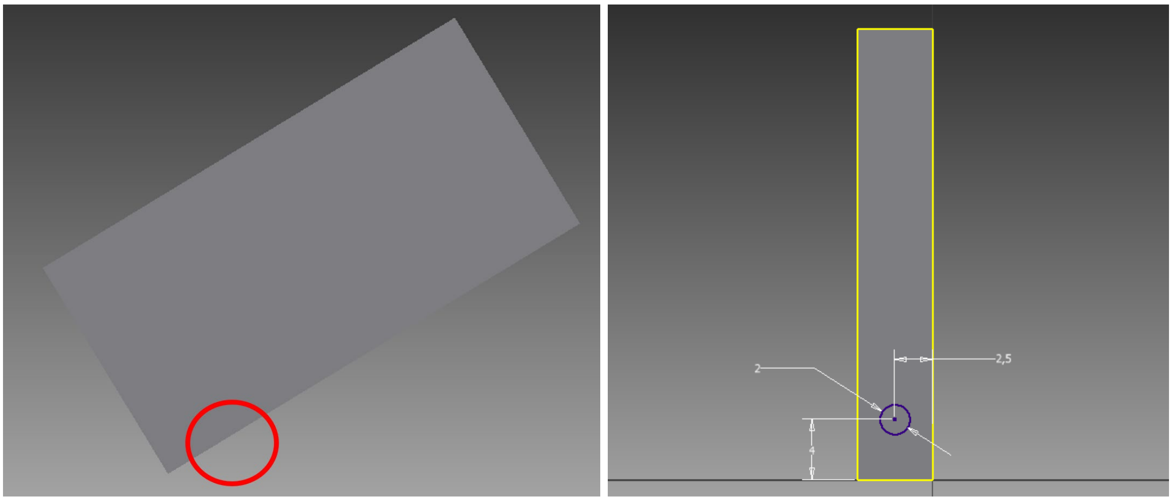

Figure 3. Position for technological hole

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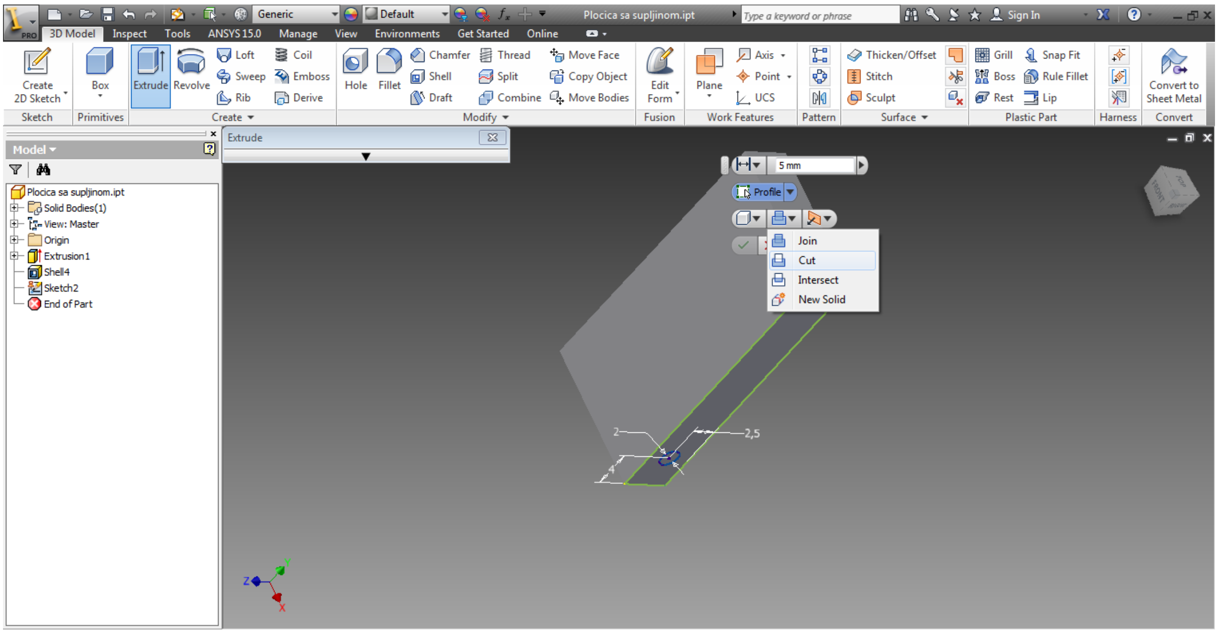

Figure 4. Definition of technological hole in CAD software

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4. Materialise Magics

For the good printing of the part is important to define the machine settings. Materliase Magics offers a lot of parameters that need to be define in order to have good print. Therefor in Figures 5-43. is going to be presenting defining settings step by step. This is especially 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.

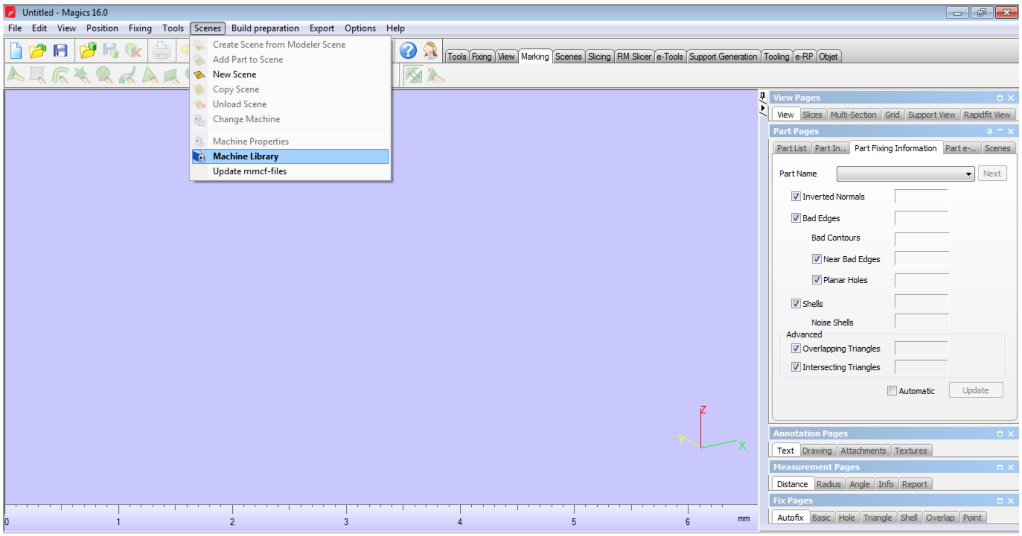

Figure 5 Surrounding in Materialise Magics

Figure 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 7.

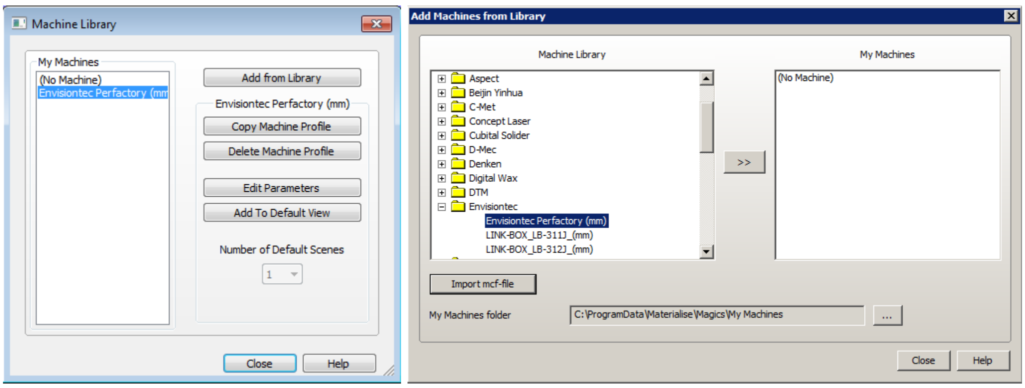

Figure 6 Introduction of Envisiontec Prefactory

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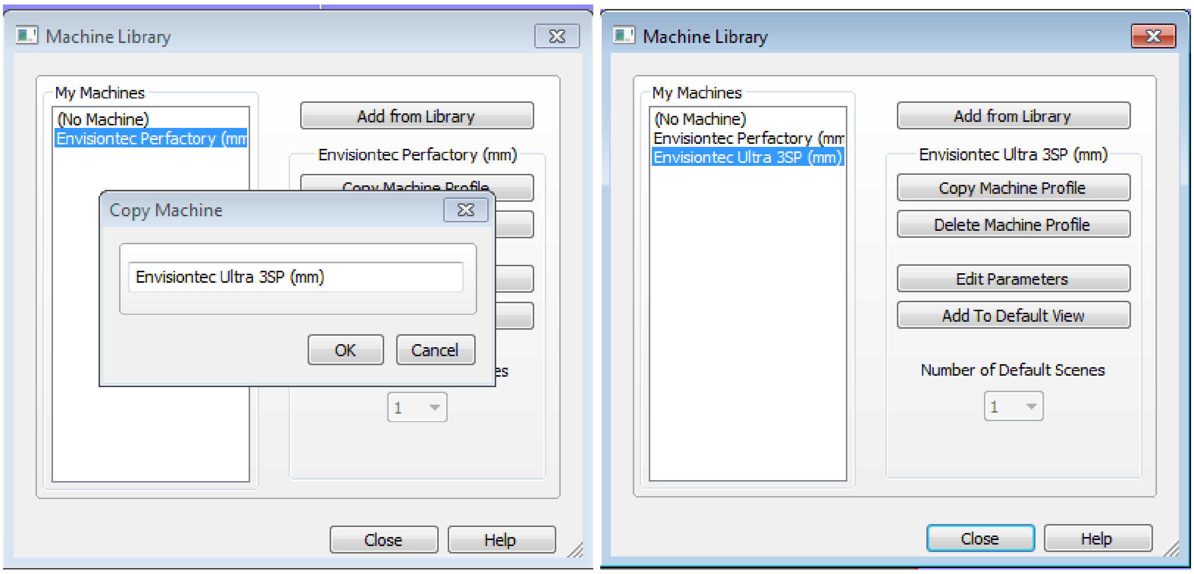

Figure 7 Defining 3D printer into Materilise Magics

In Figure 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 8 is given introducing field for Envisiontec Ultra 3SP enviroment.

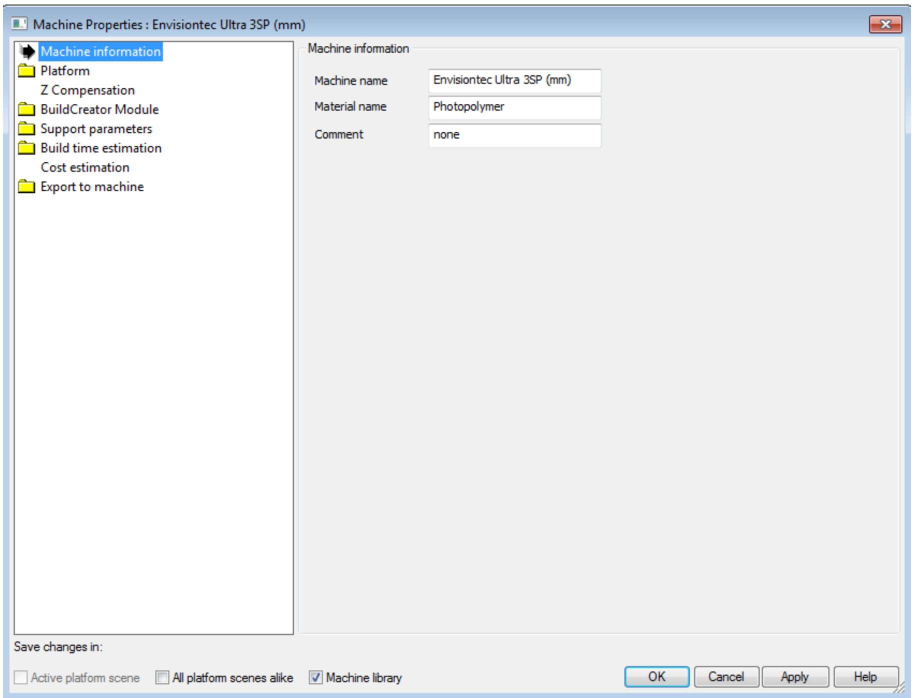

Figure 8. Introducing machine settings – machine information

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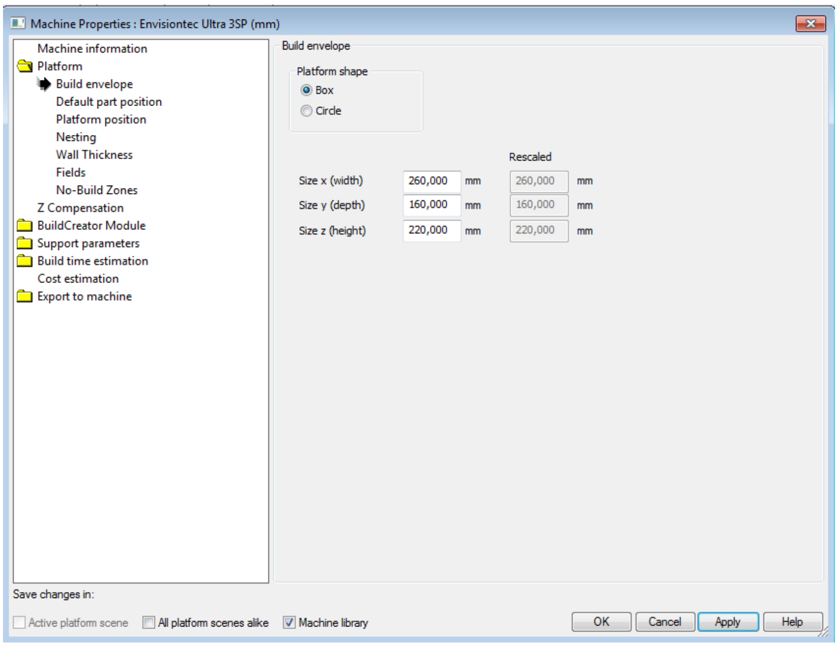

Figure 9. Introducing machine settings – platform

In Figure 9 are given machine settings for the platform. It has box shape with size 260x160x220mm. In Figure 10 is defined default part position for the position of the printing part on platform.

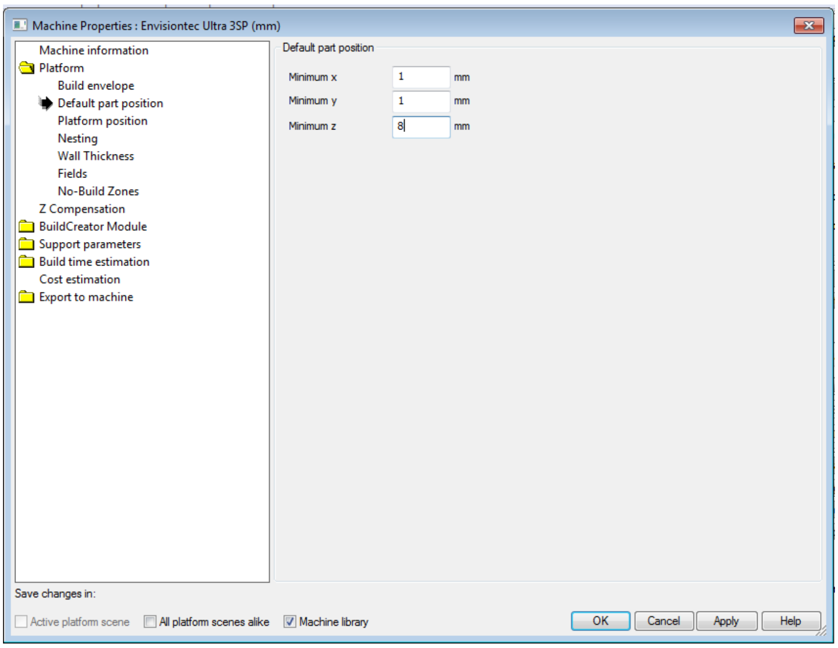

Figure 10. Introducing machine settings – default position

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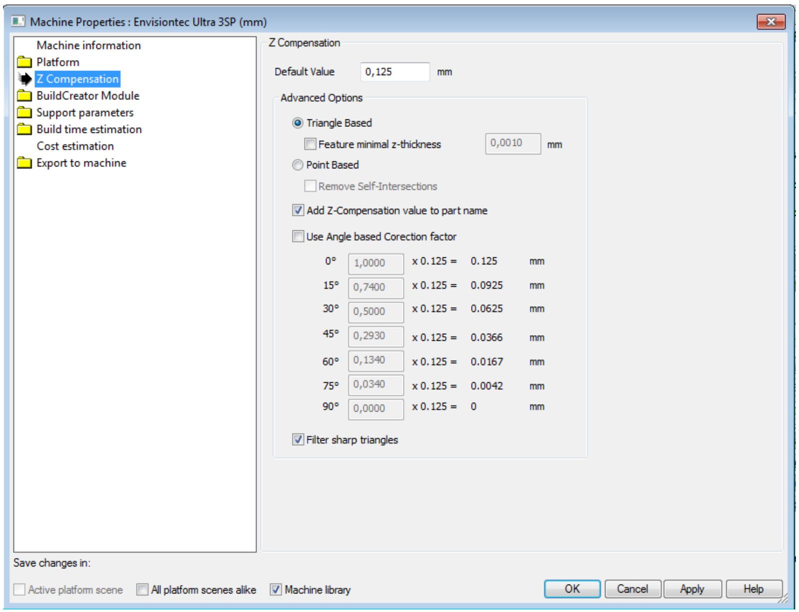

Figure 11. Introducing machine settings – platform, z Compensation

In Figure 11. is defined z-compensation for the platform – 0.125mm. In Figure 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.

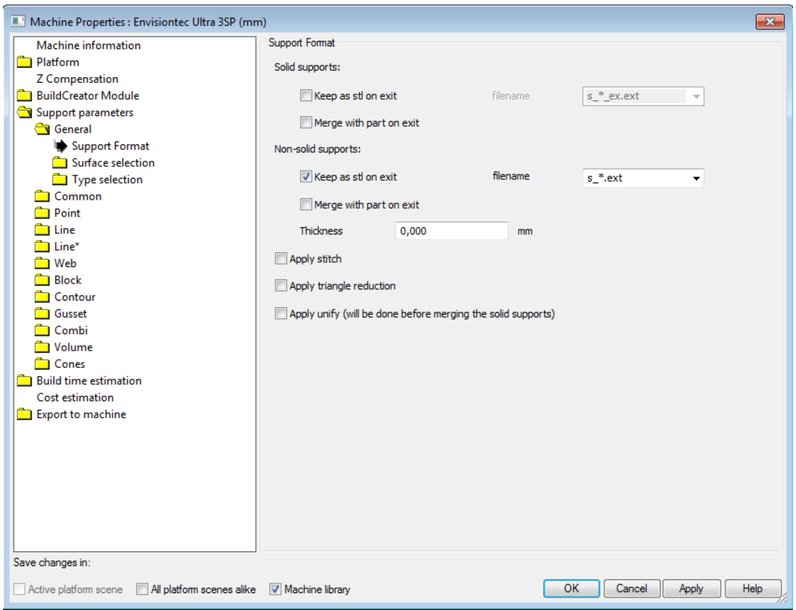

Figure 12. Introducing machine settings – support format

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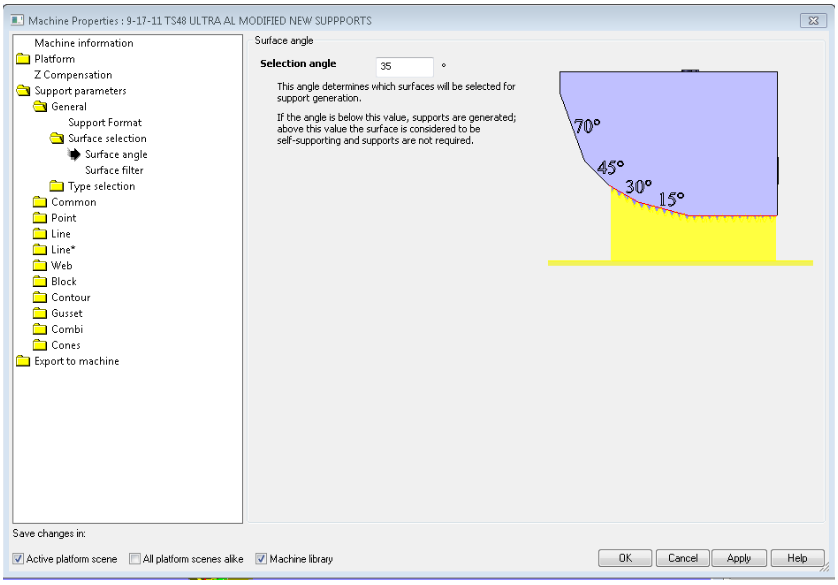

Figure 13. Introducing machine settings – surface angle

In Figure 13 is defined surface angle in which support will be generated on the part. In this case will be used 35 degrees. In Figure 14 is defined surface filter and surface angle.

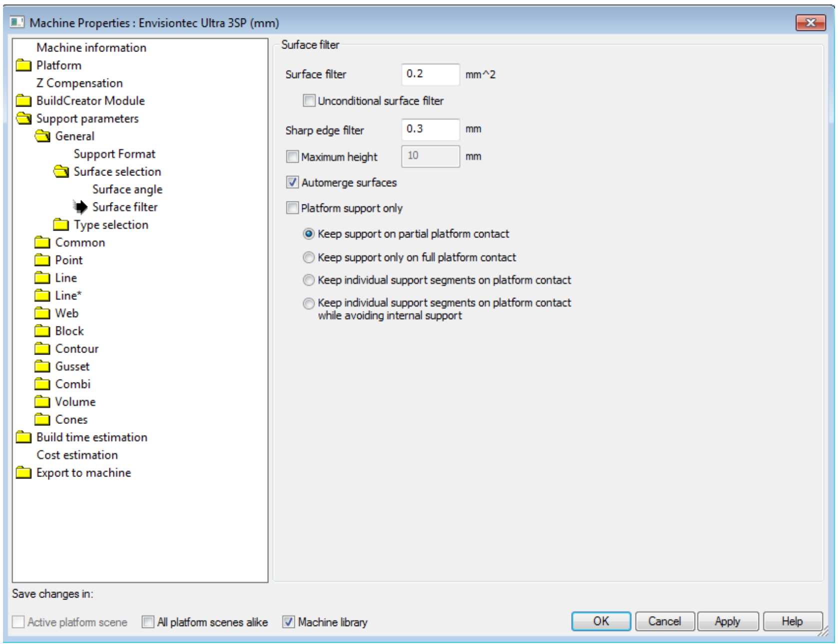

Figure 14. Introducing machine settings – surface filter

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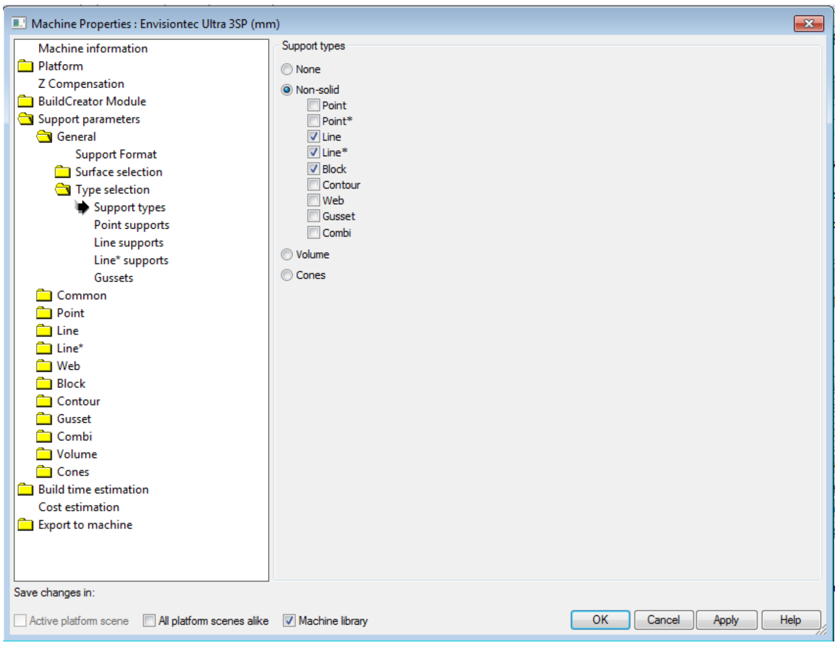

Figure 15. Introducing machine settings – support types

In Figure 15 is defined surface angle in which support type. In Figure 16 is defined basic parameter for support – gusset.

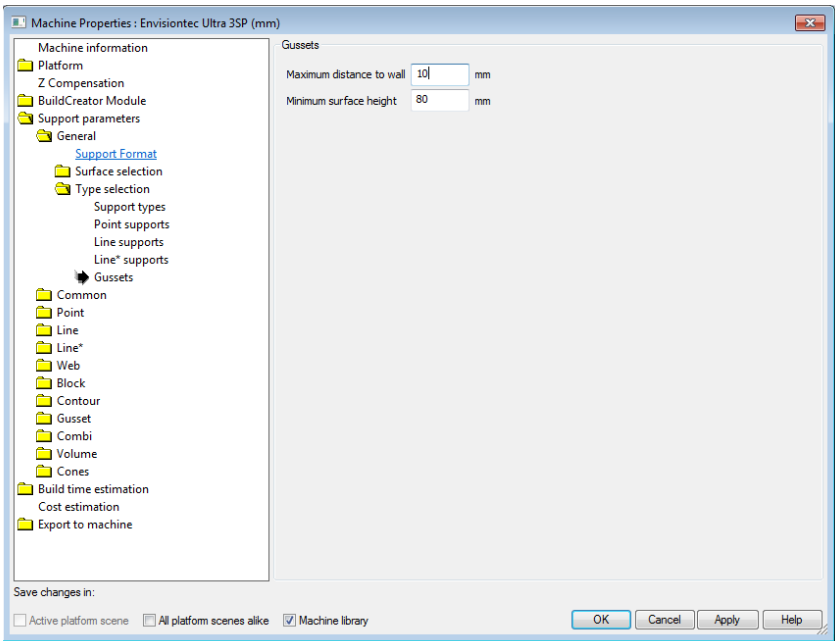

Figure 16. Introducing machine settings – gussets

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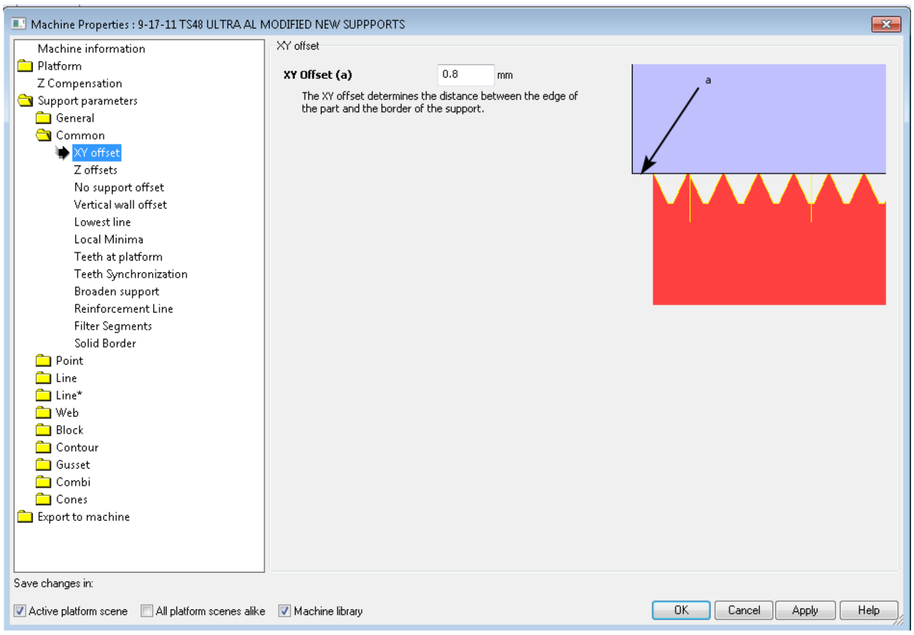

Figure 17. Introducing machine settings – XY offset

In Figure 17 is defined xy offset for generation of support structure. In Figure 18 is defined z offset parameter that has upper and lower value.

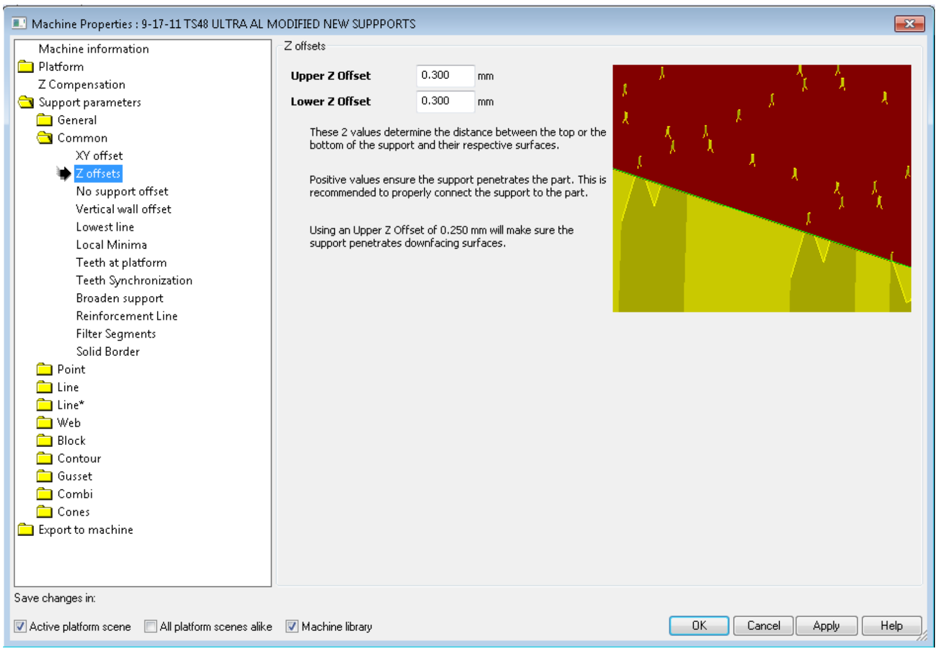

Figure 18. Introducing machine settings – Z offset

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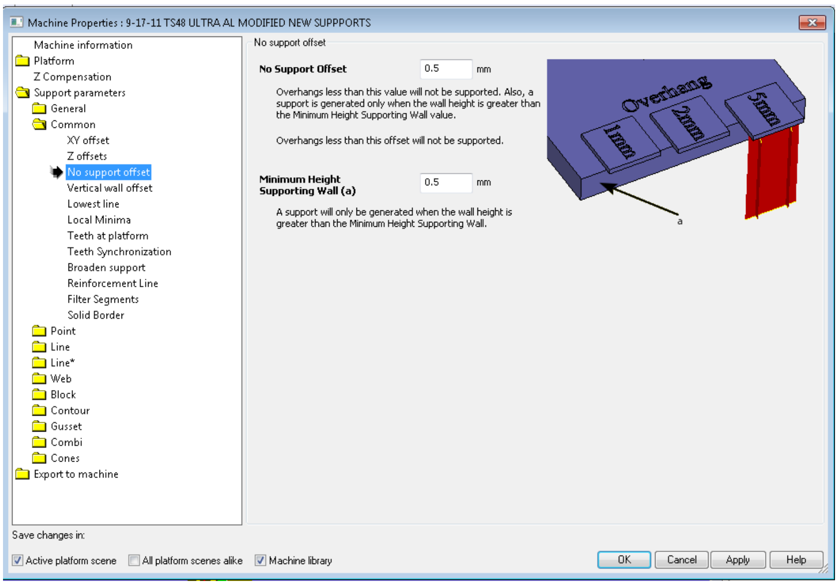

Figure 19. Introducing machine settings – No support offset

In Figure 19 is defined no support offset with minimum height supporting wall value. In Figure 20 is defined vertical wall offset value.

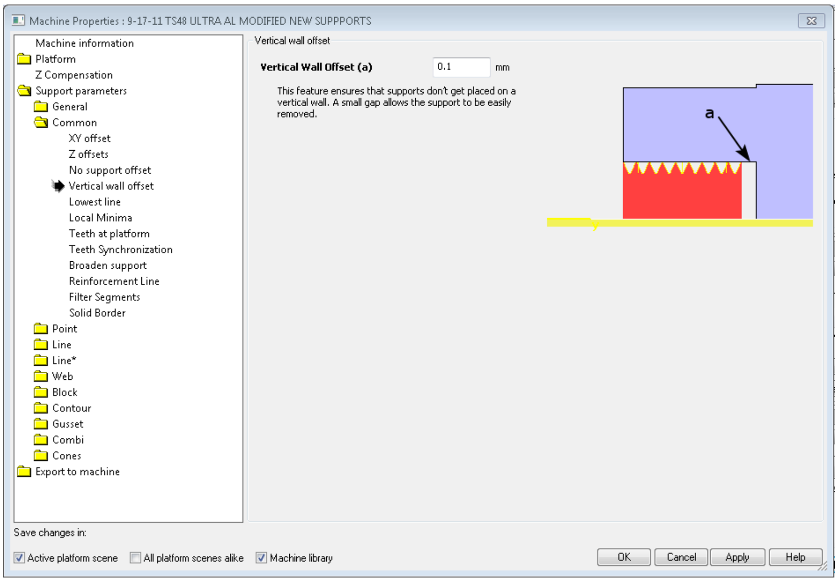

Figure 20. Introducing machine settings – Vertical wall offset

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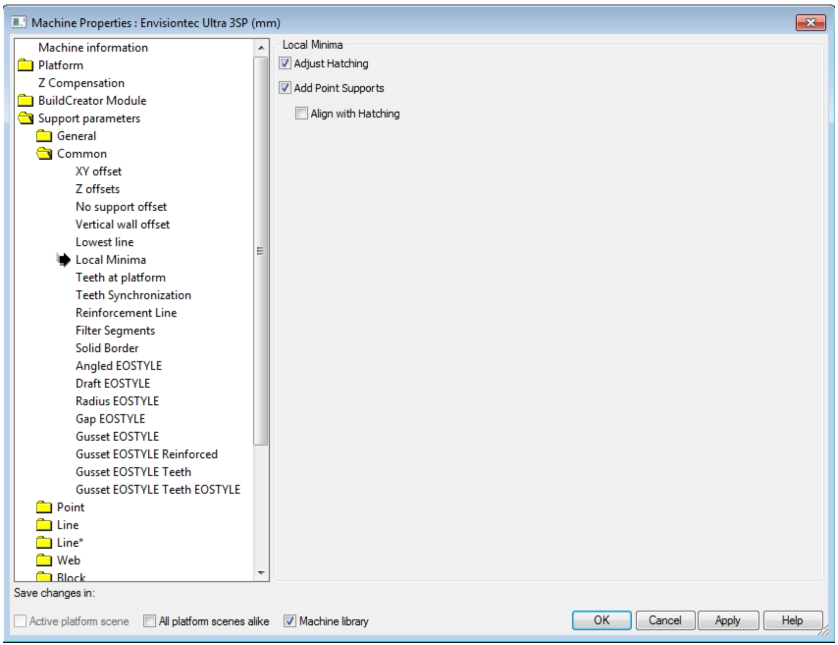

Figure 21. Introducing machine settings – local minima

In Figure 21 is defined local minima for support. In Figure 22 is defined teeth at platform that can go directly of platform or it can be defined with some value.

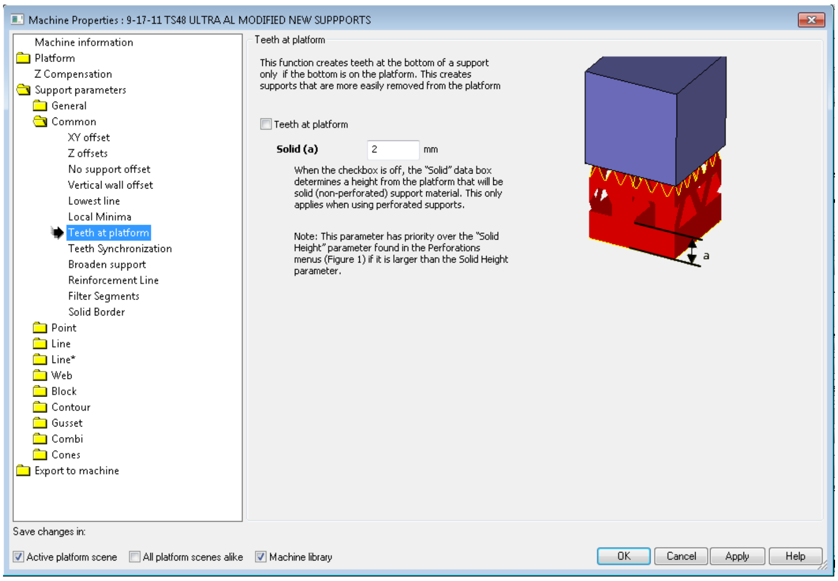

Figure 22. Introducing machine settings – Teeth at platform

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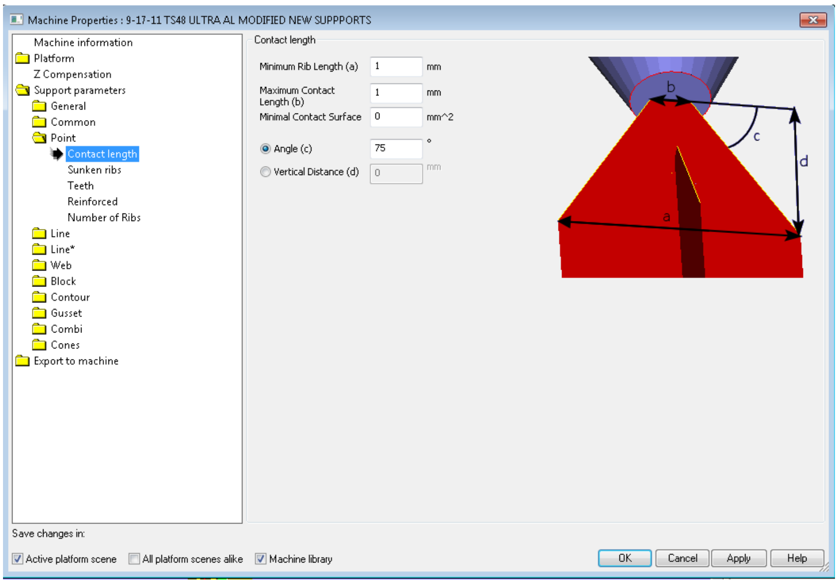

Figure 23. Introducing machine settings – Contact length

In Figure 23 is defined contact length of support structure. In Figure 24 is defined basic parameter for support – gusset.

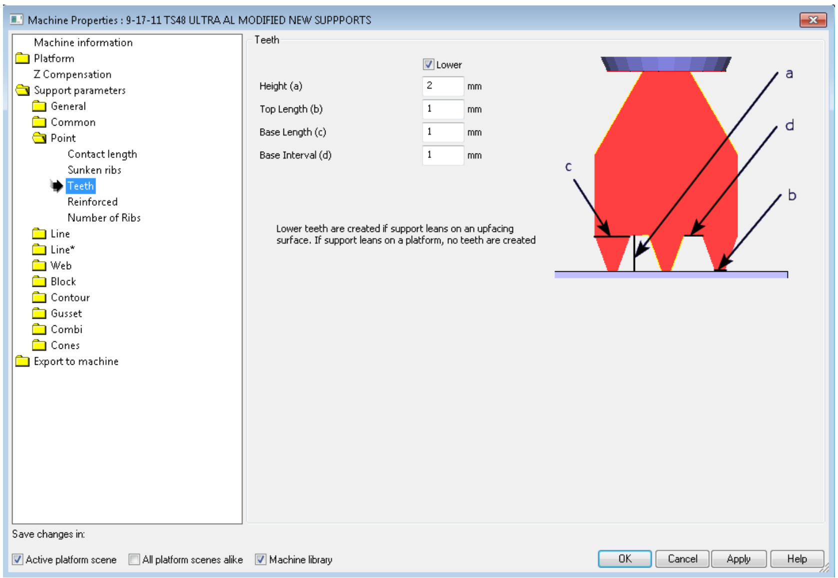

Figure 24. Introducing machine settings – Teeth

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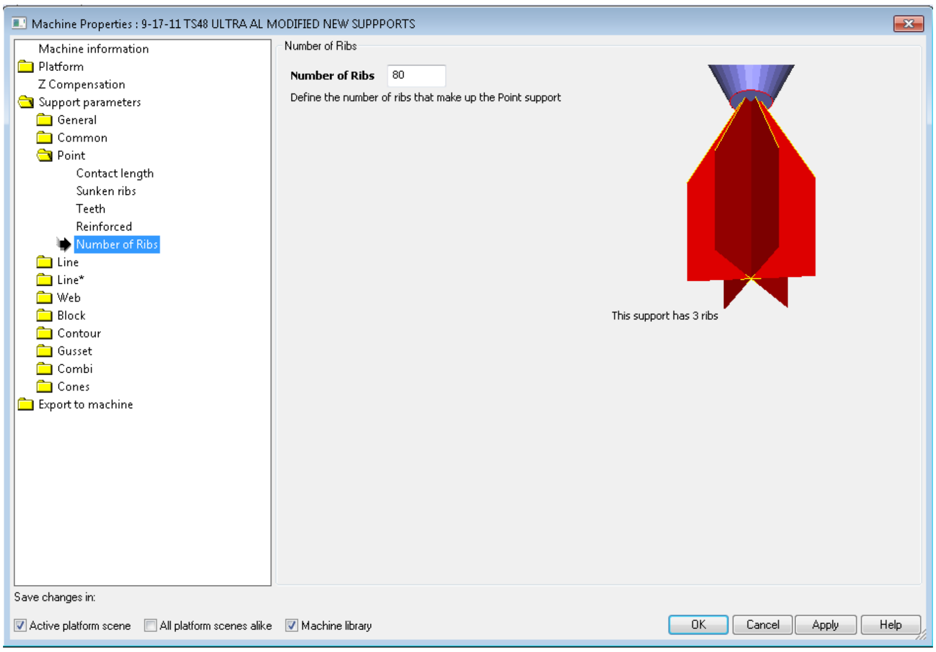

Figure 25. Introducing machine settings – number of ribs

In Figure 25 is defined number of ribs that are generated on support structure. In Figure 26 is defined minimum rib lenght and maximum contact length.

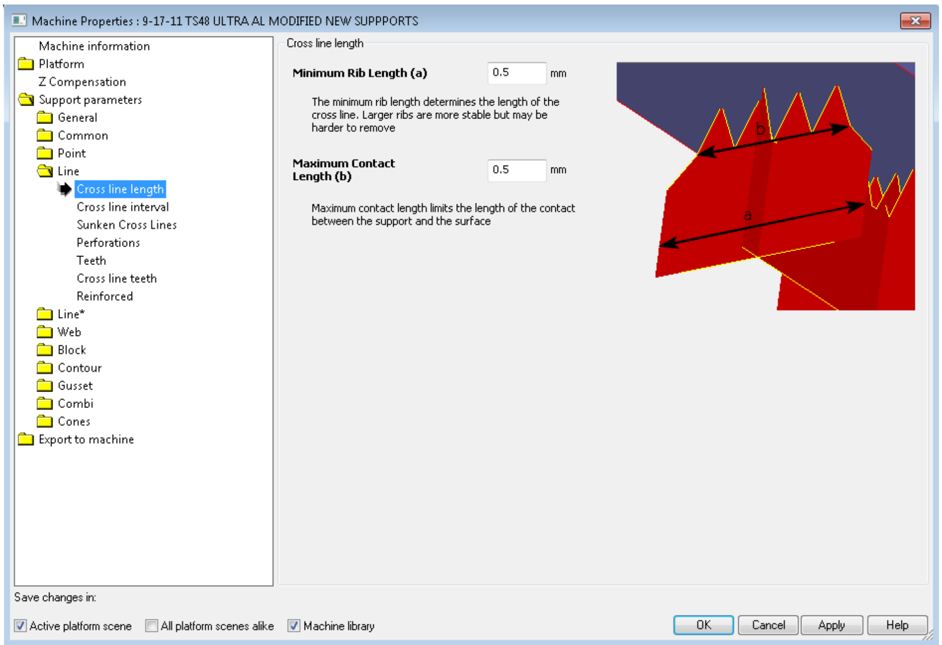

Figure 26. Introducing machine settings – cross line length

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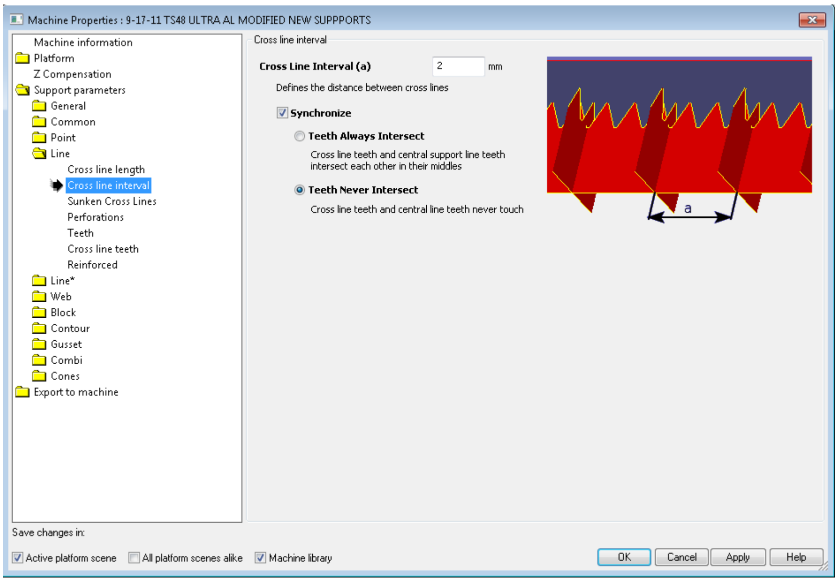

Figure 27. Introducing machine settings – Cross line interval

In Figure 27 is defined cross line interval. In Figure 28 is defined sink cross lines with distance.

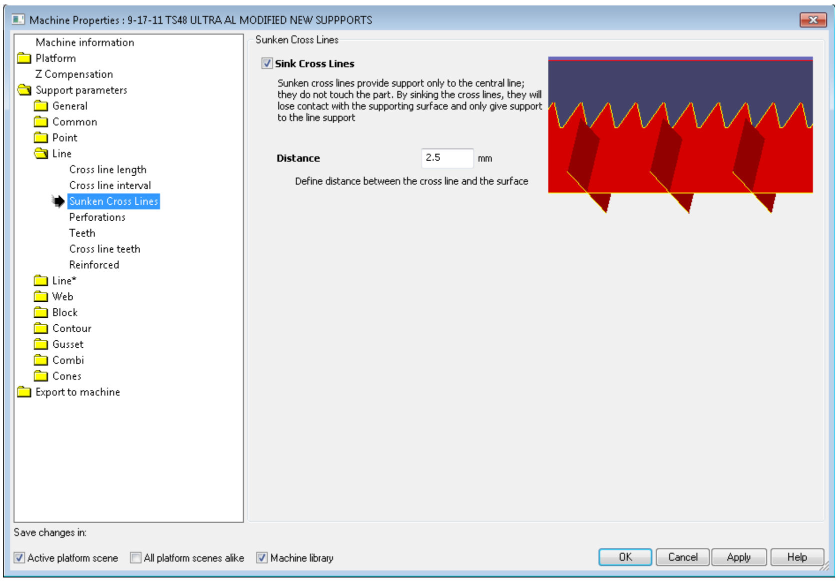

Figure 28. Introducing machine settings – sunken cross lines

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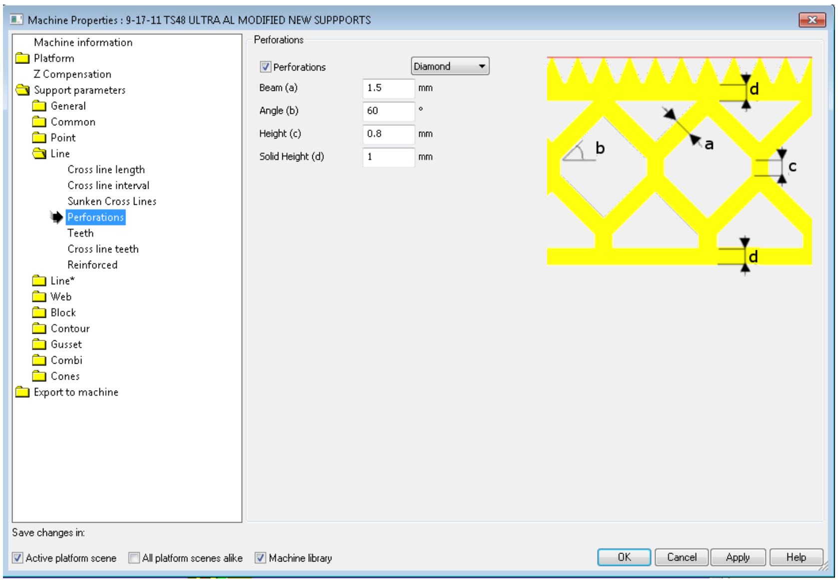

Figure 29. Introducing machine settings – perforations

In Figure 29 is defined dimensions for perforations. In Figure 30 is defined dimensions for teeth.

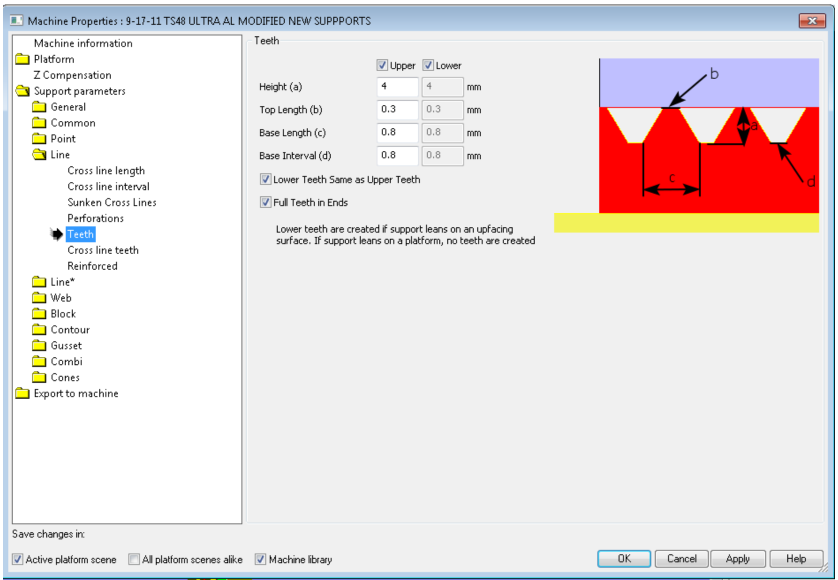

Figure 30. Introducing machine settings – line teeth

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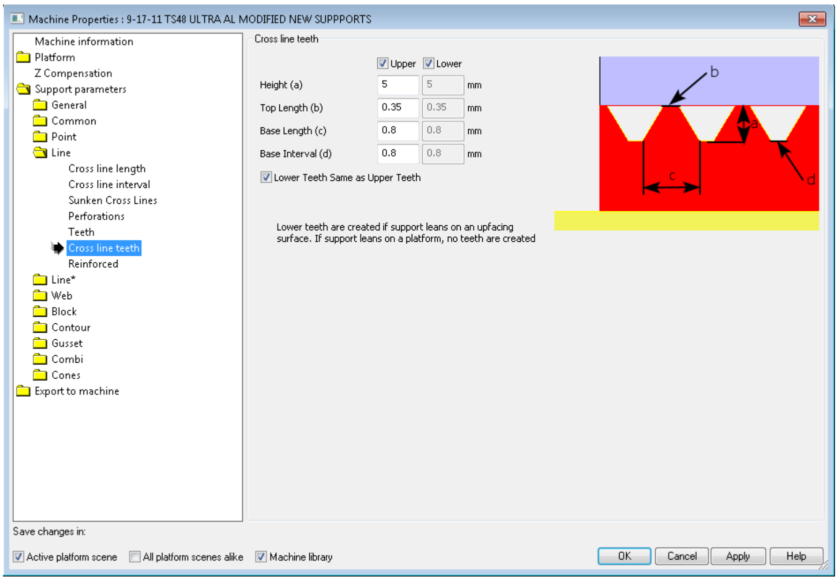

Figure 31. Introducing machine settings – cross line teeth

In Figure 31 is defined dimensions for cross line teeth. In Figure 32 is defined reinforced for line support.

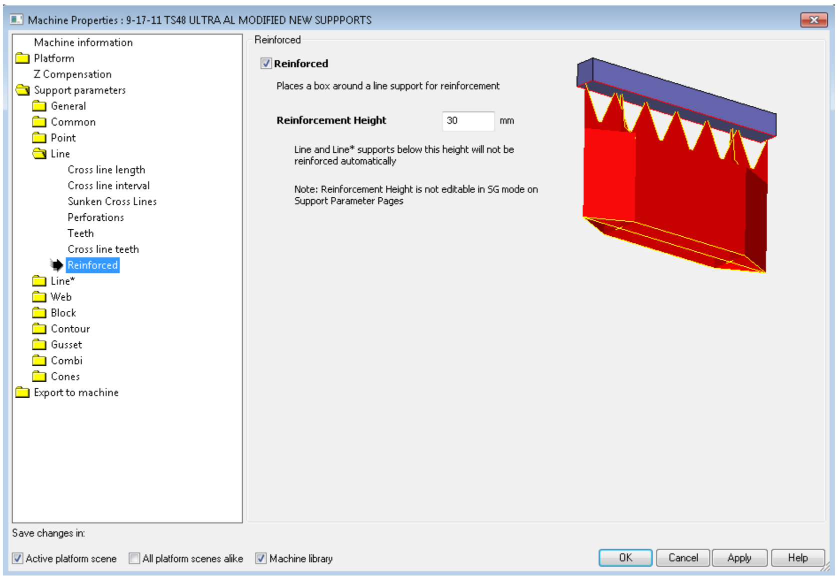

Figure 32. Introducing machine settings – reinforced

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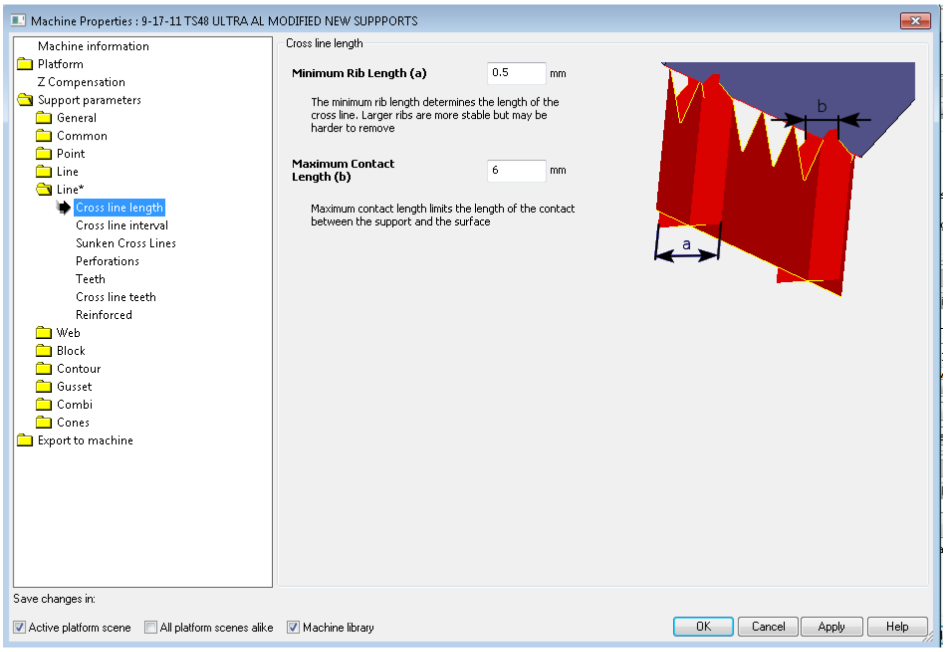

Figure 33. Introducing machine settings – cross line length

In Figure 33 is defined cross line length for support. In Figure 34 is defined cross line interval for line support structure.

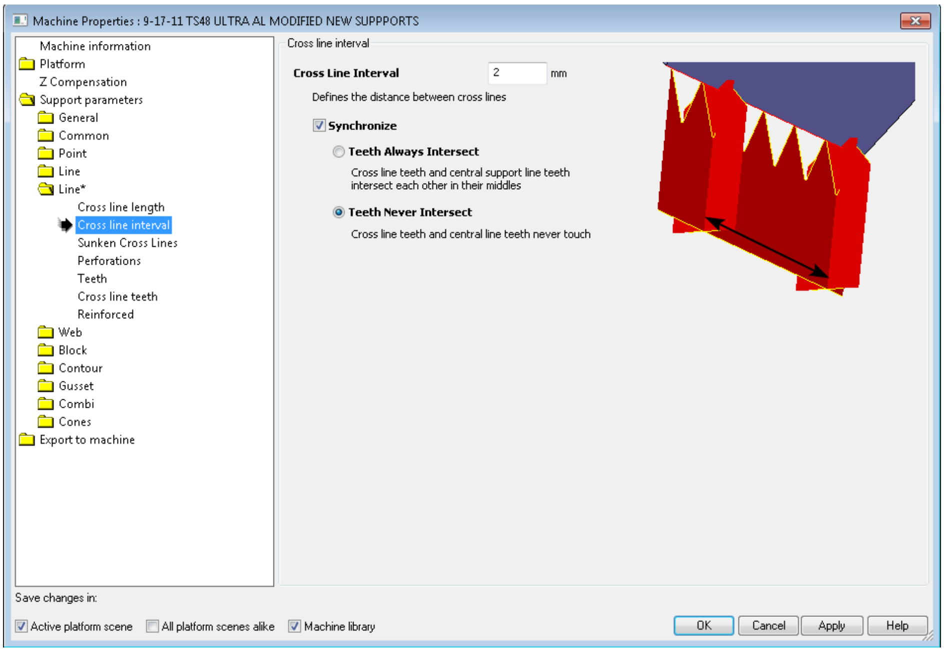

Figure 34. Introducing machine settings – cross line interval

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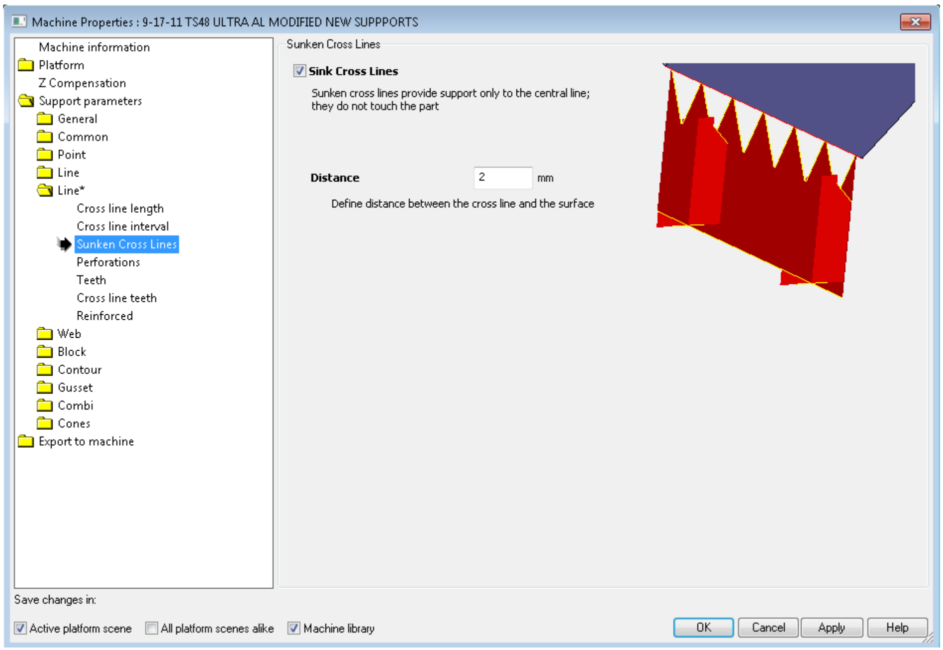

Figure 35. Introducing machine settings – sunken cross lines

In Figure 35 is defined sunken cross lines. In Figure 36 is defined dimensions for perforations.

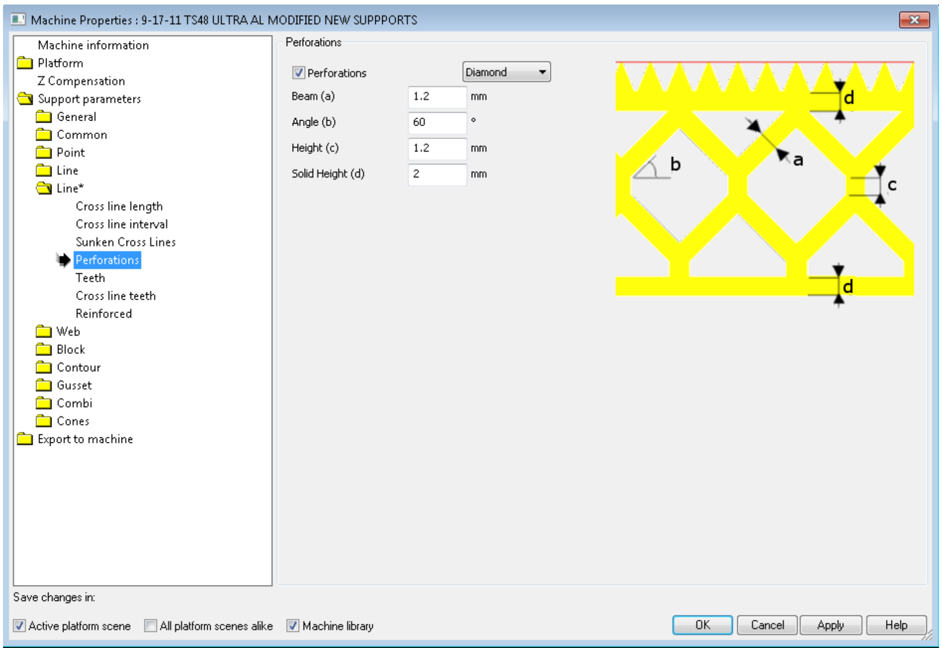

Figure 36. Introducing machine settings – perforations

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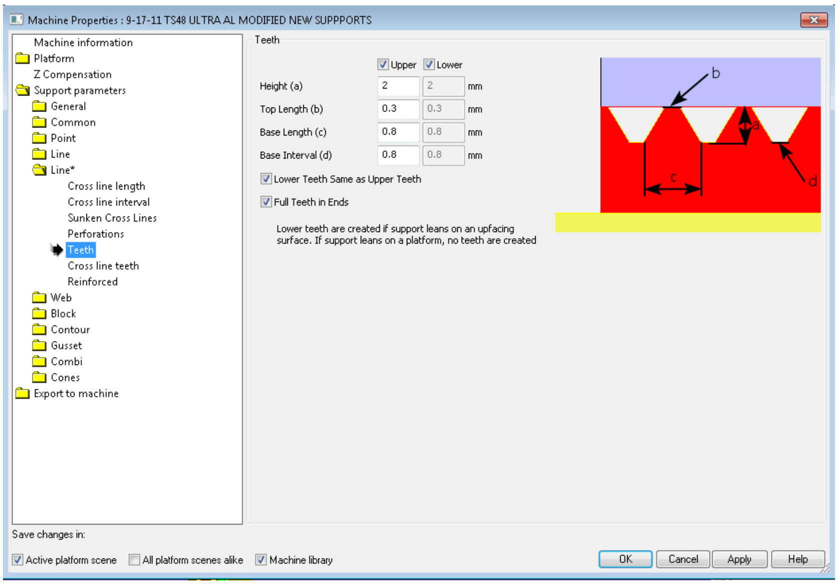

Figure 37. Introducing machine settings – teeth

In Figure 37 is defined dimensions for teeth. In Figure 38 is defined dimensions for cross line teeth.

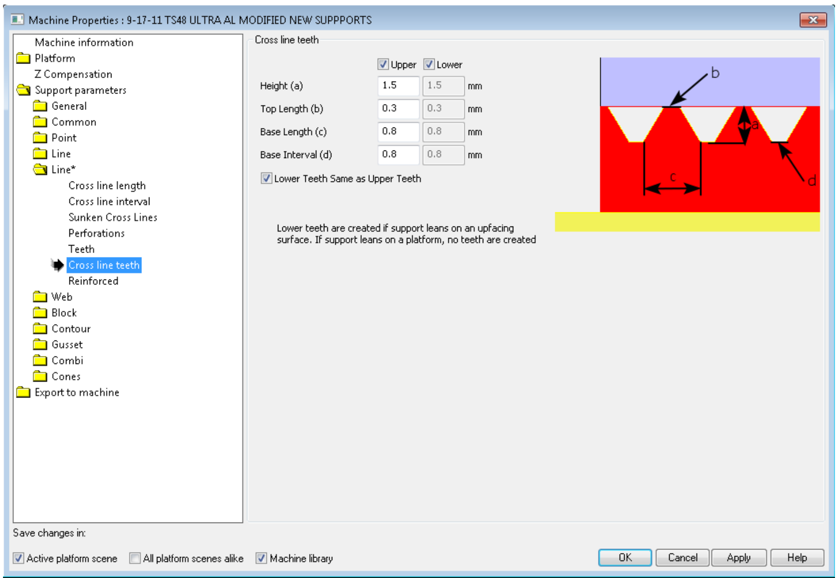

Figure 38. Introducing machine settings – cross line teeth

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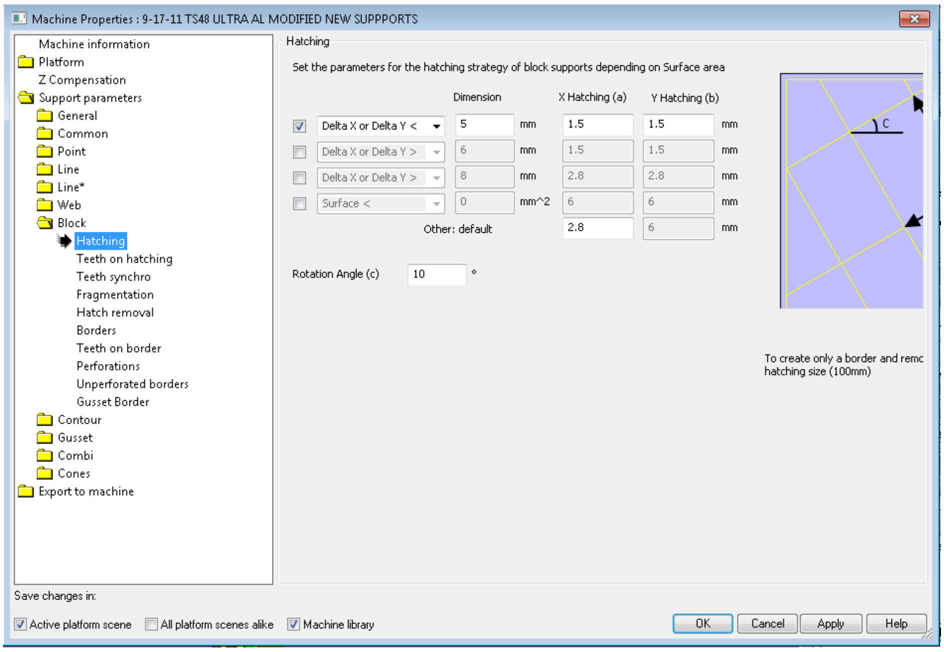

Figure 39. Introducing machine settings – hatching

In Figure 39 is defined dimensions for hatching as blocks of support structure. In Figure 40 is defined dimensions for teeth on hatching.

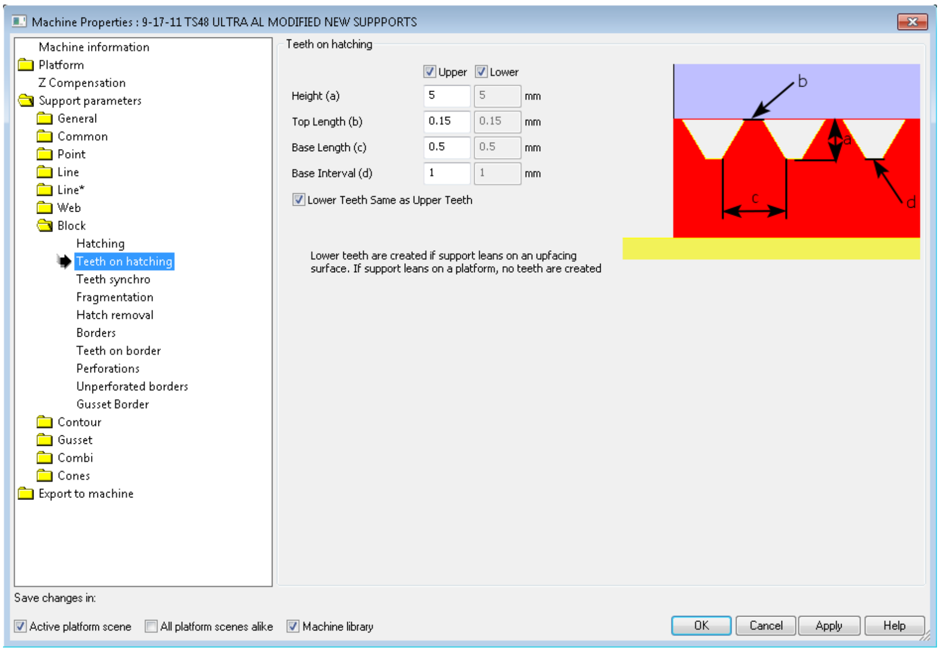

Figure 40. Introducing machine settings – teeth on hatching

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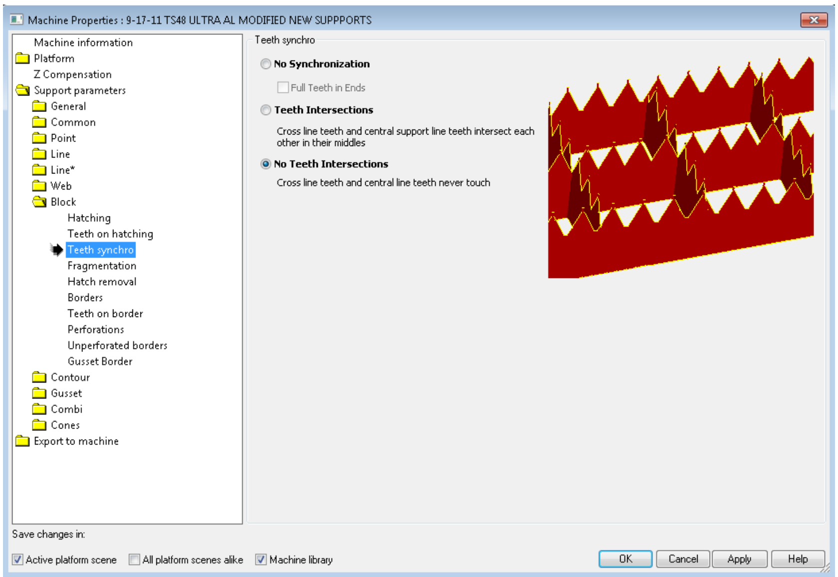

Figure 41. Introducing machine settings – teeth synchro

In Figure 41 is defined teeth synchro. In Figure 42 is defined dimensions for fragmentation.

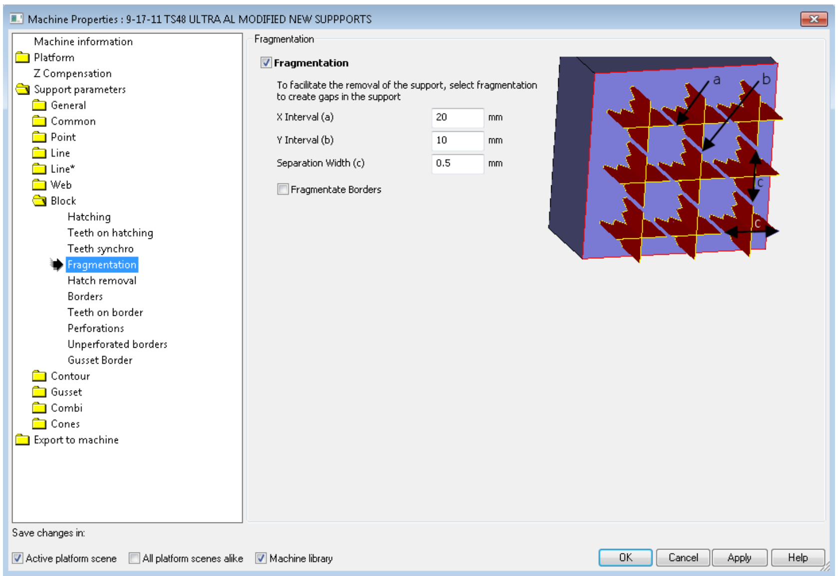

Figure 42. Introducing machine settings – fragmentation

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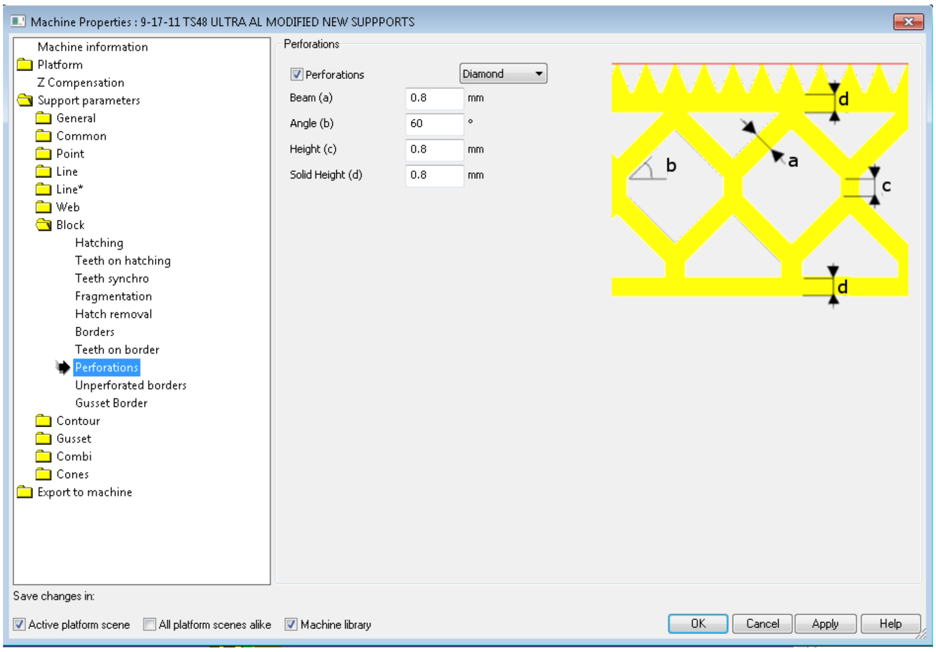

Figure 43. Introducing machine settings – block perforations

In Figure 43 is defined dimensions for block perforations. In Figure 44 is introducing new scene in the software by using card Scenes.

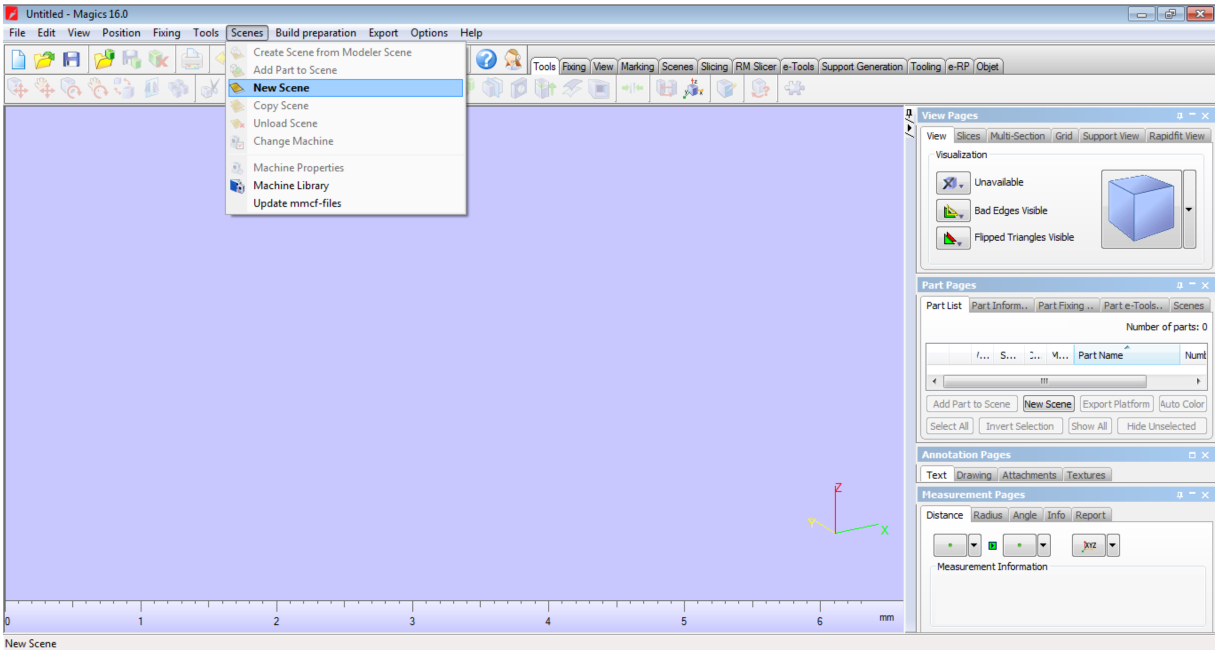

Figure 44. New scene

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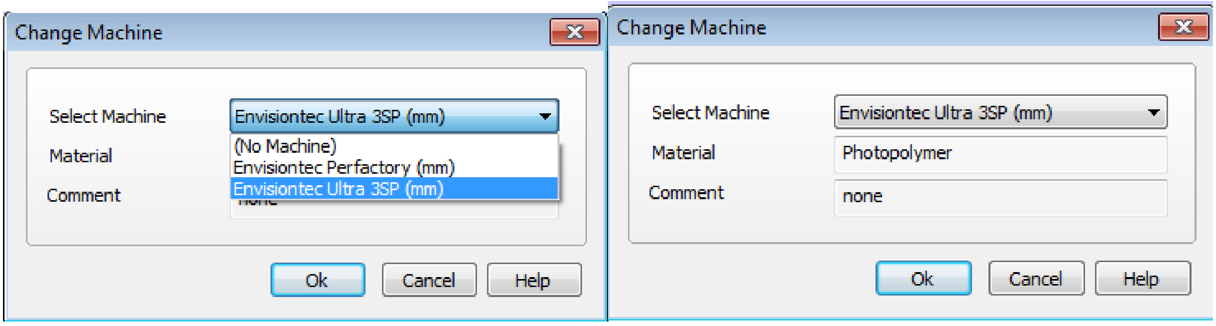

Figure 45. Introducing machine settings at new scene

In Figure 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 46-48 is shown the position and support structure by selection “block” support parameter.

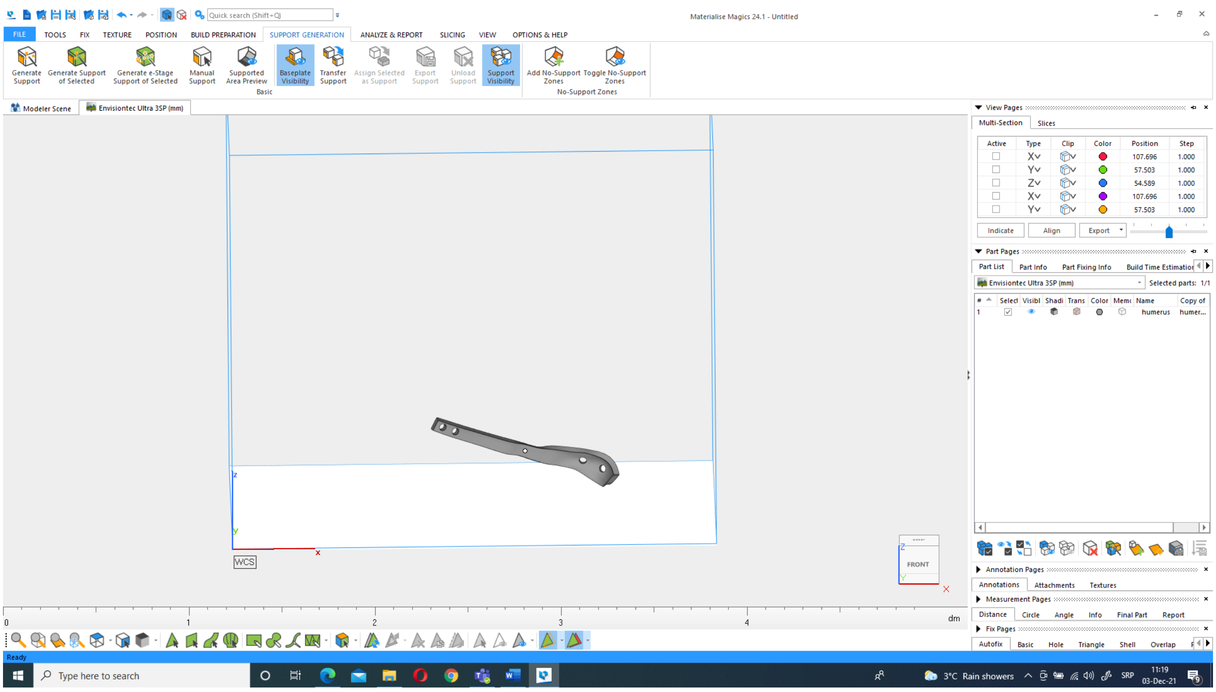

Figure 46. Importing part into Material Magics

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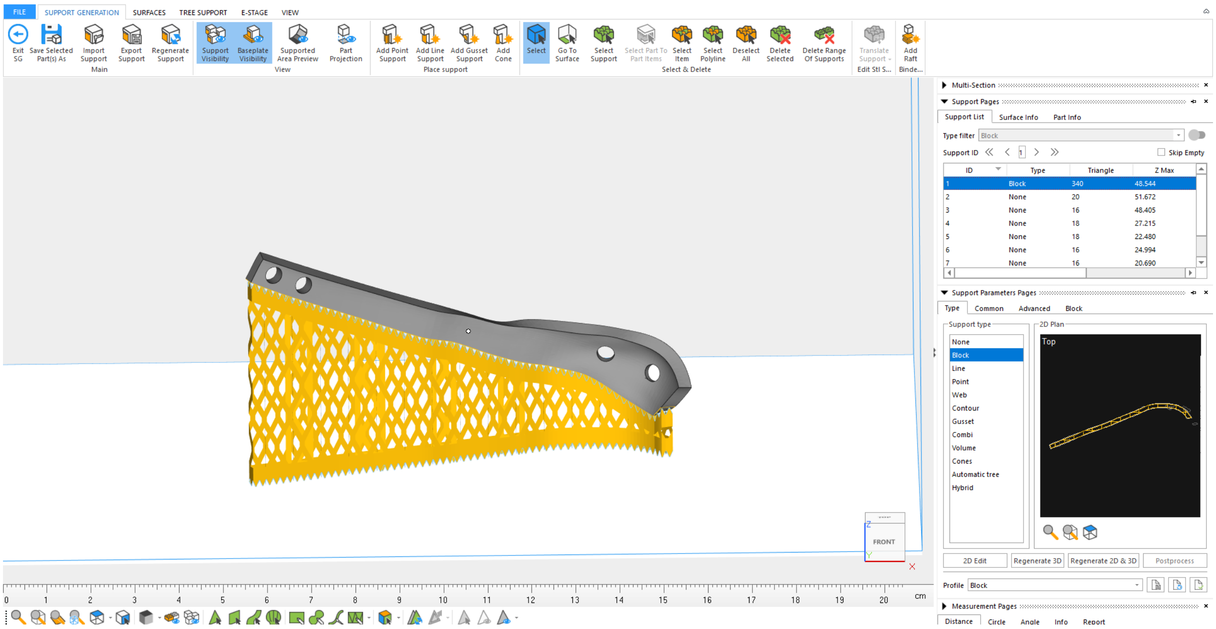

Figure 47. Defining support structure

In Figure 47 is shown part with, in previous steps, defined support structure. For this support structure is used block support. In Figure 48 is shown position of the part with support structure on the platform.

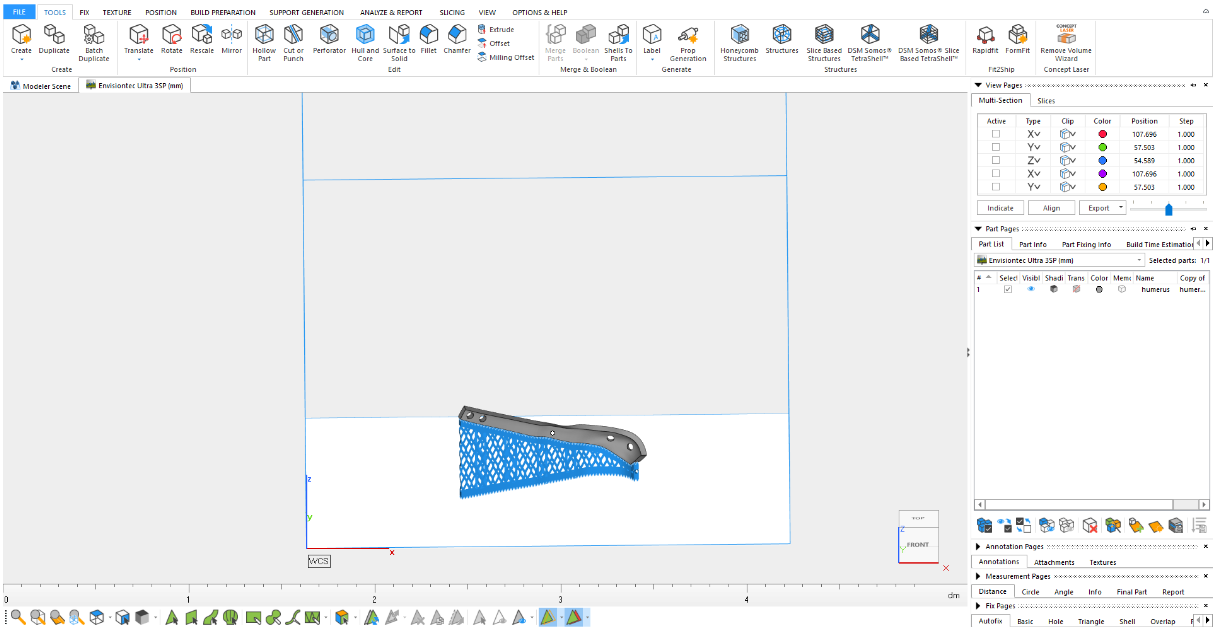

Figure 48. Part with support

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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 49. shows the laser that is on the top over the tank with resin material. Laser is moving left and right and every time makes solidification of one layer. During the printing process, printed part can not 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 49 Printing of part in the 3D printer

In Figure 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 51. is shown separation of part with support structure from the platform 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 to be immersed.

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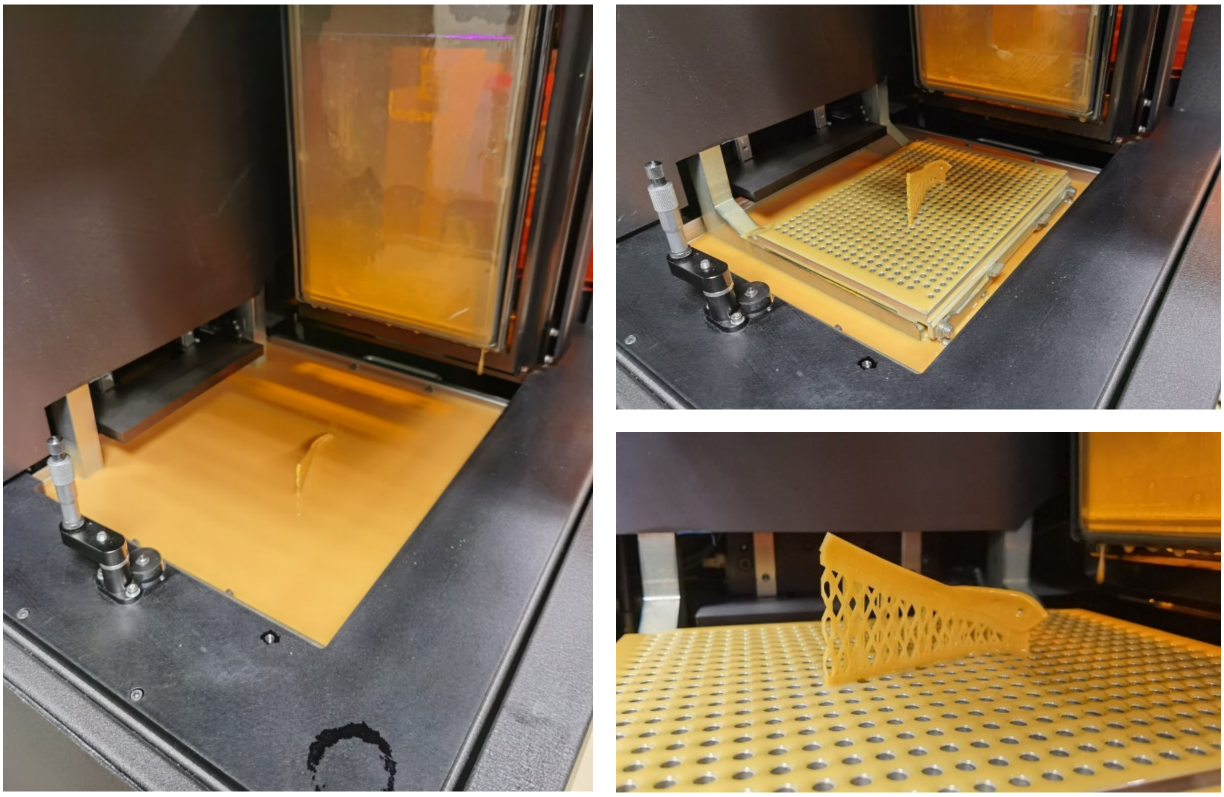

Figure 50 Finishing of printing of the part

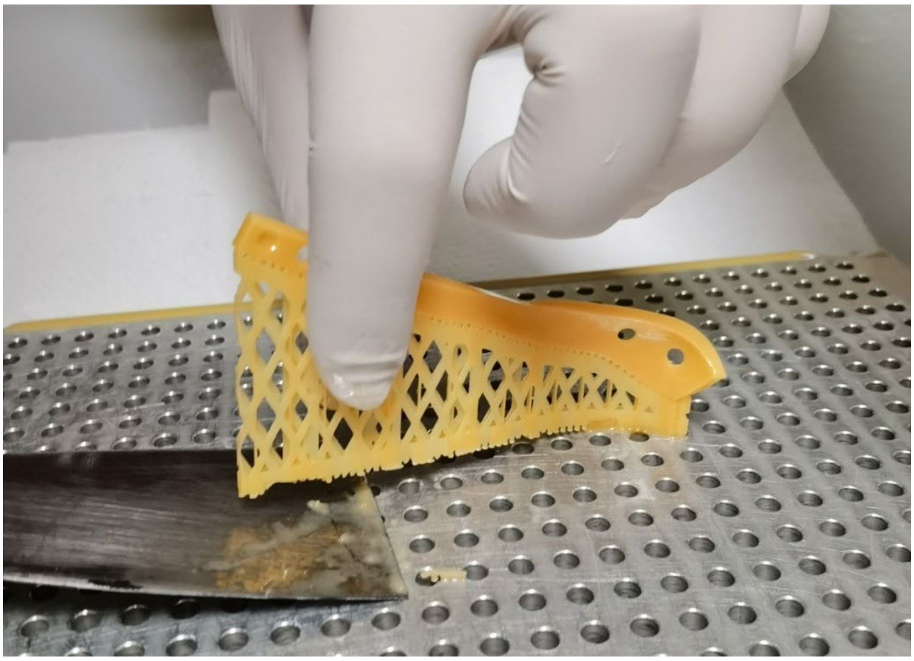

Figure 51. Separation of printed part from platform

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In Figure 51 is shown removing of part with support structure from platform by using spatula. After the part is removed it is necessary to wash it with isopropyl alcohol and it is advise it to put it in some bowl filled with isopropyl alcohol and to wash it and clean with brush.

Figure 52. Washing of part in isopropyl alcohol

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6. Postprocessing

In the Figure 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.

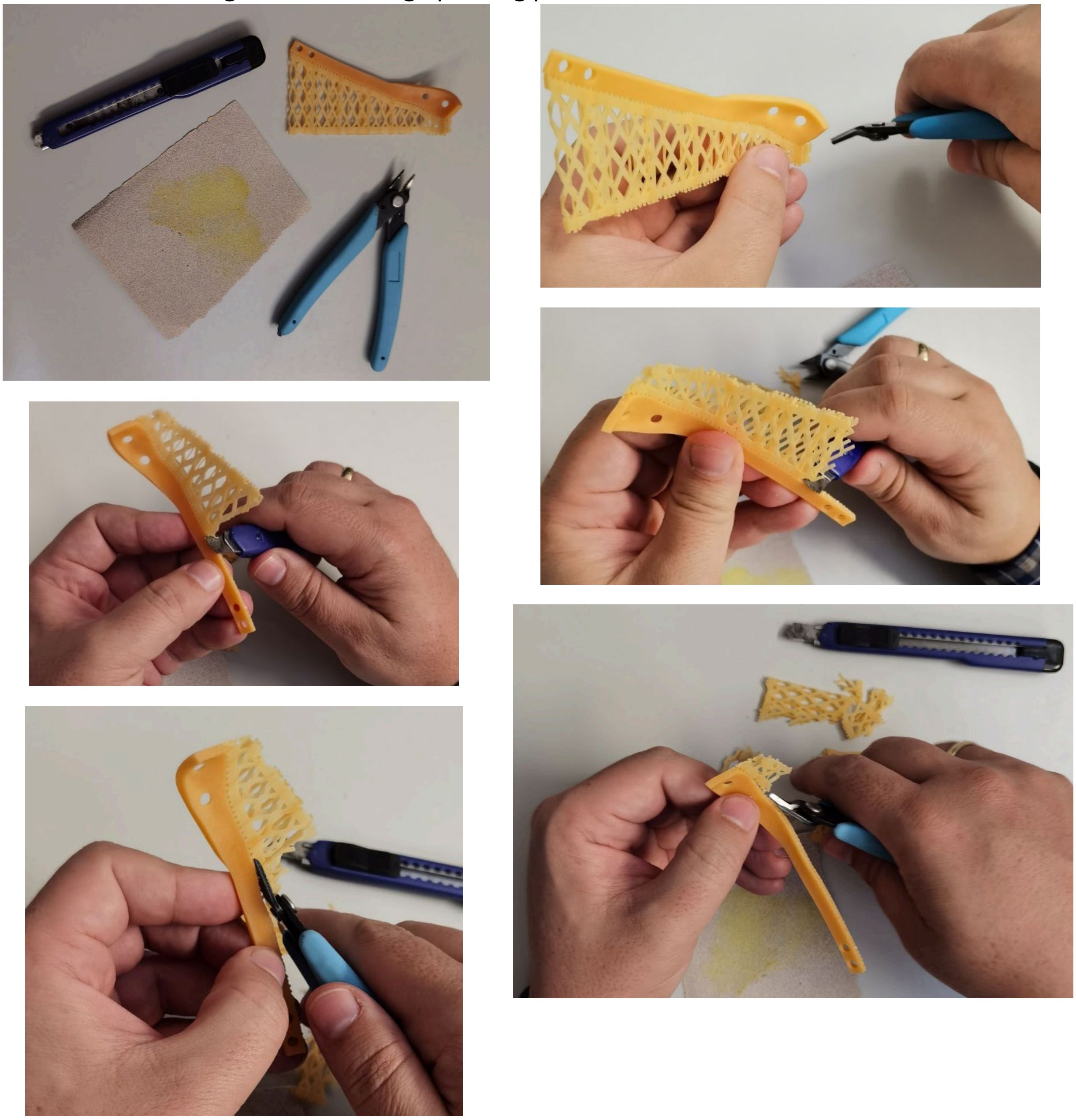

Figure 53. Postprocessing of 3D printed part

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Figure 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 54).

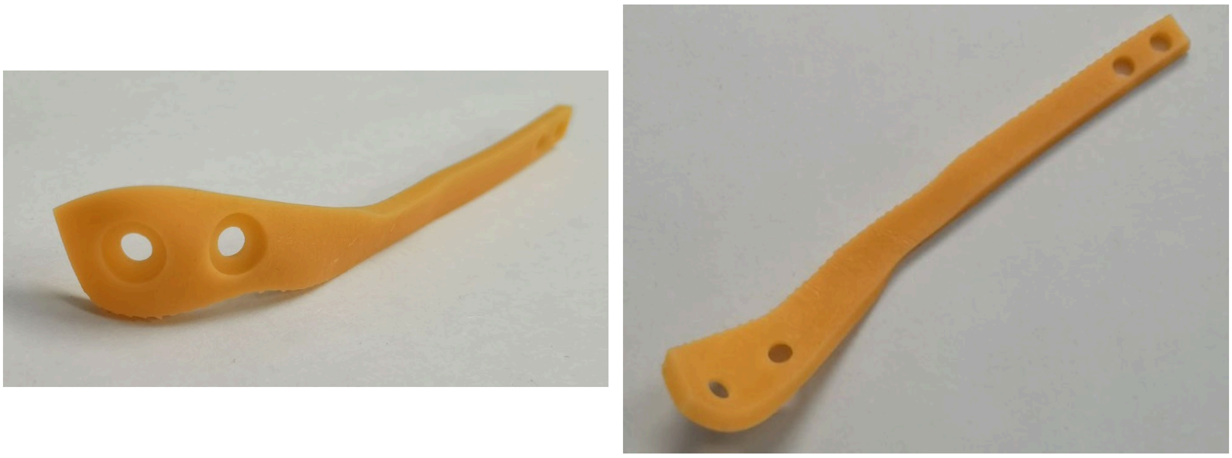

Figure 55. Printed part

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In the Figures 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 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.

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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