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Engrid User's Manual

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Table of Contents

1 Introduction

ENGRID is an open-source mesh generation software with CFD applications in mind. ENGRID uses the NETGEN [4] library for tetrahedral grid generation and an in-house development for prismatic boundary layer grids. Internally, ENGRID uses the VTK [2] 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 [1] 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 1.0 release of ENGRID provides native export to OpenFOAM®[1] [3]. 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 1.1 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 !

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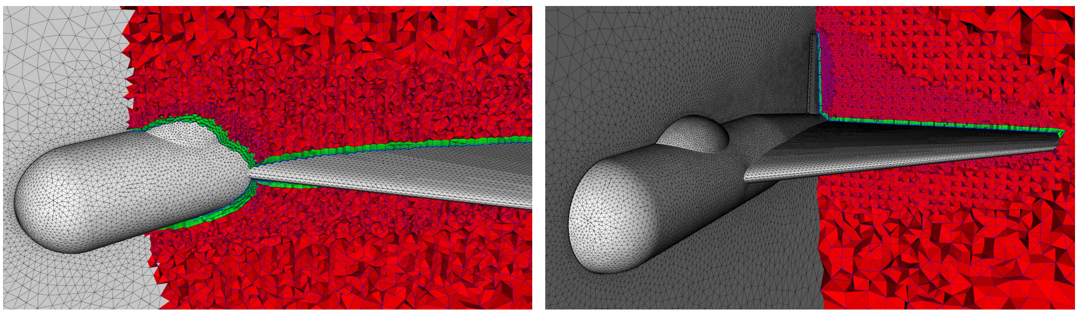


Figure 1: Prismatic boundary layer created by ENGRID

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

2 Installing Engrid

enGrid packages are now available on our FTP server: ftp://loerrach.engits.de

enGrid_1.0.1.tar.gz	stable source code
enGrid_linux32bit_1.0.tar.gz	tarball containing a compiled version of engrid for 32-bit systems with all necessary libraries
enGrid_linux64bit_1.0.tar.gz	tarball containing a compiled version of engrid for 64-bit systems with all necessary libraries
engrid_1.0_amd64.deb	Debian package for amd64 architectures
engrid_1.0_i386.deb	Debian package for i386 architectures

Source code repository to get the latest development version (UNSTABLE):

```
git clone http://engits.com/git/engrid.git
```

WARNING: The git repository may be unstable! It is the main development branch. Please use enGrid_1.0.1.tar.gz from the FTP for now if you want a stable version.

2.1 Automatic compilation from source

2.2 Manual Compilation from source

Variables to change according to your needs

```
VTKPREFIX = where to install VTK ( Default = /usr/local )
VTKVERSION = VTK version
QTPREFIX = where to install QT ( Default = /usr/local/Trolltech/Qt-4.5.0/ )
CGNSPREFIX = where to install CGNS ( Default = /usr/local/ )
```

Compiling VTK from source

You can get VTK from:

http://www.vtk.org/VTK/resources/software.html

Or from the ThirdParty package from OpenFOAM:

http://www.opencfd.co.uk/openfoam/downl ... l#download

```
cmake -DCMAKE_INSTALL_PREFIX:PATH=$VTKPREFIX -DBUILD_SHARED_LIBS:BOOL=ON
-DVTK_USE_GUISUPPORT:BOOL=ON -DVTK_USE_QVTK:BOOL=ON
-DDESIRED_QT_VERSION:STRING=4  .
```

```
chmod 644 Utilities/vtktiff/tif_fax3sm.c
make && su -c 'make install'
```

Optionally, you may also use ccmake or cmake-gui to simplify defining the configuration variables:

```
cmake.
ccmake.
```

or

```
cmake.
cmake-gui.
```

Configuration variables

```
CMAKE_INSTALL_PREFIX = VTKPREFIX
BUILD_SHARED_LIBS = ON
VTK_USE_GUISUPPORT = ON
VTK_USE_QVTK = ON
DESIRED_QT_VERSION = 4
```

If you also want the Java, Python and Tcl/Tk wrappers:

```
VTK_WRAP_JAVA
VTK_WRAP_PYTHON
VTK_WRAP_TCL
```

Compiling Qt from source

You can get Qt from:

http://www.qtsoftware.com/downloads

```
./configure --prefix=$QTPREFIX && make && su -c 'make install'
```

Compiling CGNS from source

You can get CGNS from:

http://cgns.sourceforge.net/download.html

```
mkdir -p $CGNSPREFIX/include
mkdir -p $CGNSPREFIX/lib
./configure --prefix=$CGNSPREFIX && make && make install
```

Compiling enGrid from source

```
export VTKINCDIR=$VTKPREFIX/include/vtk-VTKVERSION/
export VTKLIBDIR=$VTKPREFIX/lib/ (or sometimes VTKPREFIX/lib/vtk-VTKVERSION)
export LD_LIBRARY_PATH=$VTKLIBDIR:$LD_LIBRARY_PATH

export CGNSINCDIR=/opt/shared/cgns/include/
export CGNSLIBDIR=/opt/shared/cgns/lib/
export LD_LIBRARY_PATH=$CGNSLIBDIR:$LD_LIBRARY_PATH
```

```
export PATH=$QTPREFIX/bin:$PATH
export QTDIR=$QTPREFIX
export LD_LIBRARY_PATH=$QTPREFIX/lib:$LD_LIBRARY_PATH
```

```
./build-nglib.sh
qmake
make
```

Note: When using libqt4-dev from the repositories on Debian-based systems, make sure you use qt4 instead of qt3 by running:

```
sudo update-alternatives --config qmake
```

3 Tutorial: Volume Meshing from Existing Surface Meshes

3.1 Description

This tutorial will demonstrate how to read a surface mesh and create a volume mesh for a CFD simulation. Figure 1 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.

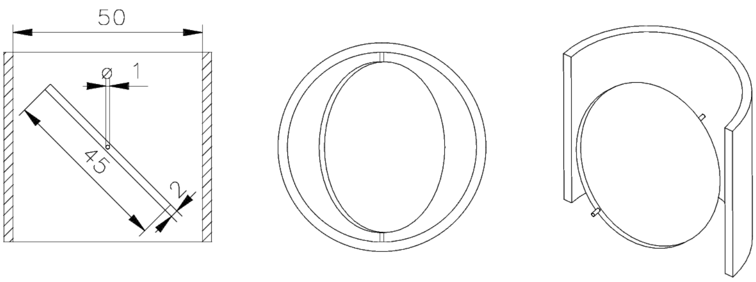


Figure 2: Throttle geometry

3.2 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 2 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.

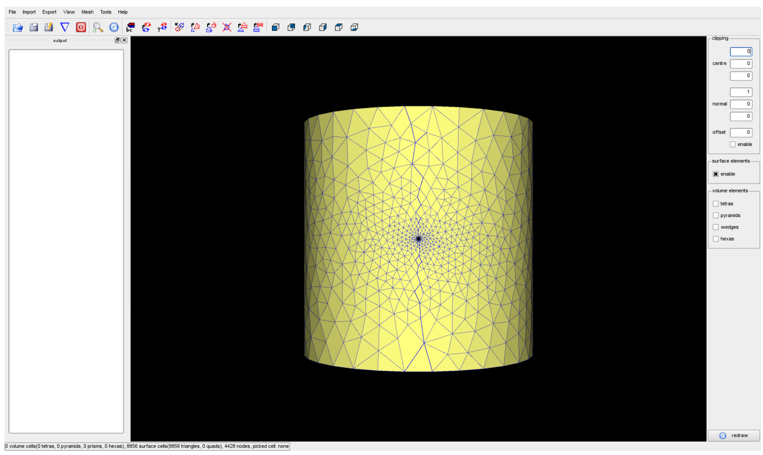


Figure 3: After importing the surface mesh

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 2 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.

3.3 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 the “P” key on your keyboard. Afterwards you should see something similar to figure 2.3. 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.

Due to the upcoming support for multiple volumes, you also need to define a volume. This is done by adding a new volume and indicating which boundary codes are part of it and which color the outer side of the boundary relative to the volume currently has.

To do this, select:

Simulation » Edit boundary conditions

First, add a new volume by entering a name like “vol” in the “new volume” field and clicking on “add”.

Then, in the new column “vol”, set all cells to “green” by double-clicking on them and selecting “green” from the dropdown box.

3.4 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 2.4. To create the grid, simply select

Mesh » create prismatic boundary layer

select the boundary conditions 1 and 2 and the volume “vol”. Then 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.

Don't forget to also check “Enable volume elements”.

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 2.5. 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 2.5).

3.4.1.1 Appendix A: Element Types

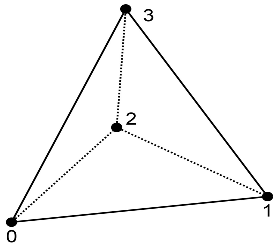
VTK_TETRA (=10)	faces		edges	
	0	2,1,0	0	0,1
	1	1,3,0	1	0,2
	2	3,2,0	2	0,3
	3	2,3,1	3	1,2
			4	1,3
			5	2,3

Figure 4: Faces and edges of a tetrahedrom

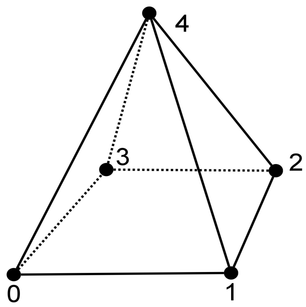
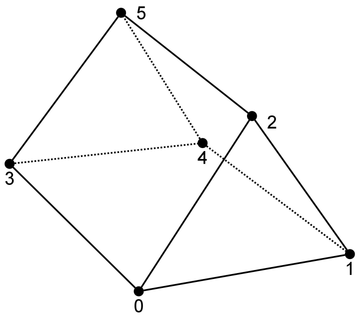
VTK_PYRAMID (=14)	faces		edges	
	0	0,3,2,1	0	0,1
	1	0,1,4	1	0,3
	2	1,2,4	2	0,4
	3	2,3,4	3	1,2
	4	3,0,4	4	1,4
			5	2,3
			6	2,4
			7	3,4

Figure 5: Faces and edges of a pyramid

VTK_WEDGE (=13)

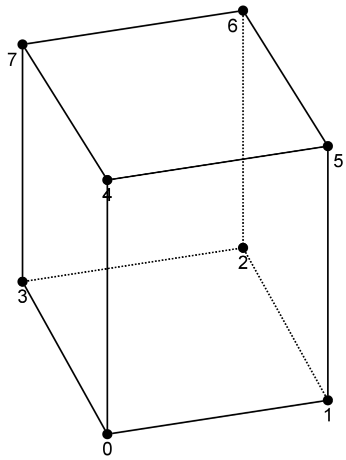


faces	
0	0,1,2
1	3,5,4
2	3,4,1,0
3	1,4,5,2
4	0,2,5,3

edges	
0	0,1
1	0,2
2	0,3
3	1,2
4	1,4
5	2,6
6	3,4
7	3,5
8	4,5

Figure 6: Faces and edges of a prism

VTK_HEXAHEDRON (=12)



faces	
0	0,3,2,1
1	4,5,6,7
2	0,1,5,4
3	3,7,6,2
4	0,4,7,3
5	1,2,6,5

edges	
0	0,1
1	0,3
2	0,4
3	1,2
4	1,5
5	2,3
6	2,6
7	3,7
8	4,5
9	4,7
10	5,6
11	6,7

Figure 7: Faces and edges of a hexahedron

3.4.1.2 Appendix B: Gnu Free Documentation Licence

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