Simulation of a **High Velocity Cooling** in the Wire Head Room of Electric Engines with **ANSYS CFX**

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ANSYS CONFERENCE & 9. CADFEM AUSTRIA USERS‘ MEETING

24.-25. April 2014
Schloss Schönbrunn
Tagungszentrum Wien

Abstract

Simulation of a High Velocity Cooling in the Wire Head Room of Electric Engines with ANSYS CFX

Electrical engines are today more than 100 years old. As they are now widespread in the world there have developed some principal building principles to gain most effectiveness on the one side and most cost effectiveness on the other side to build such devices. What is only now possible is to bridge the gap between designs that are also optimized concerning the internal cooling flow in the engine and hence a resulting cooling for the engine. The effort of cooling is paid by losing effectiveness in power to effort which is only true from a conservative classical point of view. In a restricted environment, with physical room as restriction, the room energy density becomes more important for overall effectiveness. For example in applications for driving vehicles, air vehicles or even wind generator engines. A wind generator is causing only a few percent of the total wind harvesting investment and could be upgraded cost effectively by the presented method of inner side engine cooling, applied for patent [1][2] and simulated with ANSYS CFX. By increasing power in the same wind generator housing more kWh can be sold. The simulation shows how the heat flow is changing, the heat flux is altering the total heat equilibrium and the effective energy power density is increased systematically. The result is a total heat density increase having fundamental importance for a huge variety of electric engine applications of modern civilization.

[1] *Cooling of a Wire Head Room* in German, European patent office application: EP13195074.3

[2] *Wire Head High Velocity Cooling* in German, cooling method for improvement of cooling of electric generators/engines in the same volume, Austrian patent application: A1263-2012

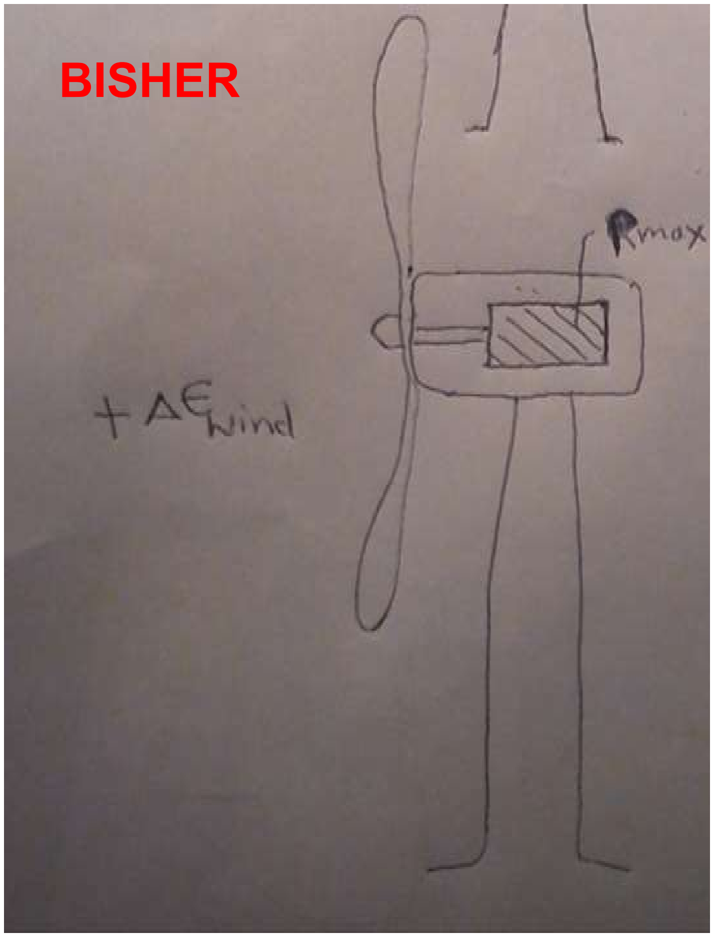
5 Erfinderklassen nach TRIZ [3]

(1) 32%, Weiterentwicklung
(2) 45% einfache Verbesserungen
(3) 18% wesentliche Verbesserungen
(4) 4% neue Systemgeneration
(5) 1% grundlegende Erfindungen auf Basis neuer Entdeckungen

[3] Pocket Power, C. Hentschel, C. Gundlach, H.T. Nähler; Hrsg.: G.F.Kamiske, Triz-Innovation mit System, 2010, Hanser Verlag

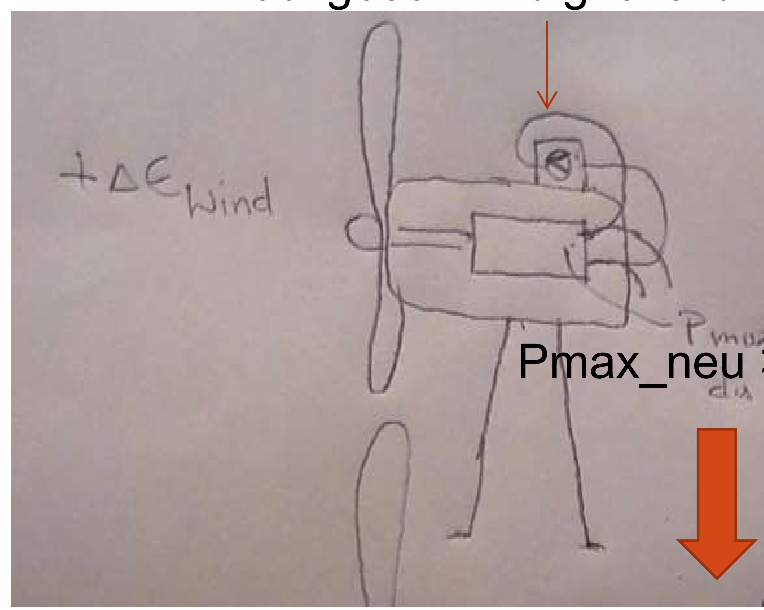
Bsp. Windenergie

BISHER



Mit der Patentenmeldung EP13195074.3

Hochgeschwindigkeitskühlung



Pmax_neu > Pmax

+€€€€€€€€€€€

Theorie:

Fanning Friction Factor

Nußeltzahl …
dimensionslose Wärmeübergangskennzahl

$$Re\frac{f}{2}=Nu=Sh$$

…*Reynolds Analogie*

Sherwoodzahl …
dimensionslose Stoffübergangskennzahl

Reynoldszahl
…Dimensionslose Strömungskennzahl

$$Re\frac{f}{2}=Nu\,Pr^{-1/3} \quad 0.6<Pr<60$$

…*Chilton-Colburn analogy*

…gilt für laminare und turbulente Strömungen

Prandtlzahl
…Dimensionslose Stoffwerte des Fluids

Jayanti, Sreenivas DOI: 10.1615/AtoZ.r.reynolds_analogy

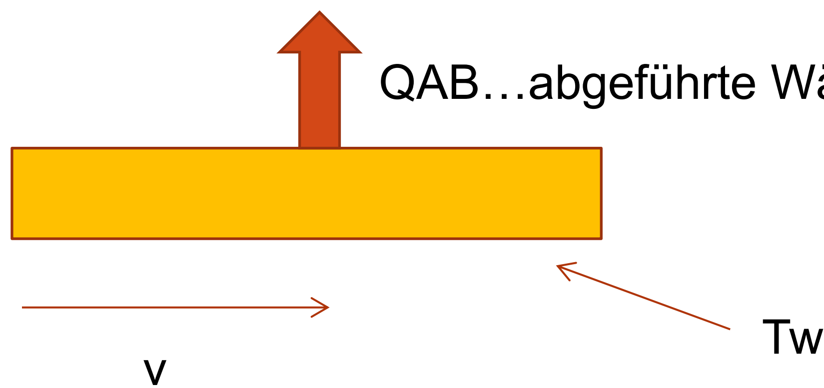
http://www.thermopedia.com/content/1092/?tid=110&sn=22 [23.4.2014]

Theorie:

numerische Berechnung,
Experimente

$$v \sim \alpha^n$$

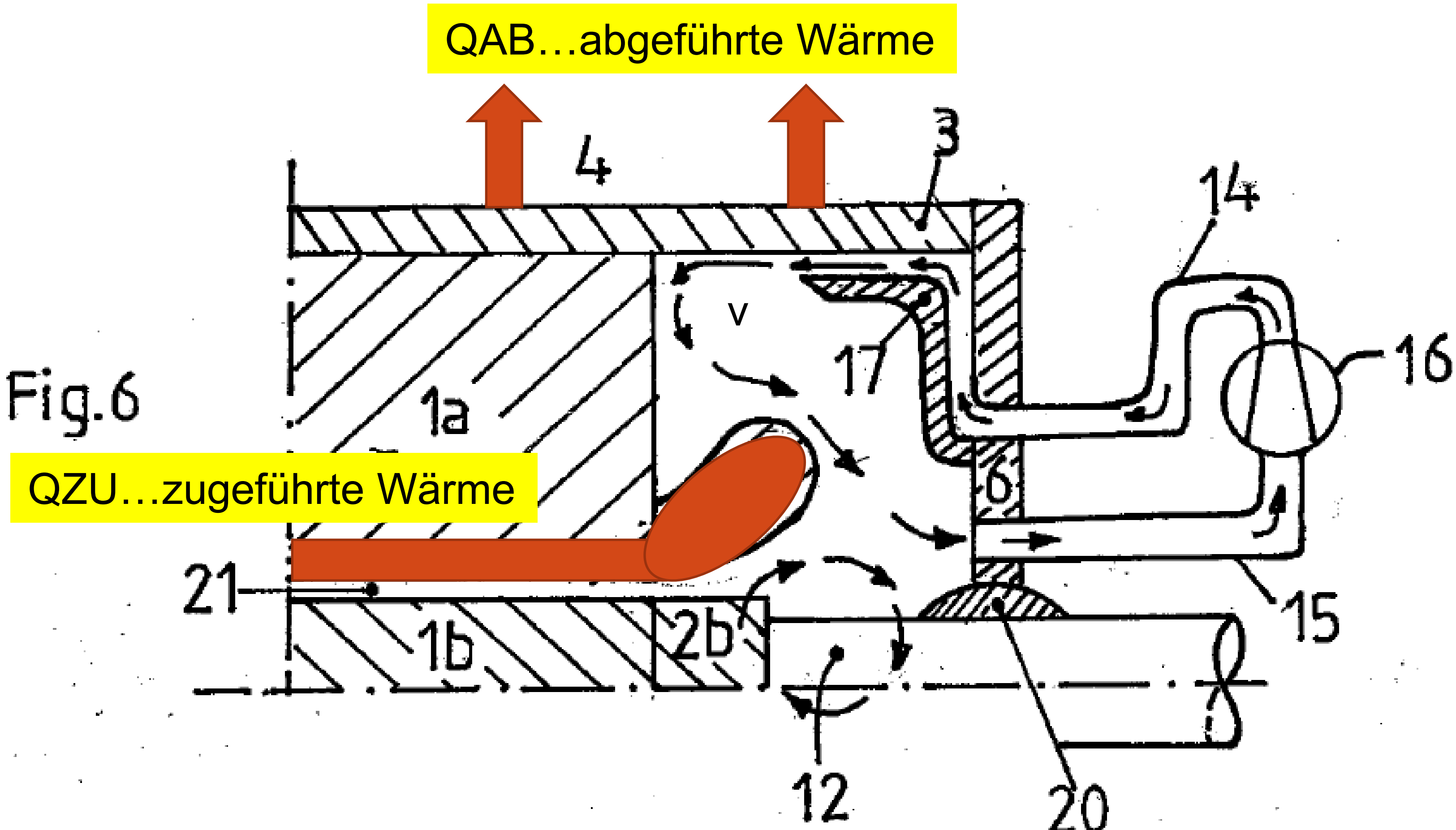
Strömungsgeschwindigkeit Wärmeübergangskoeffizient



Tw	…Wandtemperatur [°C]
Tu	...Umgebungstemperatur [°C]
Q	…Spez. Wärmeübergangstrom [W/m^2]
QAB	...Übertragene Wärme [W]
A	…Wärmeübertragungsfläche

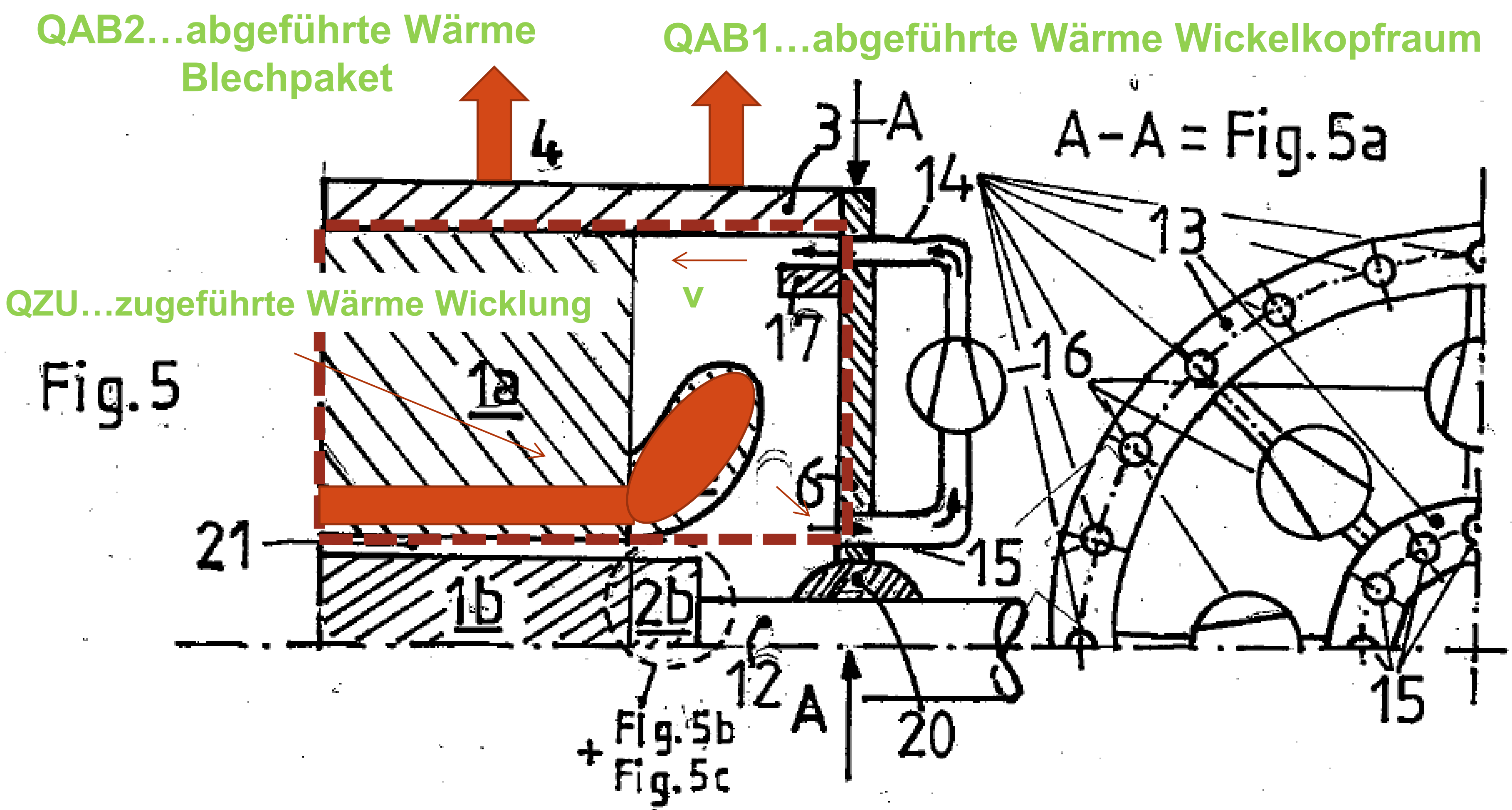
$q = \alpha * (Tw – Tu)$
$Q = q*A$

Patentanmeldung EP13195074.3*



* http://www.dr-heiden.com/patente/2013_11_29_EuropaeischePatentanmeldung_EP13195074.3.pdf

Patentanmeldung EP13195074.3*



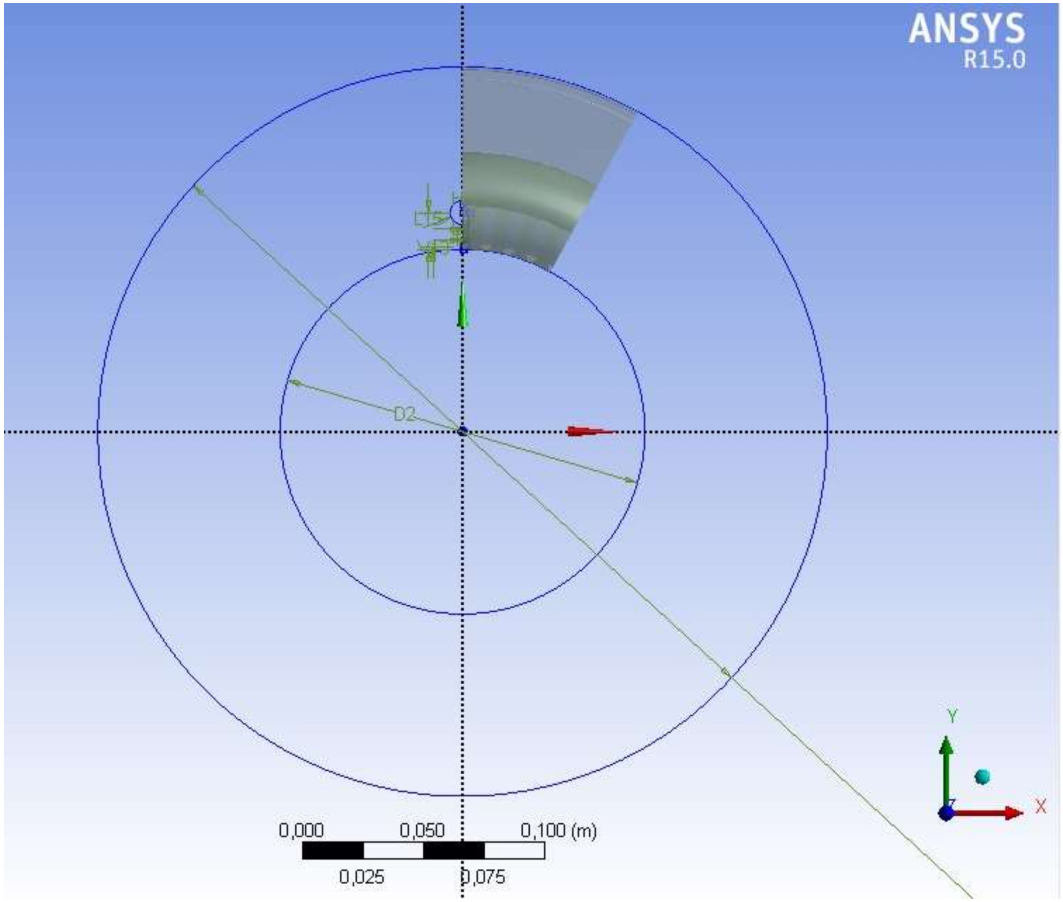
* http://www.dr-heiden.com/patente/2013_11_29_EuropaeischePatentanmeldung_EP13195074.3.pdf

Patentanmeldung EP13195074.3

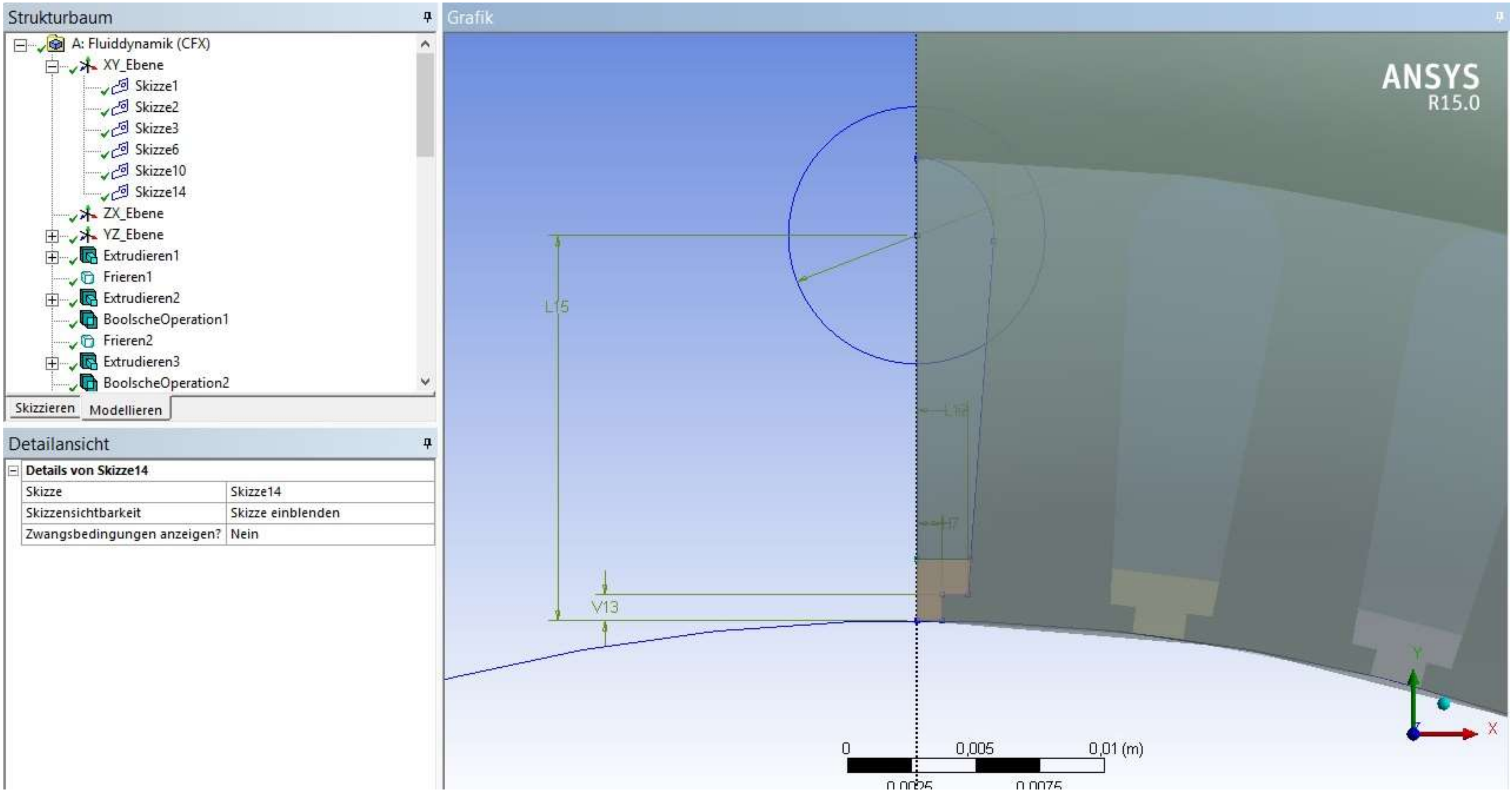
Bezugszeichenliste:

01	Rotor
02	Wickelkopf
03	Gehäuse
04	Wassermantelkühlung
05	Drehachse
06	Stirnwand
07	Wickelkopfraum
08	Pfeil Fluidstrom
09	Düse
10	Wassermantelinnenfläche
11	Radiallüfter
12	Welle
13	Torus, Hohltori
14, 15	Rohrabstecher
14'	Strömungseinlass
16	Verdichter
17	Leitvorrichtung
18, 19	freigelassen
20	Lager
21	Spalt
22	K-Ring
23	Wicklung

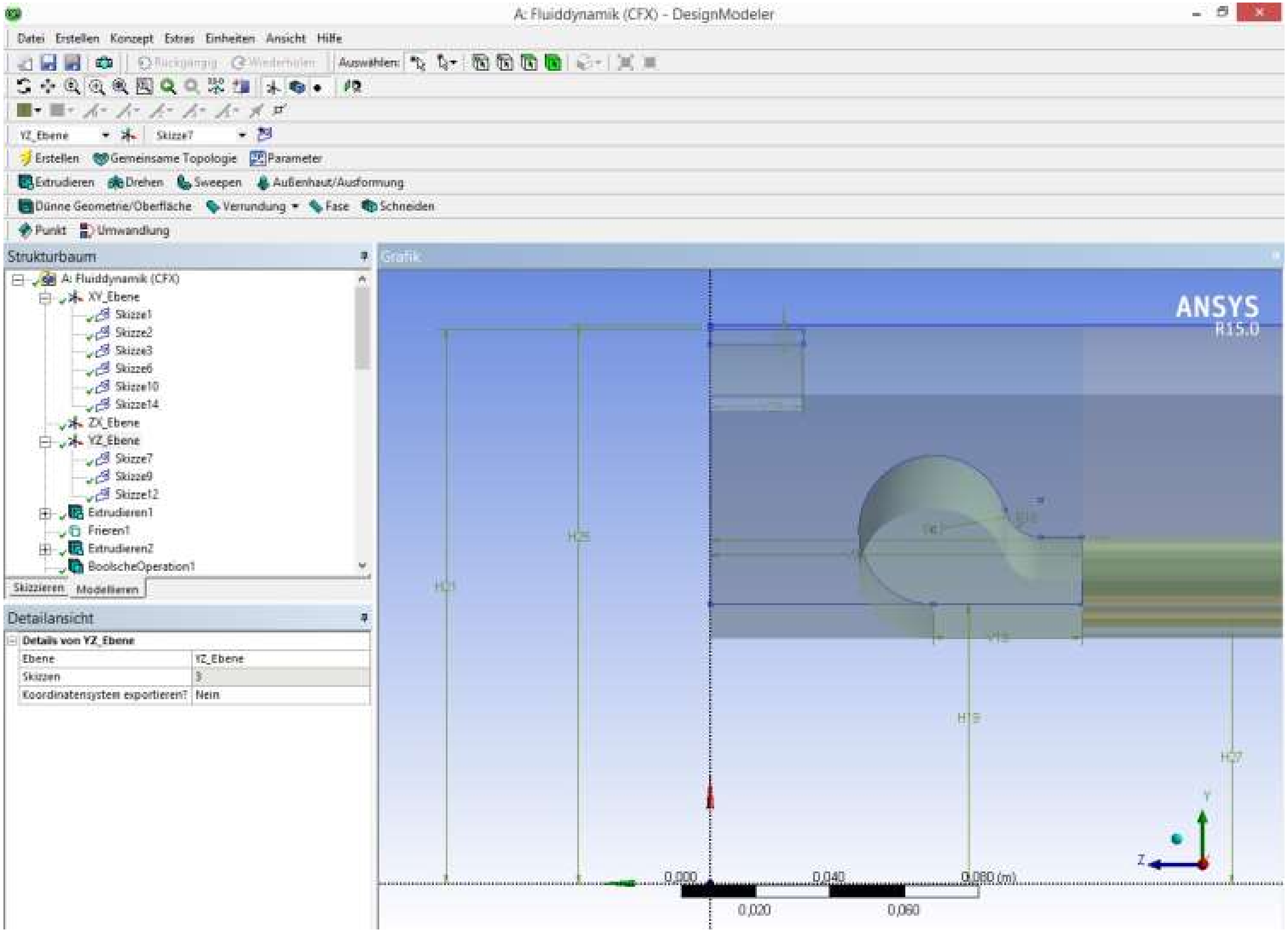
Modell Geometrie - Segment



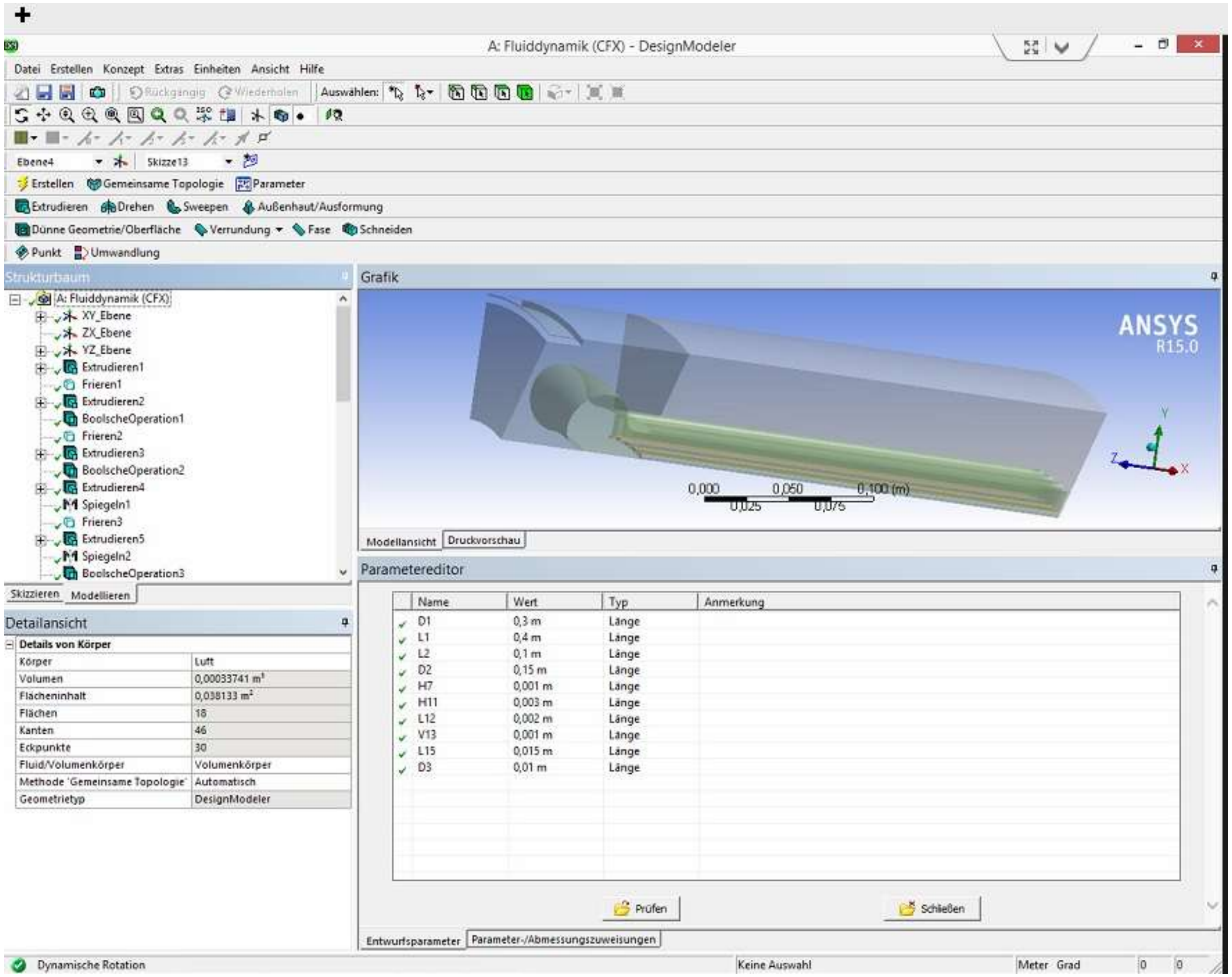
Modell Geometrie   x-y Ebene



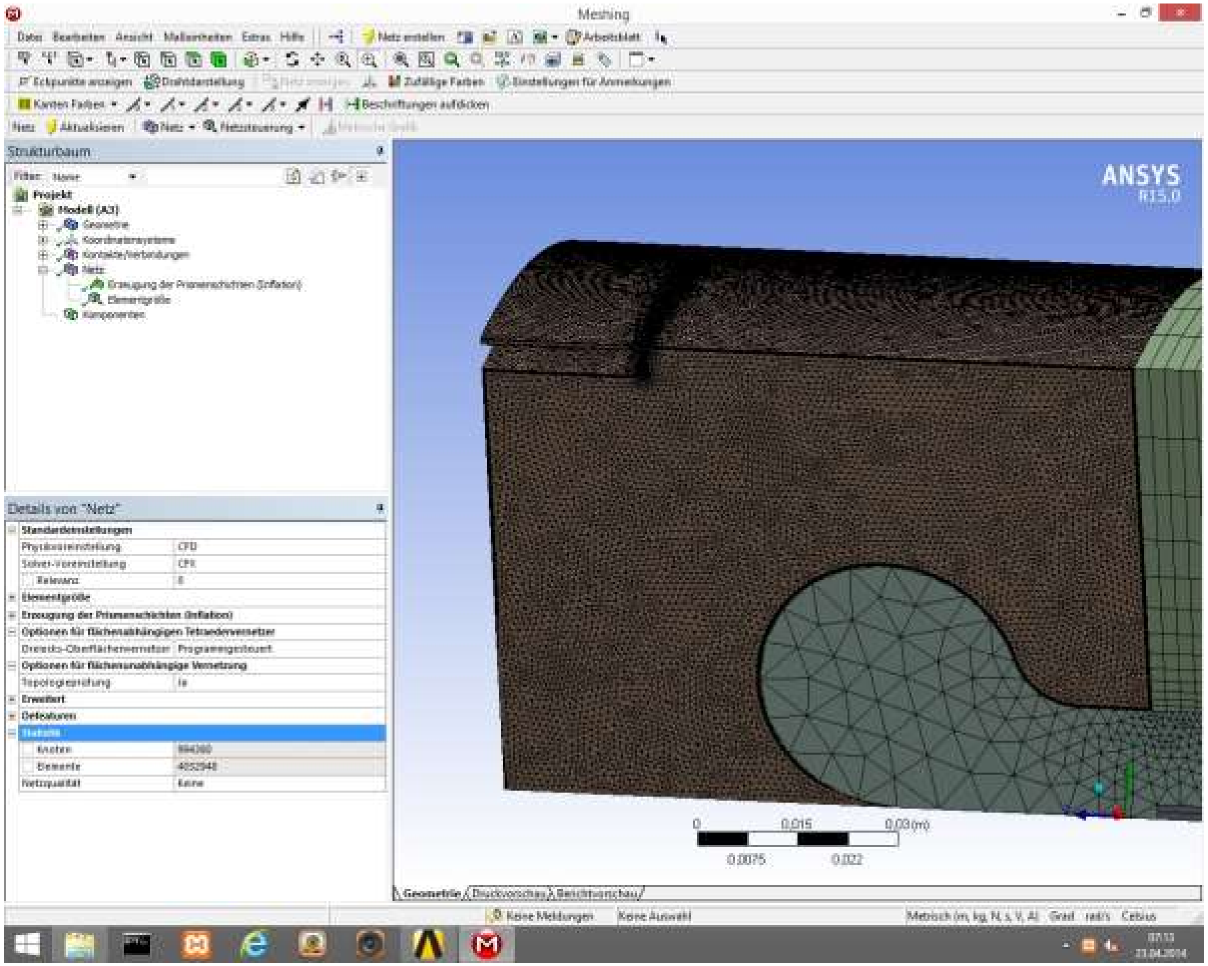
Modell Geometrie – y-z Ebene



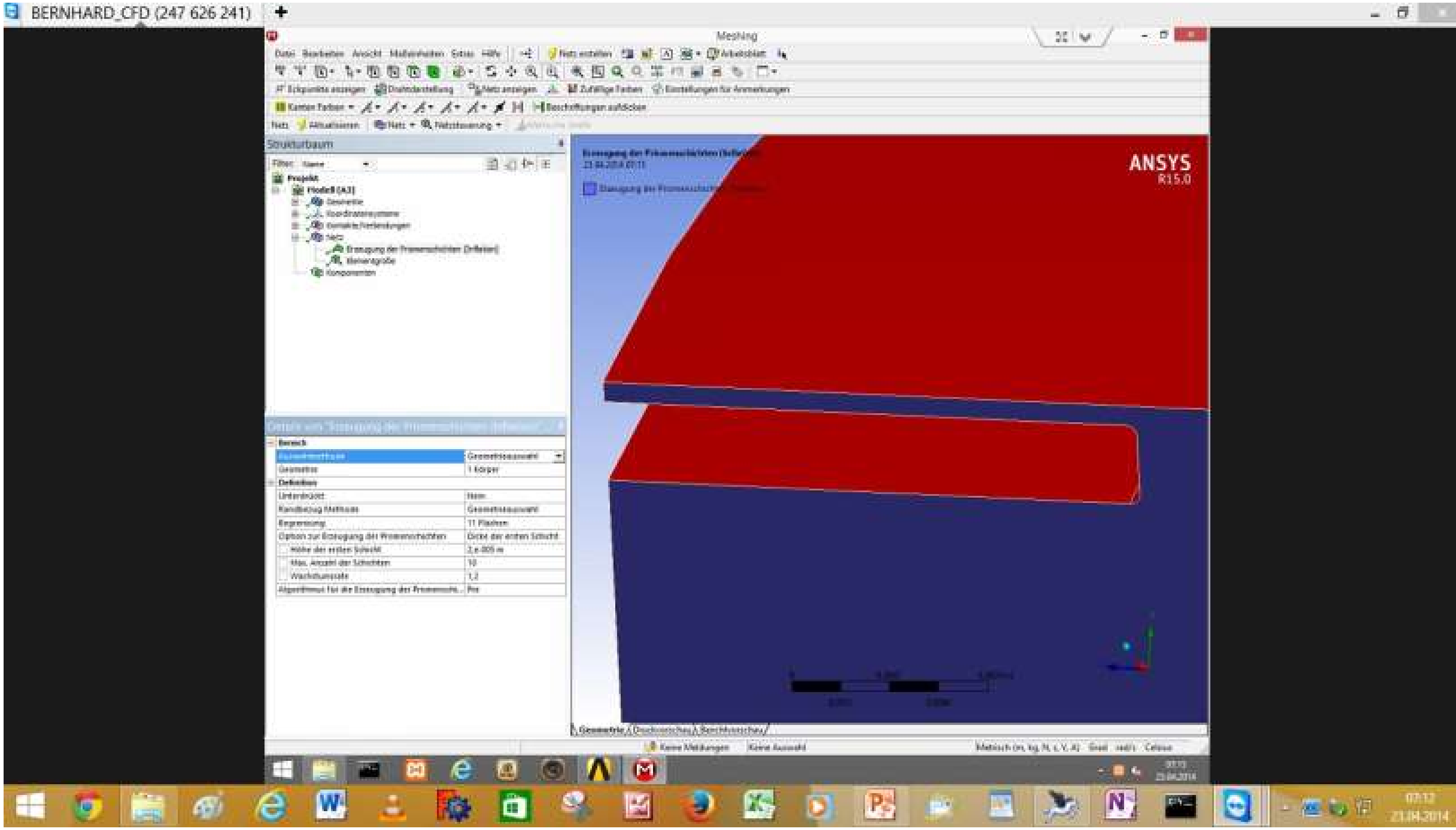
Modell Geometrie – 3D Modell und Parameter



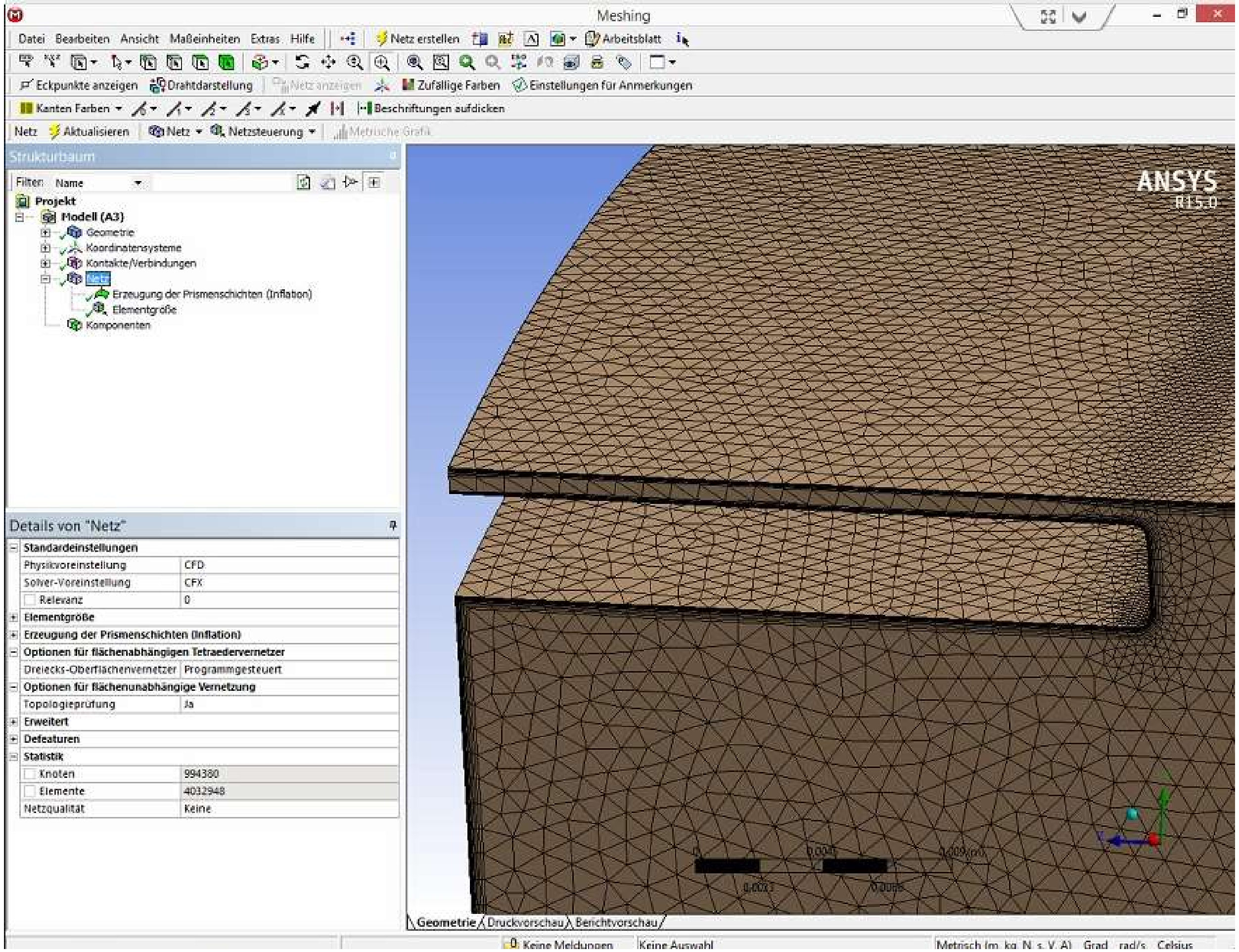
Modell Netz


Meshing
ANSYS
R15.0
Strukturbaum
Details von "Netz"
Standardeinstellungen
Physikvoreinstellung
CFD
Solver-Voreinstellung
CFX
Elementgröße
Erzeugung der Prismenschichten (Inflation)
Statistik
Knoten
Elemente
0
0,015
0,03 (m)
0,0075
0,022

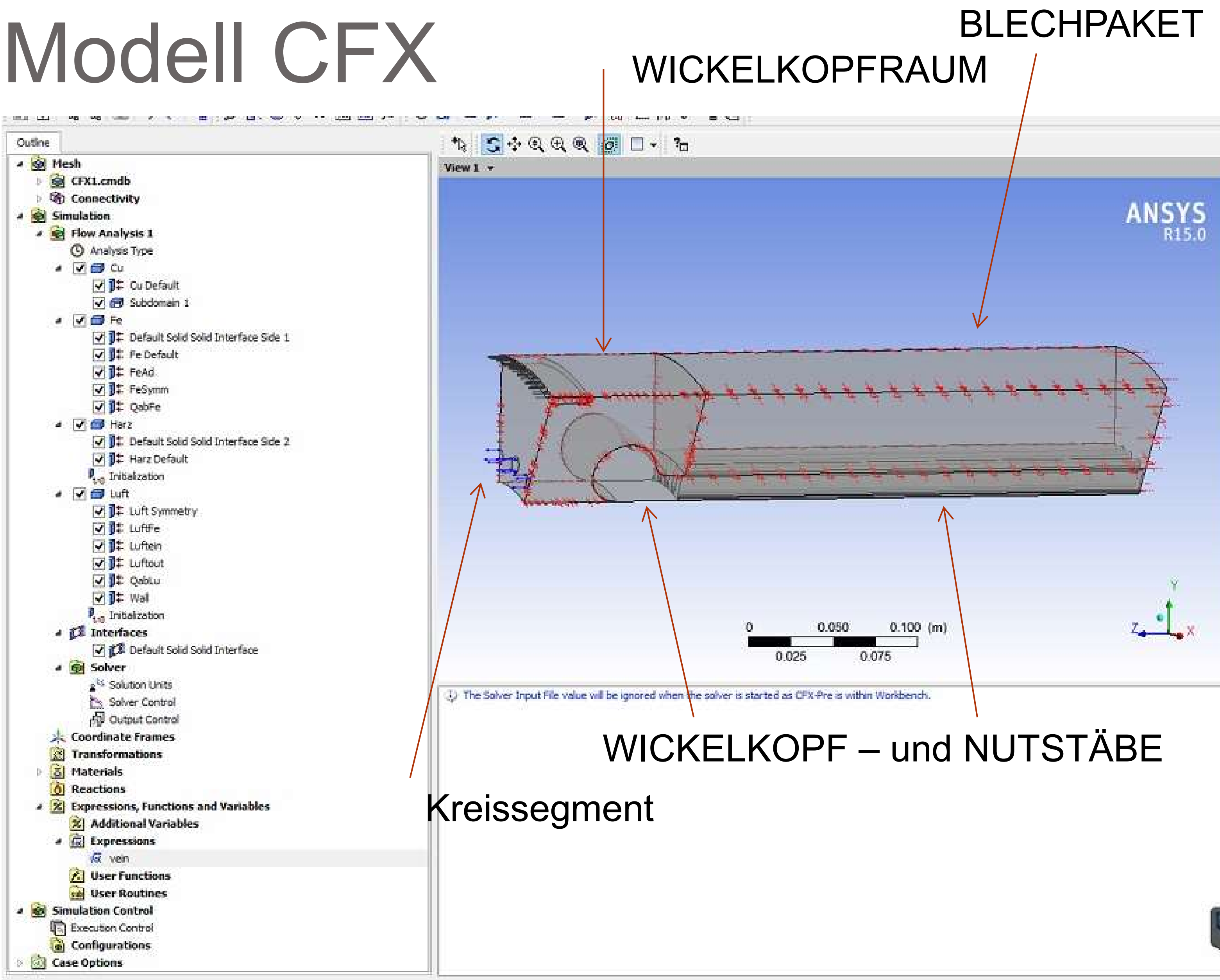
Modell Netz - Inflation layer Wand



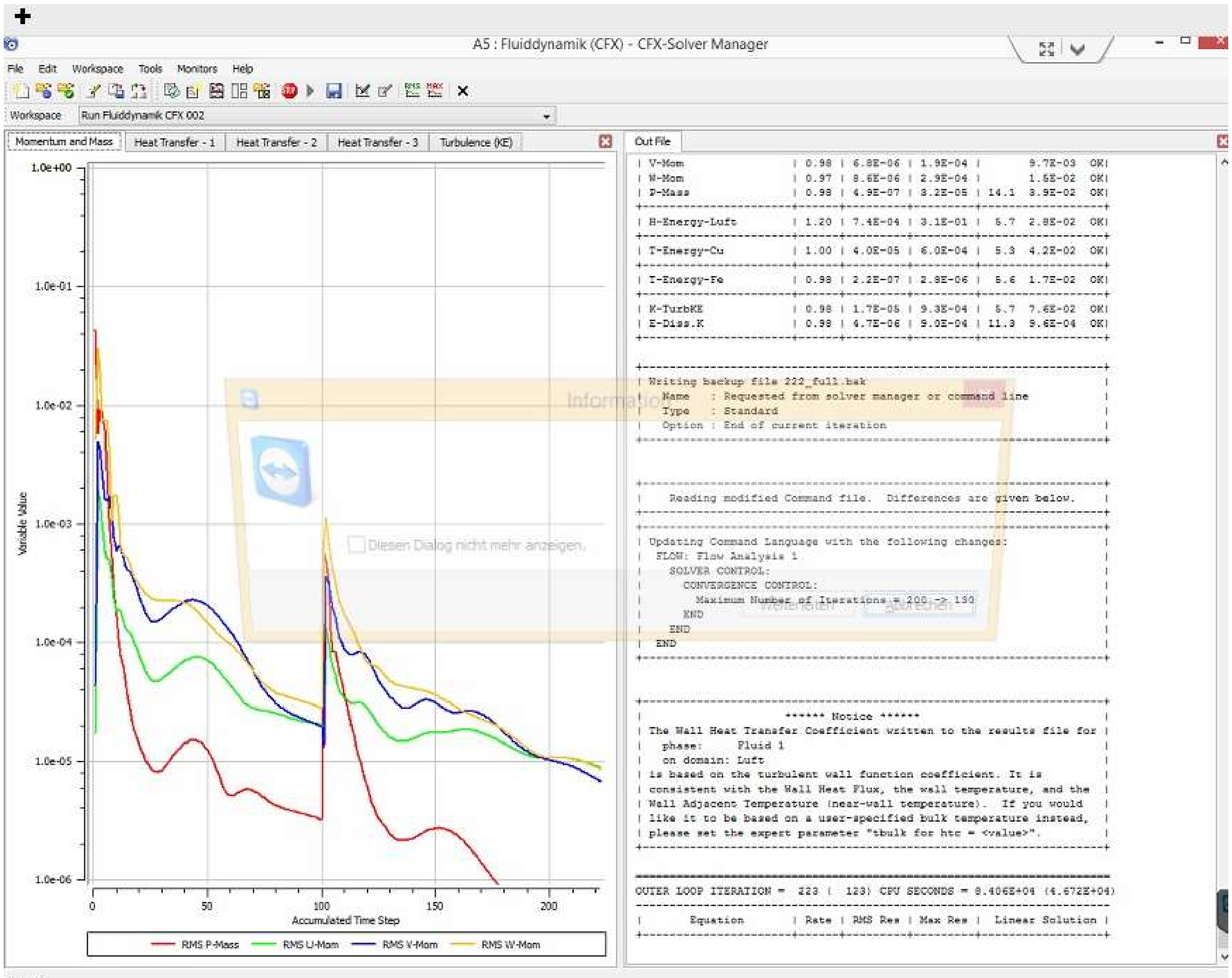
Modell Netz - Inflation layer Wand



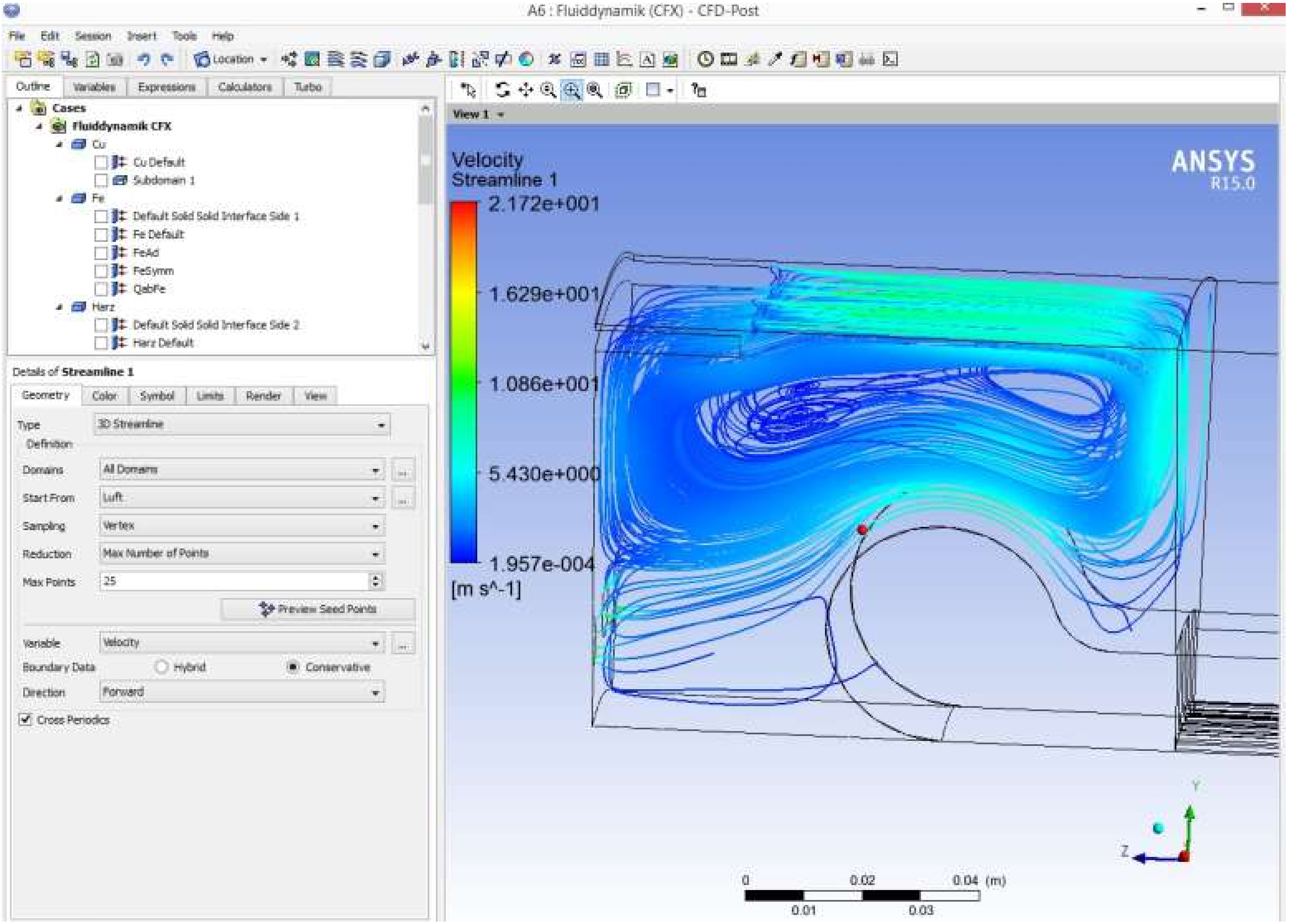
Modell CFX


BLECHPAKET
WICKELKOPFRAUM
WICKELKOPF – und NUTSTÄBE
Kreissegment
Outline
Mesh
CFX1.cmdb
Connectivity
Simulation
Flow Analysis 1
Analysis Type
Cu
Cu Default
Subdomain 1
Fe
Default Solid Solid Interface Side 1
Fe Default
FeAd
FeSymm
QabFe
Harz
Default Solid Solid Interface Side 2
Harz Default
Initialization
Luft
Luft Symmetry
LuftFe
Luftein
Luftout
QabLu
Wall
Initialization
Interfaces
Default Solid Solid Interface
Solver
Solution Units
Solver Control
Output Control
Coordinate Frames
Transformations
Materials
Reactions
Expressions, Functions and Variables
Additional Variables
Expressions
vein
User Functions
User Routines
Simulation Control
Execution Control
Configurations
Case Options
View 1
ANSYS
R15.0
0
0.050
0.100 (m)
0.025
0.075
The Solver Input File value will be ignored when the solver is started as CFX-Pre is within Workbench.

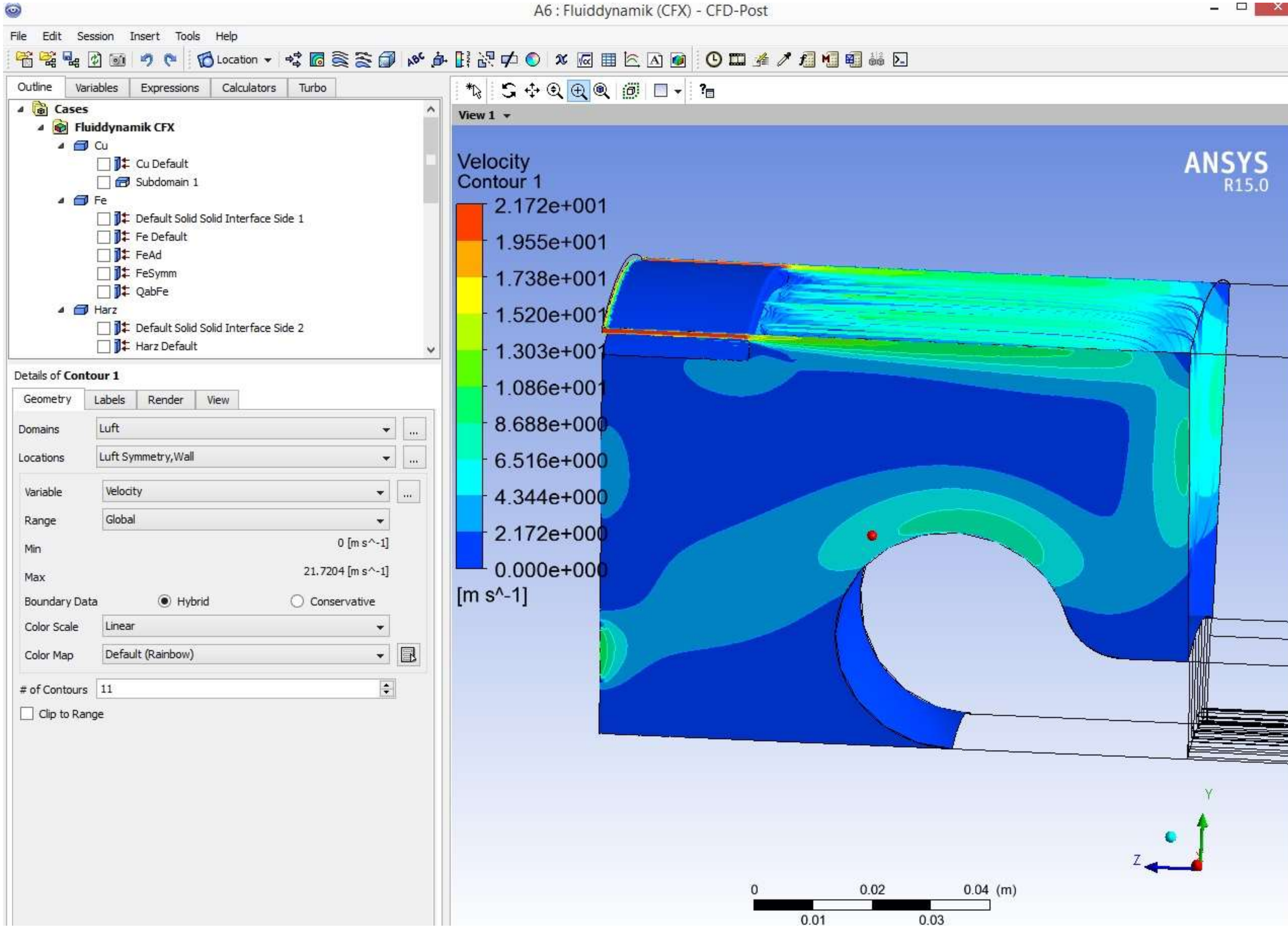
Results


A5 : Fluiddynamik (CFX) - CFX-Solver Manager
File Edit Workspace Tools Monitors Help
Workspace Run Fluiddynamik CFX 002
Momentum and Mass
Heat Transfer - 1
Heat Transfer - 2
Heat Transfer - 3
Turbulence (KE)
Variable Value
1.0e+00
1.0e-01
1.0e-02
1.0e-03
1.0e-04
1.0e-05
1.0e-06
0
50
100
150
200
Accumulated Time Step
RMS P-Mass
RMS U-Mom
RMS V-Mom
RMS W-Mom
Diesen Dialog nicht mehr anzeigen.
Out File
V-Mom	0.98	6.8E-06	1.9E-04	9.7E-03 OK
W-Mom	0.97	8.6E-06	2.9E-04	1.6E-02 OK
P-Mass	0.98	4.9E-07	3.2E-05	14.1 3.9E-02 OK
H-Energy-Luft	1.20	7.4E-04	3.1E-01	5.7 2.8E-02 OK
T-Energy-Cu	1.00	4.0E-05	6.0E-04	5.3 4.2E-02 OK
T-Energy-Fe	0.98	2.2E-07	2.8E-06	5.6 1.7E-02 OK
K-TurbKE	0.98	1.7E-05	9.3E-04	5.7 7.6E-02 OK
E-Diss.K	0.98	4.7E-06	9.0E-04	11.3 9.6E-04 OK
Writing backup file 222_full.bak
Name : Requested from solver manager or command line
Type : Standard
Option : End of current iteration
Reading modified Command file. Differences are given below.
Updating Command Language with the following changes:
FLOW: Flow Analysis 1
SOLVER CONTROL:
CONVERGENCE CONTROL:
Maximum Number of Iterations = 200 -> 130
END
END
END
****** Notice ******
The Wall Heat Transfer Coefficient written to the results file for
phase: Fluid 1
on domain: Luft
is based on the turbulent wall function coefficient. It is
consistent with the Wall Heat Flux, the wall temperature, and the
Wall Adjacent Temperature (near-wall temperature). If you would
like it to be based on a user-specified bulk temperature instead,
please set the expert parameter "tbulk for htc = <value>".
OUTER LOOP ITERATION = 223 (123) CPU SECONDS = 8.406E+04 (4.672E+04)
Equation	Rate	RMS Res	Max Res	Linear Solution
Running

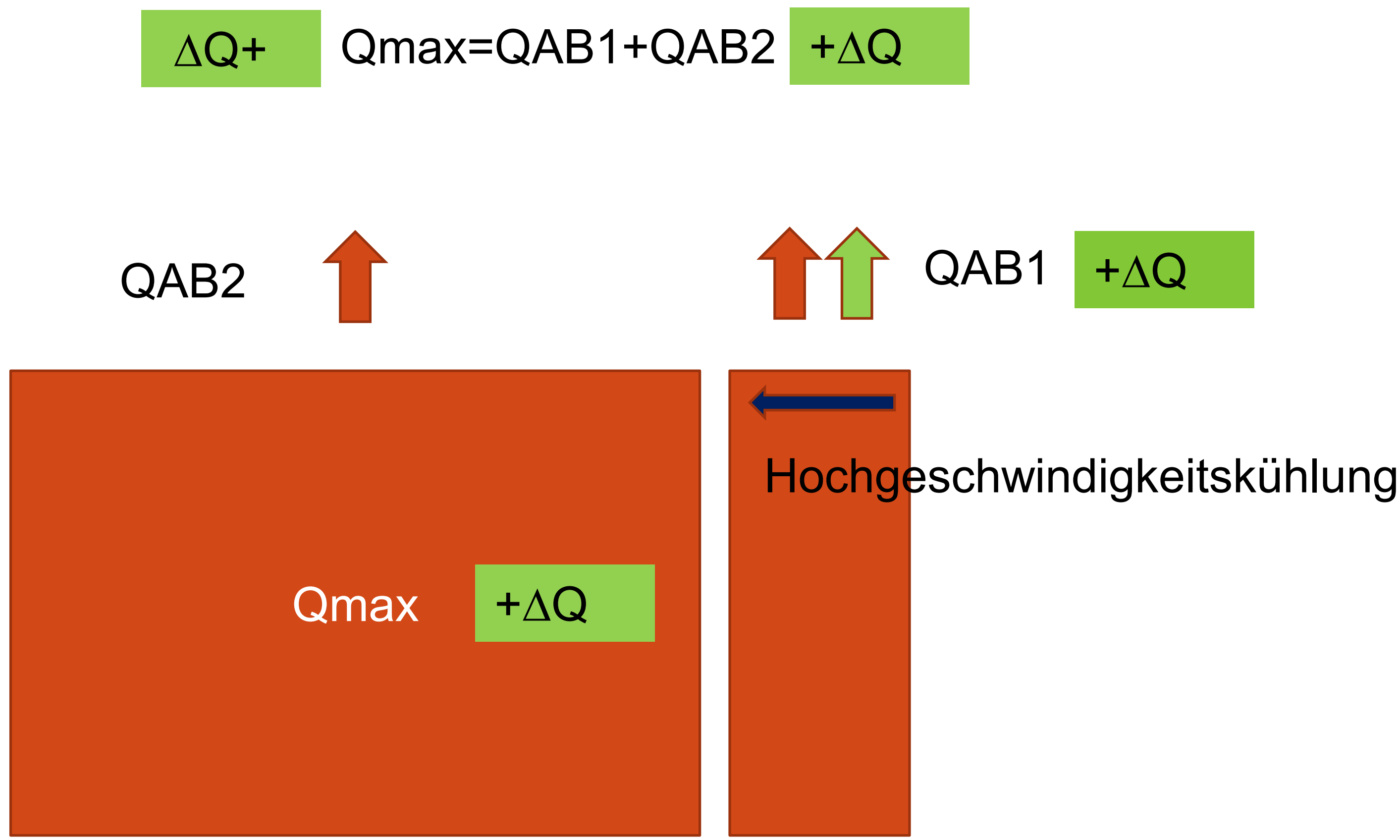
Results v_0=20 [m/s]



Results v_0=20 [m/s]



Results


ΔQ+
Qmax=QAB1+QAB2
+ΔQ
QAB2
QAB1
+ΔQ
Hochgeschwindigkeitskühlung
Qmax
+ΔQ

DI Dr. techn. Bernhard Heiden

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www.SLL.at & www.dr-heiden.com

Herzlichen Dank für die Aufmerksamkeit!