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enGrid manual

title	enGrid manual
date	28th June 2015
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version	draft

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Chapter 1

Introduction

ENGRID is an open-source mesh generation software with CFD applications in mind. ENGRID uses the NETGEN **?** library for tetrahedral grid generation and an in-house development for prismatic boundary layer grids. Internally, ENGRID uses the VTK **?** data structures as well as the *.vtu file format. To create grids for Currently ENGRID cannot generate surface grids. In order to create a volume grid it is required to import an existing surface mesh. Gmsh **?** is an excellent open-source tool to create surface triangulations for ENGRID . Gmsh is able to import STEP and IGES files and it can also be used for simple geometry modelling.

The 1.0release of ENGRID provides native export to OpenFOAM®[1]**?**. For future releases, export capabilities for complete OpenFOAM® cases (including boundary conditions) and support for polyhedral cells are planned as well.

ENGRID is released under the GPL and we hope that it is a useful addition to the open-source CFD community. So far the implemented algorithm proved to be quite robust and it does not require much user interaction. Figure **??**shows a boundary layer grid that has been created around the geometry of what could be a toy plane.



This manual is very much a work in progress and does not claim to be finished, comprehensive, complete, or anything else. We hope that, even in this early stage, it offers a little help while using ENGRID !

1.1 Current Release (1.0)

- volume grids from existing surface triangulations (no surface meshing support yet, but planned for future releases)

[1] OpenFOAM® is a registered trade mark of OpenCFD®Limited

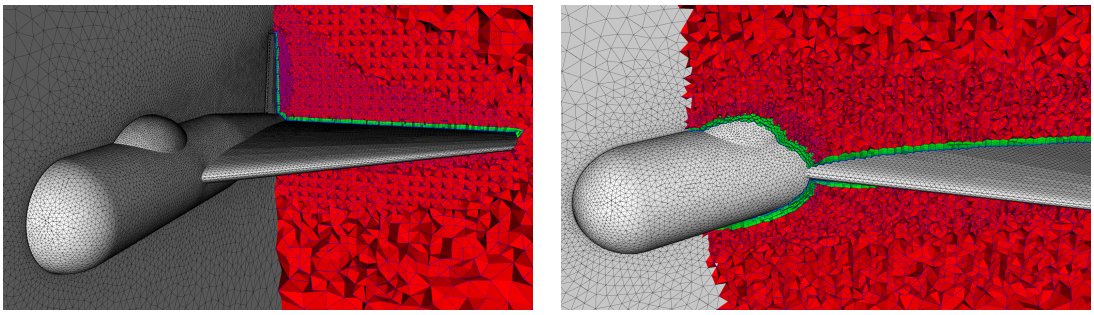

Figure 1.1: Prismatic boundary layer created by ENGRID

- prismatic boundary layer support
- GUI based on Qt4
- direct export to OpenFOAM
- experimental support for polyhedral grids in OpenFOAM

1.2 Supported Platforms

- ENGRID is developed on a LINUX system (OpenSUSE 10.3), using Qt-4.4.1, VTK 5.2, and an SVN snapshot of NETGEN.
- A Windows executable for Windows-XP (32bit) is also available.

1.3 Supported File Formats

- VTK unstructured grids in XML format (ENGRID 's native format)
- VTK poly data in XML format (import)
- legacy VTK files (import)
- OpenFOAM (export)
- Gmsh (import & export)
- STL (import & export)
- NETGEN neutral format (export)

Chapter 2

Tutorials

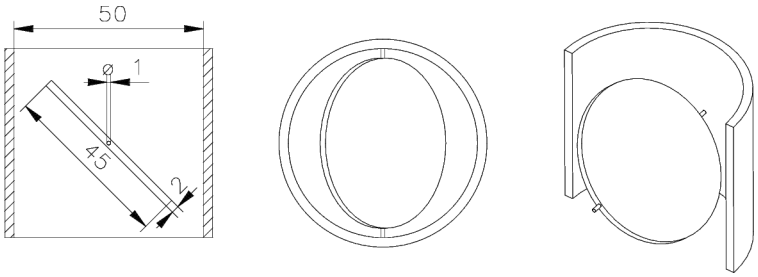

Figure 2.1: Throttle geometry

2.1 Tutorial 1: Creating a First Mesh

2.1.1 Description

This tutorial will demonstrate how to read a surface mesh and create a volume mesh for a CFD simulation. Figure **??**shows the geometry which will be used for this tutorial; it represents an adjustable throttle. The file containing the surface mesh for this tutorial is called "Throttle.msh" and it can be downloaded from the ENGRID download page.

2.1.2 Importing the Surface Mesh

To start, please import the file choosing

Import » Gmsh » v2.0 (ASCII)

from the menu bar. A file-dialogue will show and you can browse for the file and open it. Figure **??** shows a screen-shot of ENGRID after importing the file. You can use the mouse to rotate, move, and zoom the view. This mouse interaction is the default mouse interaction provided by VTK.

ENGRID colours the faces of the surface grid in order to determine which side of the surface is inside a flow domain and which is outside. The outside is coloured in a pale green, but figure **??** shows pale yellow; this means the surface is wrongly oriented and it needs to be corrected. To do this, please choose

Mesh » change surface orientation

from the menu-bar. Afterwards the surface will be oriented correctly.

2.1.3 Defining Boundary Conditions

Unfortunately all faces belong to the same boundary condition and thus it is not possible to see inside the domain. To change this you can pick a surface on the side of the cylindrical geometry and then change its boundary condition to a different value. To pick a face, please point the mouse over a triangle and press

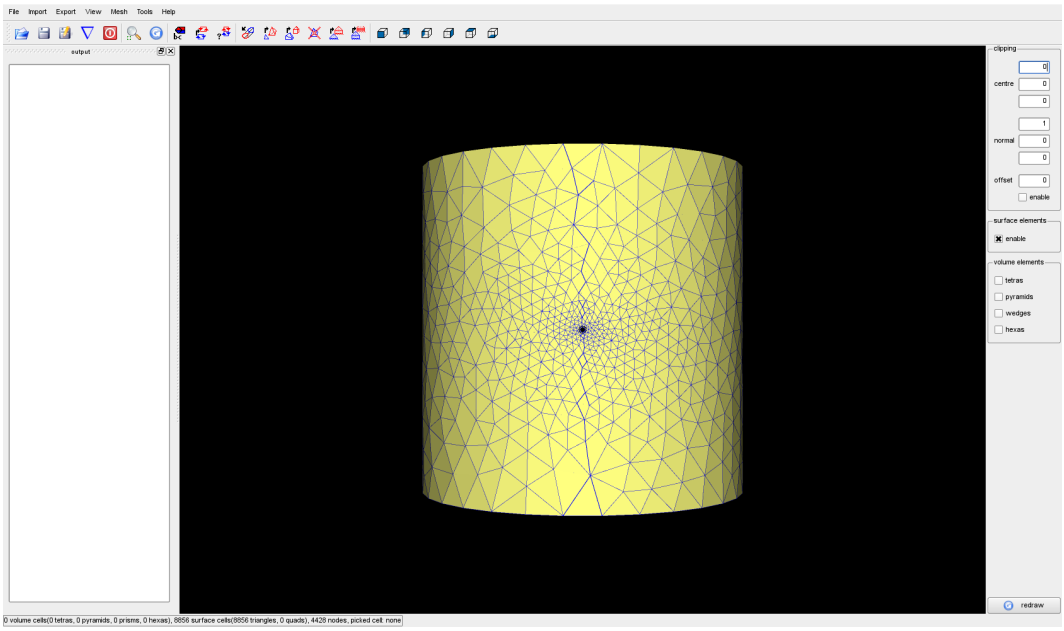

Figure 2.2: After importing the surface mesh

the “P” key on your keyboard. Afterwards you should see something similar to figure **??**. To change the boundary code, please select

Mesh » set boundary code.

A small dialogue will pop up and it offers to select a feature angle and a new boundary code. The new boundary code should be set to "2" and the feature angle can remain at 45 degrees. With this setting you should set the whole side of the cylinder to a new boundary code and the faces should disappear, because they have not been selected for viewing yet. Now, do the same with the top (boundary condition 3) and the bottom (boundary condition 4) of the cylinder. To get rid of the red box, please point the mouse into an empty space and press “P” again. Now would be a good time to save your work. Select

File » Save Grid As

to save the file.

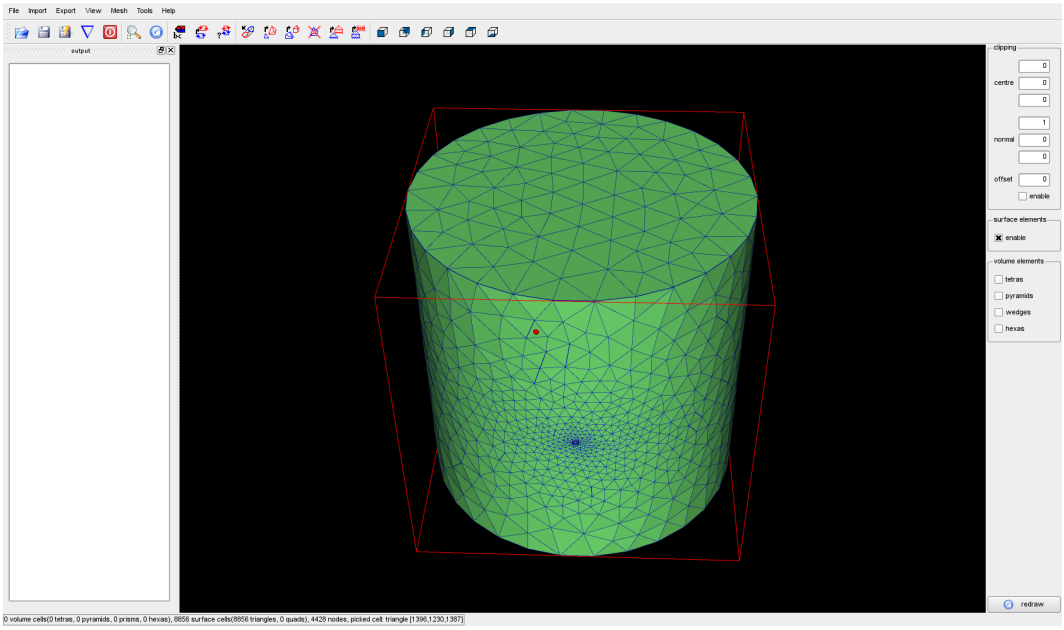

Figure 2.3: After picking a face

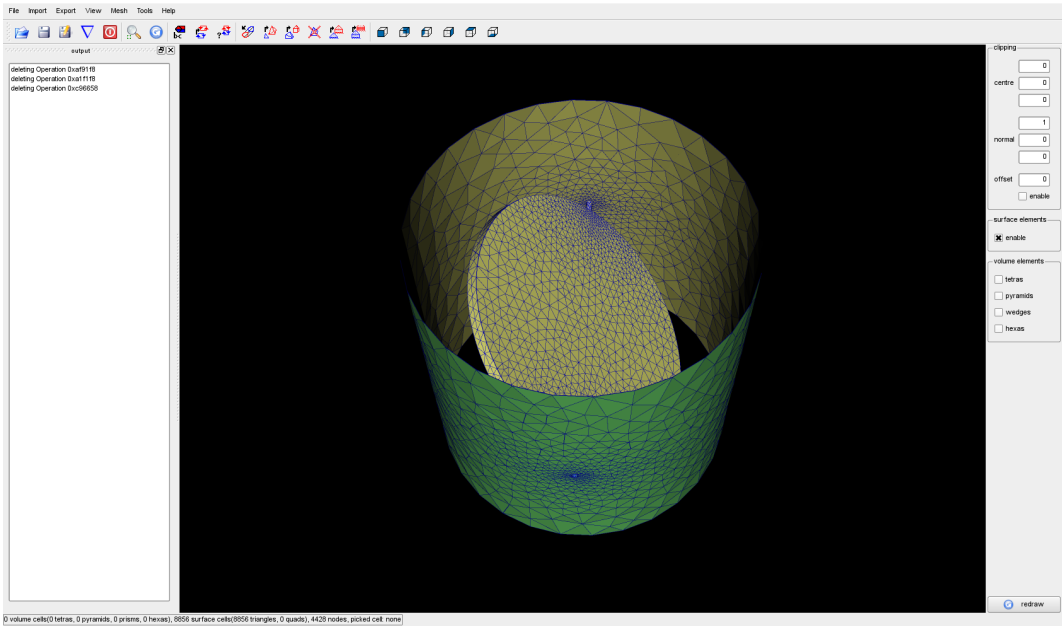

Figure 2.4: Physical walls for prismatic boundary layer

2.1.4 Create Volume Mesh

Creating a first volume mesh, including the boundary layer, is fairly easy now. First choose

View » boundary codes

and select the boundary conditions 1 and 2, because these represent the physical walls of the geometry. You should now have something similar to figure **??**. To create the grid, simply select

Mesh » create prismatic boundary layer,

select the boundary conditions 1 and 2 and click “OK”. You can watch the progress in the output window on the left side of the screen. This output window can be detached, moved somewhere else, or hidden completely. ENGRID indicates that it is busy in the status line at the bottom of the window. After ENGRID has finished you can select “tetras” and “wedges” from the available options on the right side of ENGRID ’s main window. In order to see inside you should also enable the clipping options. The origin of the clipping plane can be set to (0,0,0) and the normal vector to (0,0,-1). If you now select to view only boundary condition 1 and choose

View » redraw

your screen should look similar to figure **??**. To get a nice tetrahedral part of the grid it is advisable to execute

Mesh » create improve volume mesh (NETGEN)

once or twice. The mesh size distribution is not ideal for the first run of NETGEN. ENGRID uses an existing volume grid to compute a mesh size distribution and uses this as input for the next call of NETGEN. Normally you get a rather coarse tetrahedral grid together with the prismatic layer. The next call will produce a grid that might be somewhat too fine. Starting from the second call of

Mesh » create improve volume mesh (NETGEN)

the grid should look rather nice (see figure **??**).

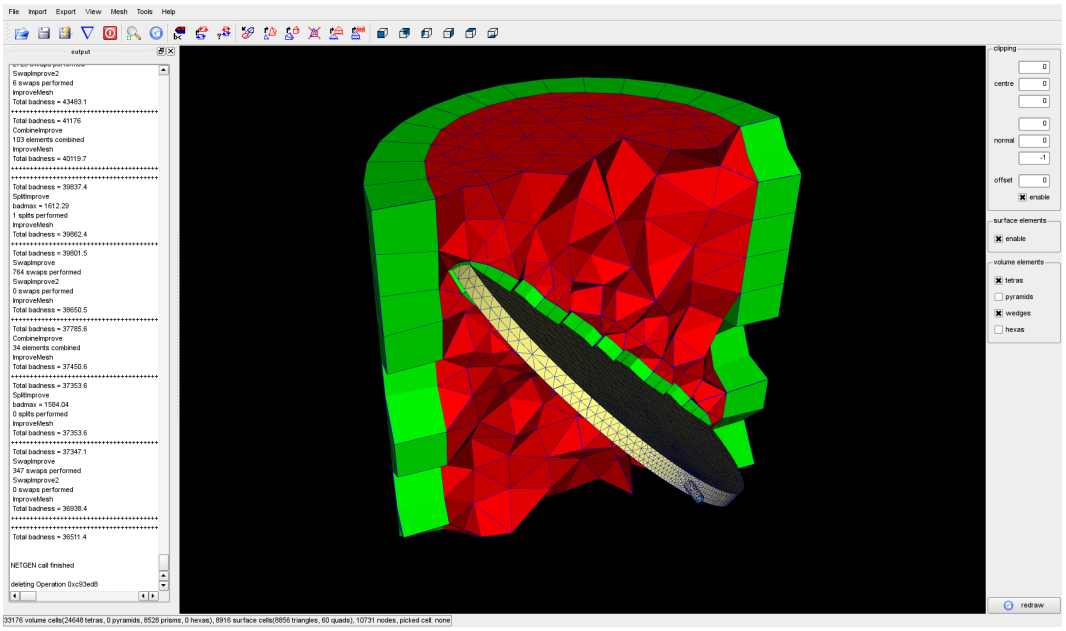

Figure 2.5: First volume grid

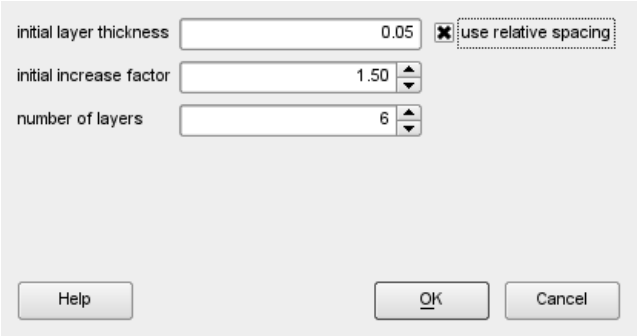

Figure 2.6: Parameters for boundary layer

2.1.5 Refining the Boundary-Layer

At the moment the boundary layer consists of a single layer of prisms. Refining the boundary layer is a straightforward process.



Save the grid with the refined boundary layer to a different file name, or don't save it at all (just export). At the moment the refinement cannot be reversed and thus the grid spacing cannot be changed. To do this, load the file with the initial one-layer boundary layer and refine again.

To refine the boundary layer, choose

Mesh » divide prismatic boundary layer.

A small pop-up dialogue appears, where you can enter how many layers and how to space them. Relative spacing means, that the initial step size (on the wall) is a fraction of the average local edge length around a node. Absolute spacing uses a fixed distance for all first layer prisms; this will lead to a first layer of prisms which is parallel to the wall. Not all step sizes are possible and ENGRID will issue a warning if it cannot refine your boundary layer. For this tutorial the settings in figure **??** should result in a decent boundary layer mesh.

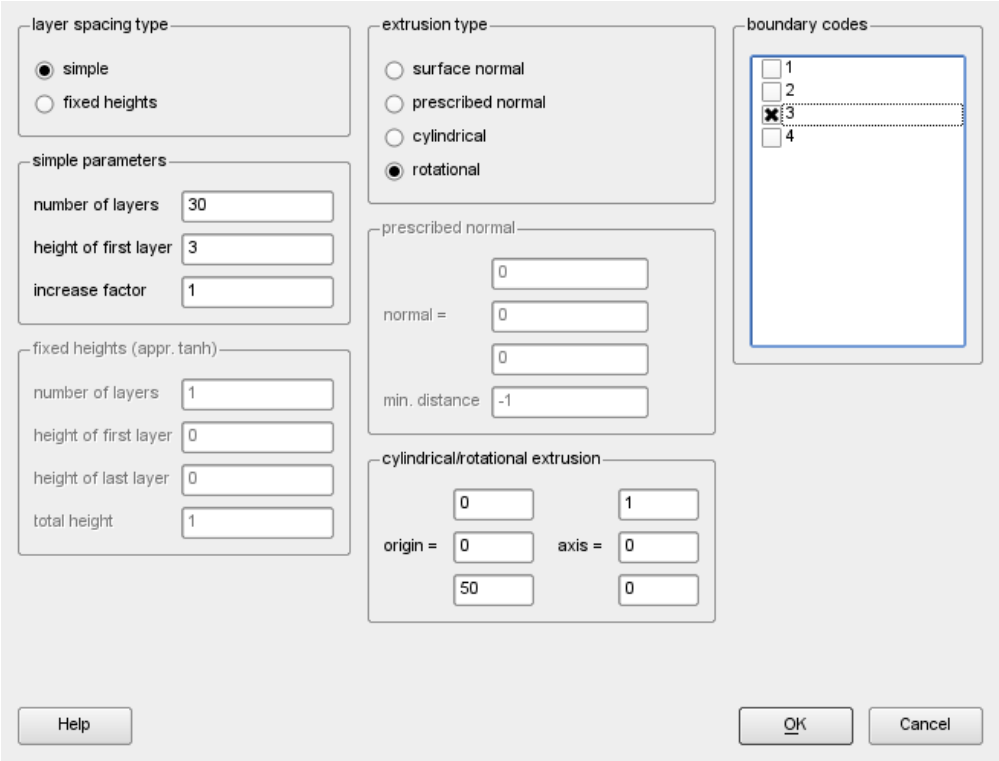

Figure 2.7: Parameters for rotational extrusion

2.1.6 Applying a few Simple Modifications

ENGRID offers the possibility to modify the grid by extruding certain boundaries. First we will add a pipe bend by applying a rotational extrusion to the upper boundary (code 3). Afterwards we will add straight sections for the in-flow and out-flow boundaries with the help of a normal extrusion. Please select

Mesh » extrusion

and enter the parameters exactly as shown in figure **??**. After clicking OK you should get a grid like the one shown in figure **??**. The extrusion adds a new boundary code (5) which needs to be enabled with

View » boundary codes

in order to view the newly created geometry. The layer height in figure **??** corresponds to an angle in degrees for a rotational extrusion. To extend the pipe at the inlet a normal extrusion with the parameters from figure **??** shall be used. If you do the same for boundary code 4 the grid should look like in figure **??**. To simplify the later setup of a simulation it is advisable to reset the newly created boundary codes (5,6,8) to the initially set value of 2 for the pipe.

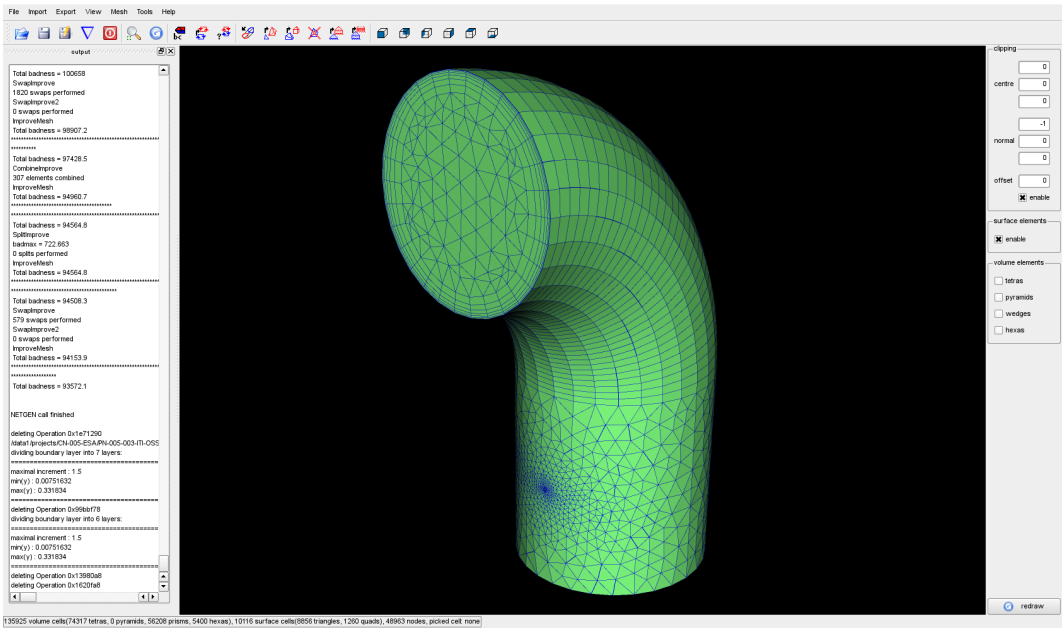

Figure 2.8: Grid after rotational extrusion

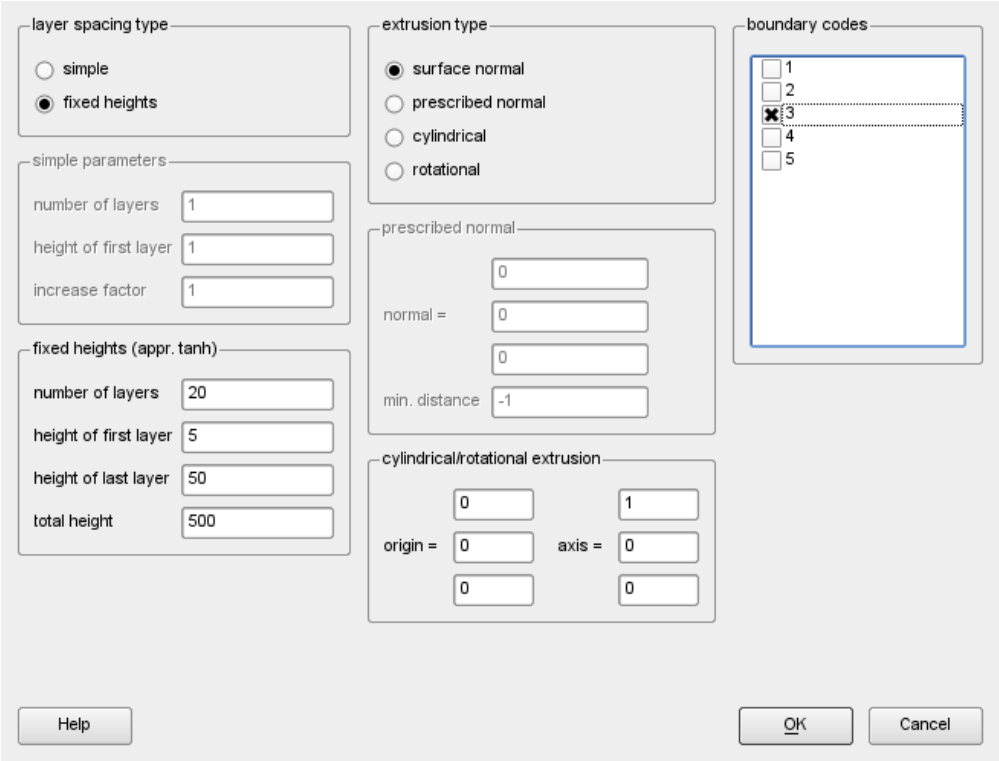

Figure 2.9: Parameters for normal extrusion

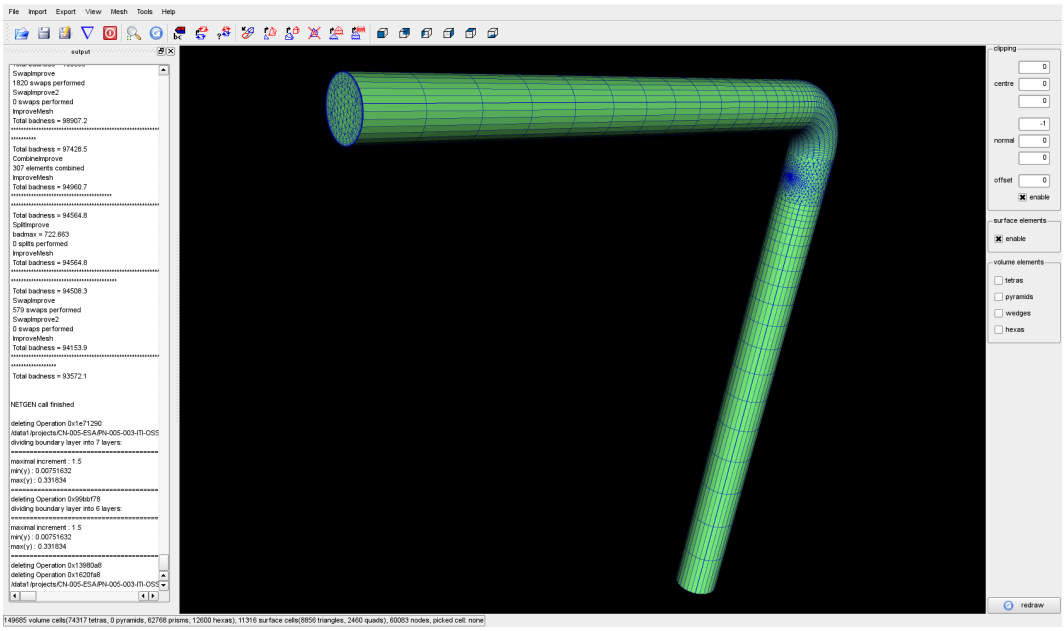

Figure 2.10: Grid after normal extrusion

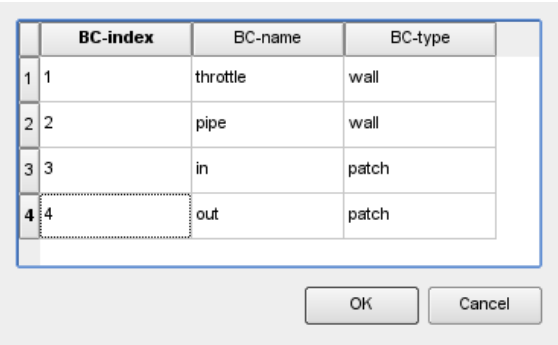

Figure 2.11: Editing the boundary conditions

2.1.7 Export the Grid to OpenFOAM®

Please select

Tools » edit boundary conditions

and edit the boundary names and types according to figure **??**. You can export the mesh using:

Export » OpenFOAM » OpenFOAM.

This will prompt you for an OpenFOAM® case directory and the mesh will be directly imported to the OpenFOAM® format, using the boundary names and types you have defined earlier.



OpenFOAM's checkMesh utility might report a bad mesh in case of very thin prisms. A good strategy is to export the mesh before the boundary layer is refined, run the checkMesh utility, and then - if everything looks alright - refine the boundary layer.

Appendix A

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