



Universidade Federal de Santa Catarina

Campus Joinville

Simulação numérica de MCI usando AVL-BOOST

UNIDADE 4 – MODELAGEM DE MCI USANDO AVL-BOOST



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Engenharia Automotiva
CTJ - Centro Tecnológico de Joinville

Ementa

- ✓ Introdução
- ✓ Conceitos fundamentais em motores de combustão interna
- ✓ Programas para simulação de MCI
- ✓ Modelagem de MCI usando AVL-BOOST
- ✓ Simulações numéricas usando AVL-BOOST

Conteúdo programático

UNIDADE 4 – Modelagem de MCI usando AVL-BOOST

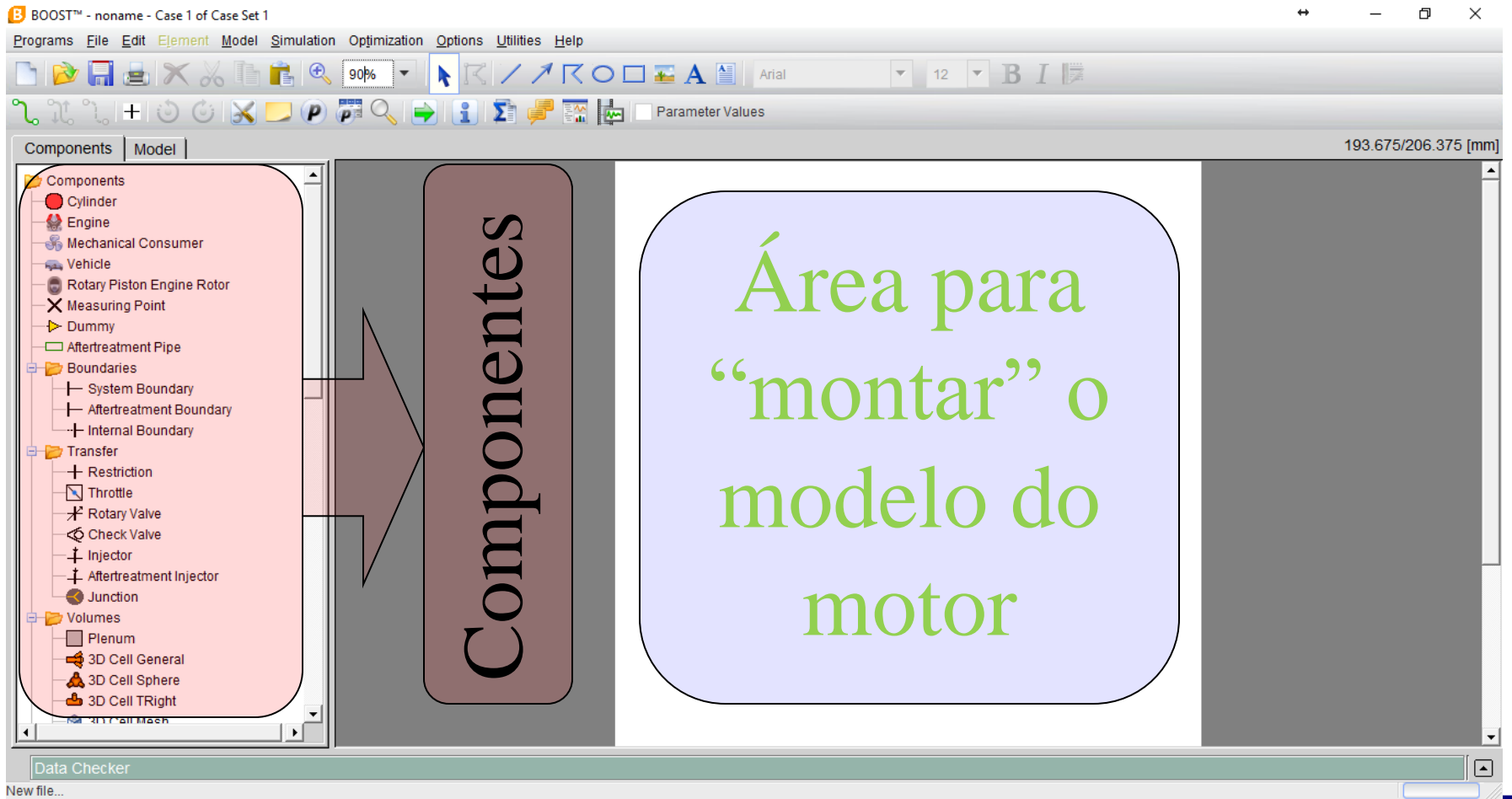
4.1 – Estrutura do AVL-BOOST

4.2 – Modelagem de componentes - dados de entrada

4.3 – Dados de saída

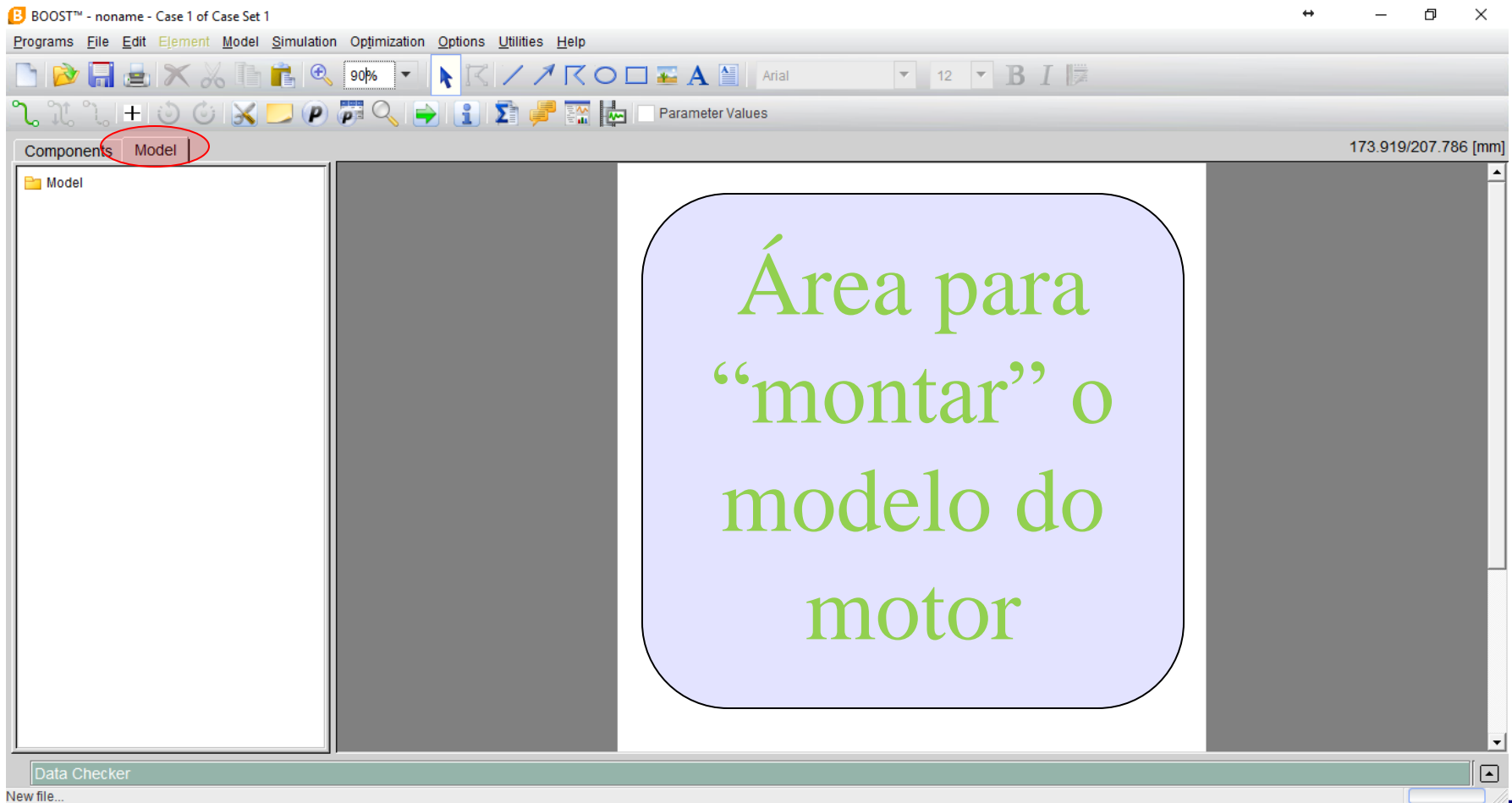
Estrutura do AVL-BOOST

Working place do BOOST



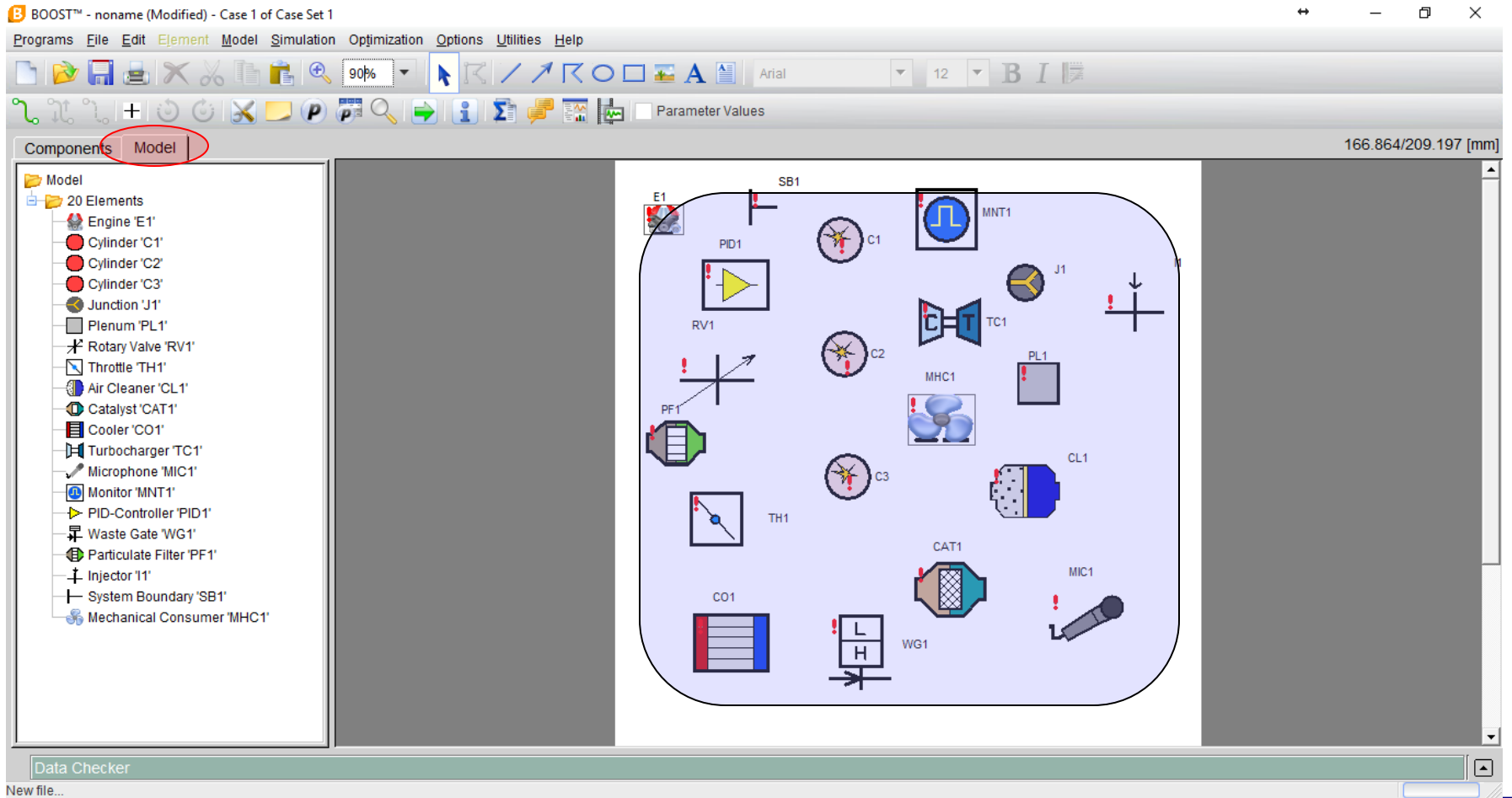
Estrutura do AVL-BOOST

Working place do BOOST



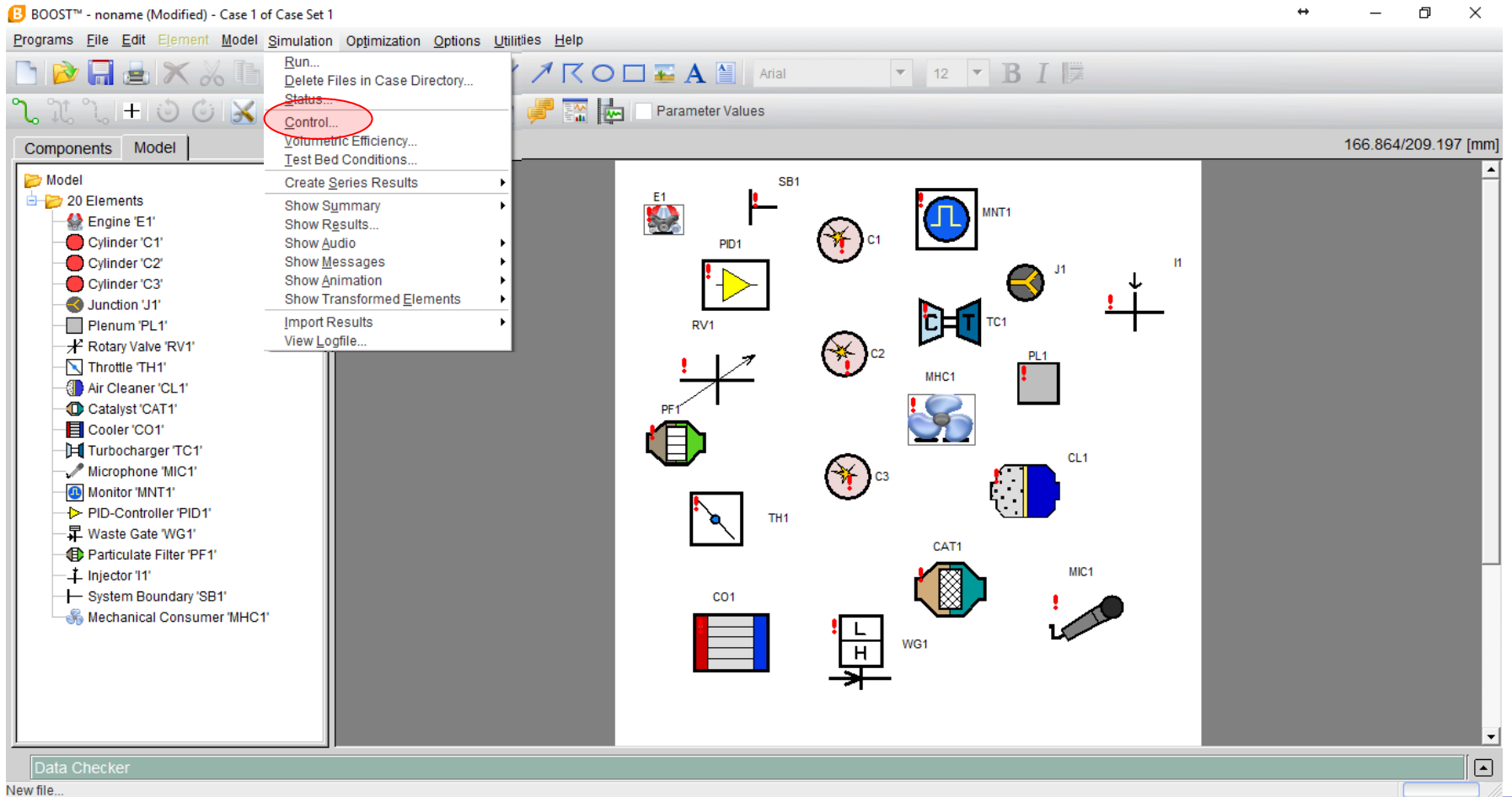
Estrutura do AVL-BOOST

Working place do BOOST



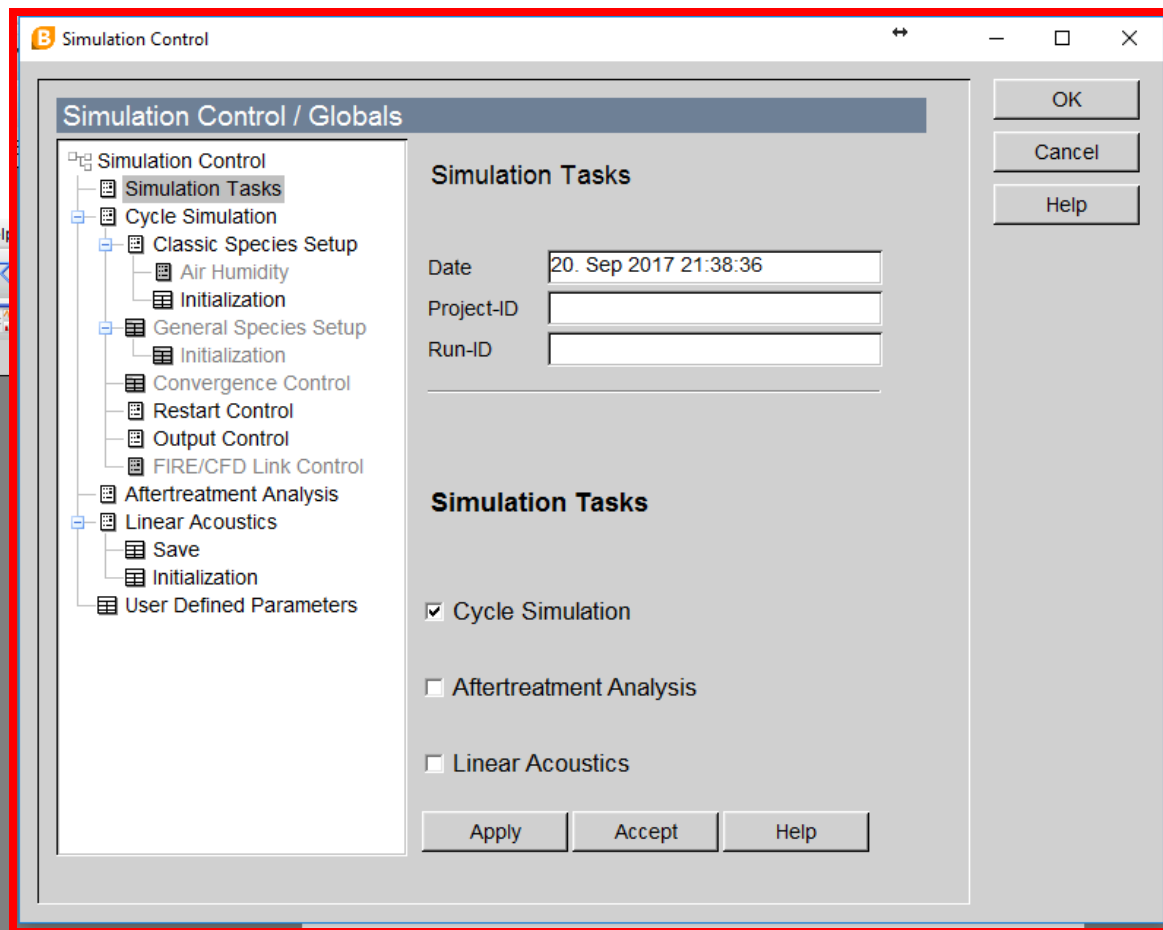
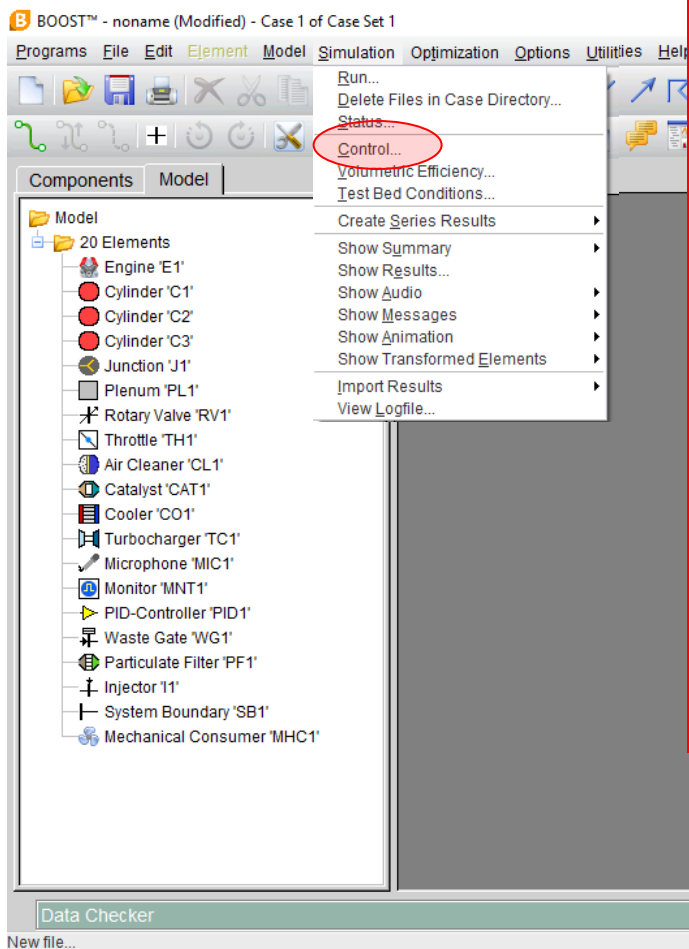
Estrutura do AVL-BOOST

Working place do BOOST



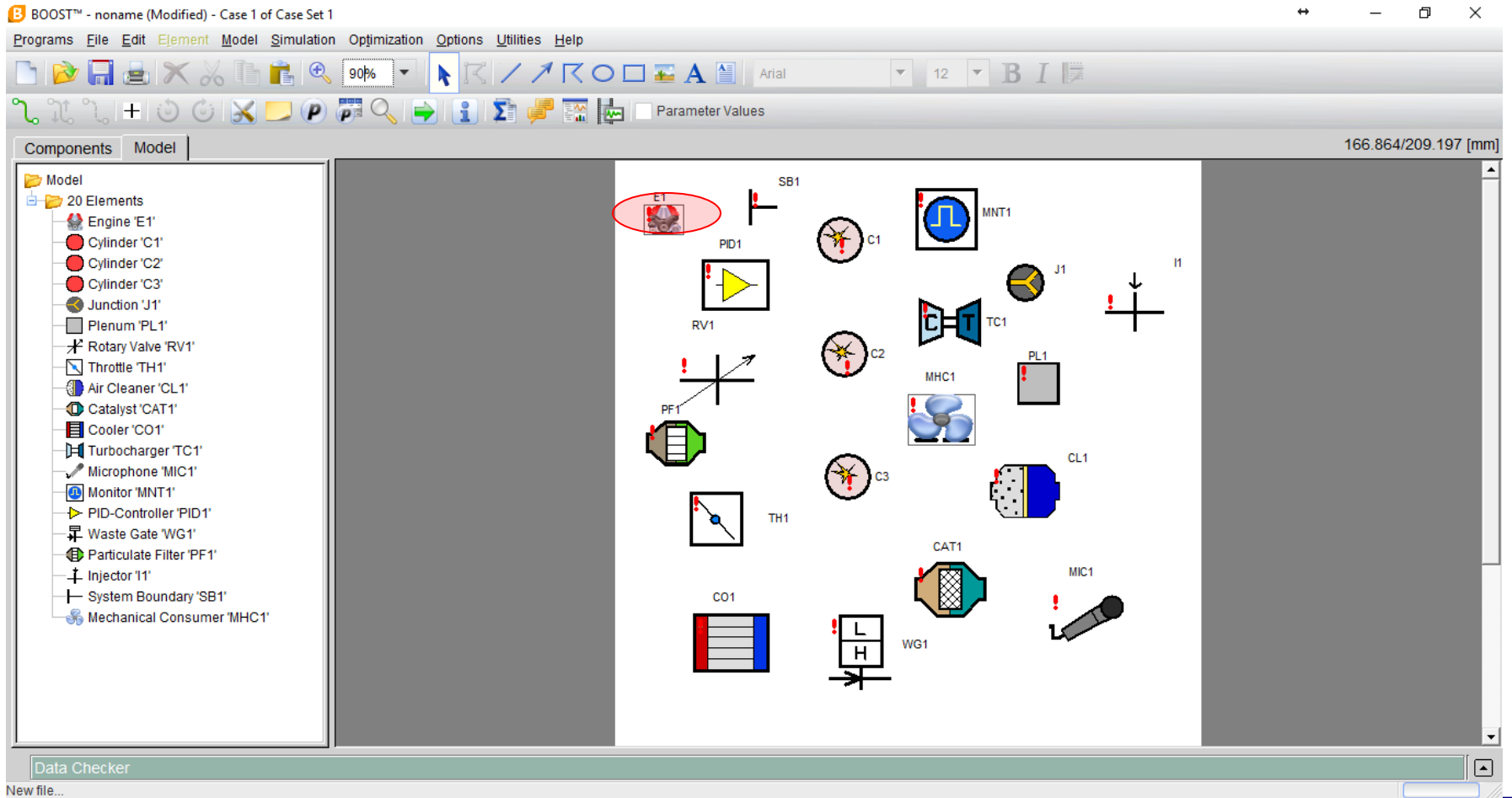
Estrutura do AVL-BOOST

Working place do BOOST



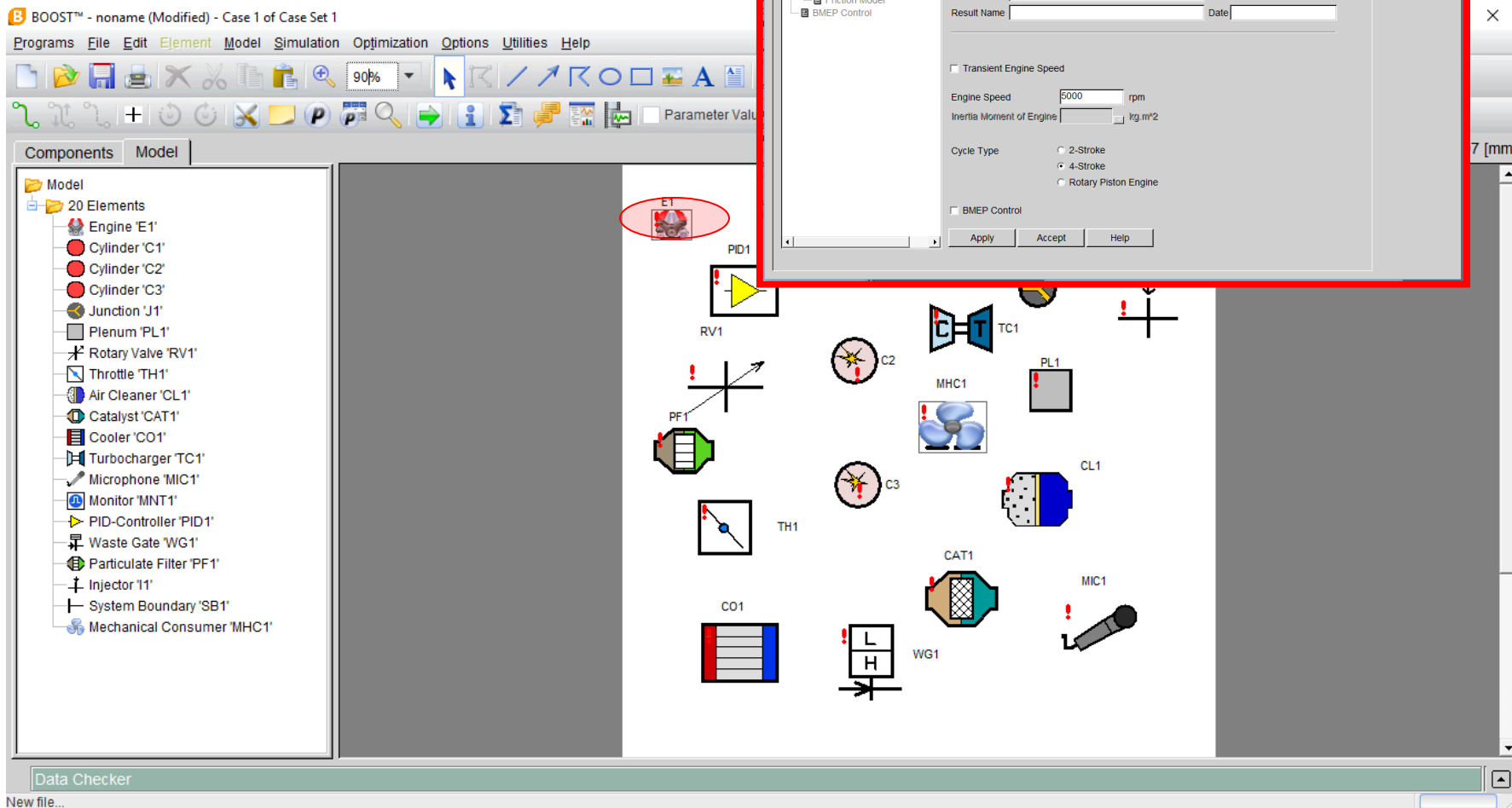
Estrutura do AVL-BOOST

Working place do BOOST



Estrutura do AVL-BOOST

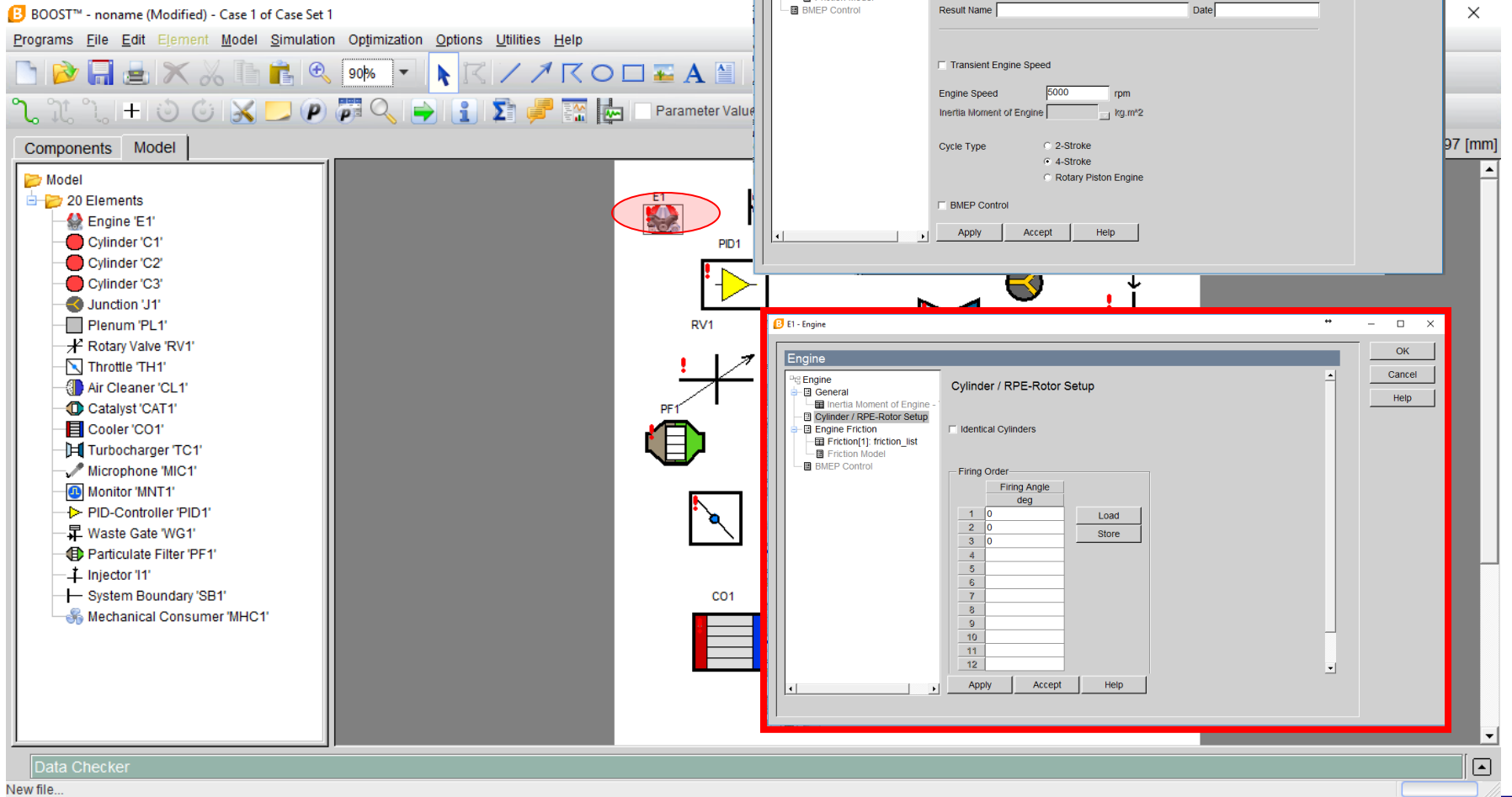
Working place do BOOST



The screenshot displays the AVL-BOOST software interface. On the left, a 'Components' tree lists 20 elements: Engine 'E1', three cylinders (C1, C2, C3), a junction (J1), a plenum (PL1), a rotary valve (RV1), a throttle (TH1), an air cleaner (CL1), a catalyst (CAT1), a cooler (CO1), a turbocharger (TC1), a microphone (MIC1), a monitor (MNT1), a PID-controller (PID1), a waste gate (WG1), a particulate filter (PF1), an injector (I1), a system boundary (SB1), and a mechanical consumer (MHC1). The main workspace shows a schematic diagram of the engine system with various components labeled (E1, RV1, TH1, CO1, PF1, C2, C3, TC1, MHC1, PL1, CL1, CAT1, WG1, MIC1). A red oval highlights the 'E1' component in the diagram. An inset window titled 'E1 - Engine' shows the configuration for the engine, including fields for 'Author' (L.R. Cancino), 'Result Name', 'Engine Speed' (5000 rpm), 'Inertia Moment of Engine', and 'Cycle Type' (4-Stroke selected).

Estrutura do AVL-BOOST

Working place do BOOST



The screenshot displays the AVL-BOOST software interface. On the left, the 'Components' pane lists 20 elements in the model, including Engine 'E1', three cylinders (C1, C2, C3), a junction (J1), a plenum (PL1), a rotary valve (RV1), a throttle (TH1), an air cleaner (CL1), a catalyst (CAT1), a cooler (CO1), a turbocharger (TC1), a microphone (MIC1), a monitor (MNT1), a PID-controller (PID1), a waste gate (WG1), a particulate filter (PF1), an injector (I1), a system boundary (SB1), and a mechanical consumer (MHC1). The main workspace shows a schematic diagram with these components connected. A red oval highlights the 'E1' engine component. Two configuration windows are overlaid on the right:

- Engine Configuration Window (Top):** Shows the 'General' tab. Fields include Author (L.R. Cancino), Comment, and Result Name. Engine Speed is set to 5000 rpm and Inertia Moment of Engine is set to kg.m². Cycle Type options are 2-Stroke, 4-Stroke, and Rotary Piston Engine. BMEP Control is unchecked.
- Engine Configuration Window (Bottom):** Shows the 'Cylinder / RPE-Rotor Setup' tab. It includes a table for Firing Order:

	Firing Angle	
	deg	
1	0	Load
2	0	Store
3	0	
4		
5		
6		
7		
8		
9		
10		
11		
12		

Estrutura do AVL-BOOST

Working place do BOOST

BOOST™ - noname (Modified) - Case 1 of Case Set 1

Programs File Edit Element Model Simulation Optimization Options Utilities Help

90%

Parameter Value

Components Model

Model

- 20 Elements
 - Engine 'E1'
 - Cylinder 'C1'
 - Cylinder 'C2'
 - Cylinder 'C3'
 - Junction 'J1'

Engine 'E1' (highlighted in red)

Engine 'E1' - Engine

Engine

- General
 - Inertia Moment of Engine
 - Cylinder / RPE-Rotor Setup
 - Engine Friction
 - Friction[1]: friction_list
 - Friction Model
 - BMEP Control

General

Author: LRCancino

Comment:

Result Name: Date:

Transient Engine Speed

Engine Speed: 5000 rpm

Inertia Moment of Engine: kg.m²

Cycle Type:

- 2-Stroke
- 4-Stroke
- Rotary Piston Engine

BMEP Control

Apply Accept Help

Engine 'E1' - Engine

Engine

- General
 - Inertia Moment of Engine
 - Cylinder / RPE-Rotor Setup
 - Engine Friction
 - Friction[1]: friction_list
 - Friction Model
 - BMEP Control

Cylinder / RPE-Rotor Setup

Identical Cylinders

Firing Order

	Firing Angle	
	deg	
1	0	Load
2	0	
3	0	Store
4		
5		
6		
7		
8		
9		
10		
11		
12		

Apply Accept Help

Engine 'E1' - Engine

Engine

- General
 - Inertia Moment of Engine
 - Cylinder / RPE-Rotor Setup
 - Engine Friction
 - Friction[1]: friction_list
 - Friction Model
 - BMEP Control

Friction Set

BMEP: bar

Engine Speed (X)	FMEP (Y)	
rpm	bar	
1	0	Insert
2	0	Removes
3		Load
4		Store
5		

FMEP (bar) graph

Apply Accept Help

Data Checker

New file...

Estrutura do AVL-BOOST

Working place do BOOST

The screenshot displays the AVL-BOOST software interface. On the left, a 'Components' tree lists 20 elements including Engine 'E1', three Cylinders ('C1', 'C2', 'C3'), Junction 'J1', Plenum 'PL1', Turbocharger 'TC1', and various sensors and actuators. The main workspace shows a schematic diagram of the engine system with these components connected. A 'Cylinder' configuration dialog box is open, showing a tree view of cylinder parameters and a 'General' tab with fields for Author, Comment, Result Name, Date, Bore, Stroke, Compression Ratio, Con-Rod Length, Piston Pin Offset, Effective Blow By Gap, and Mean Crankcase Press.

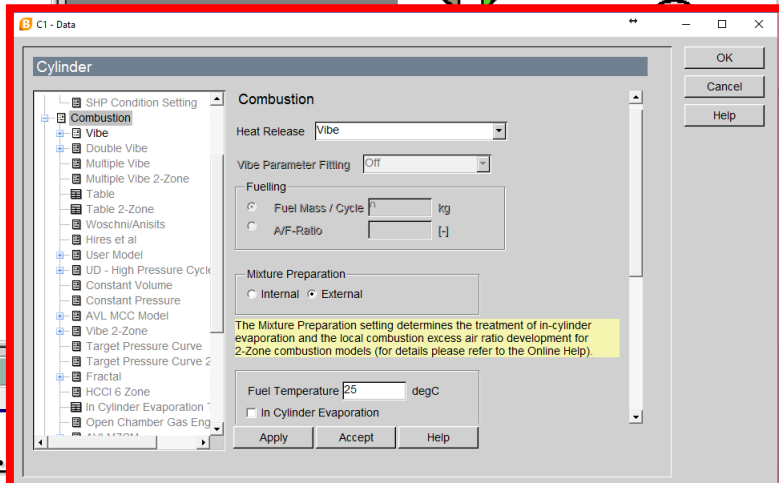
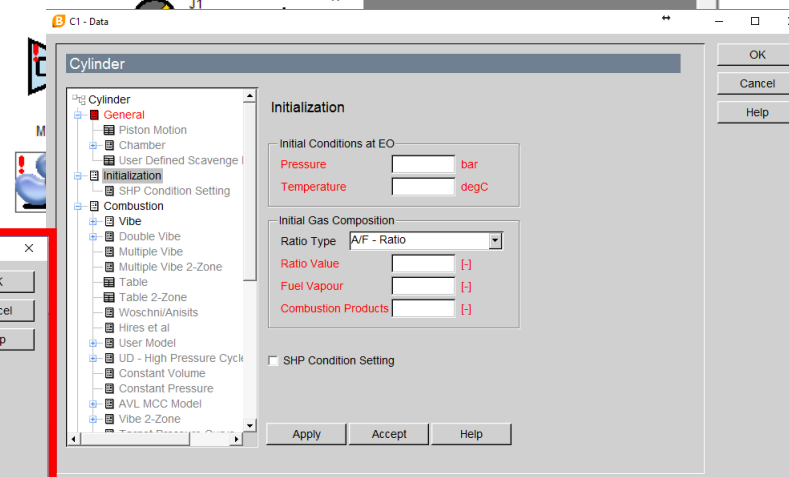
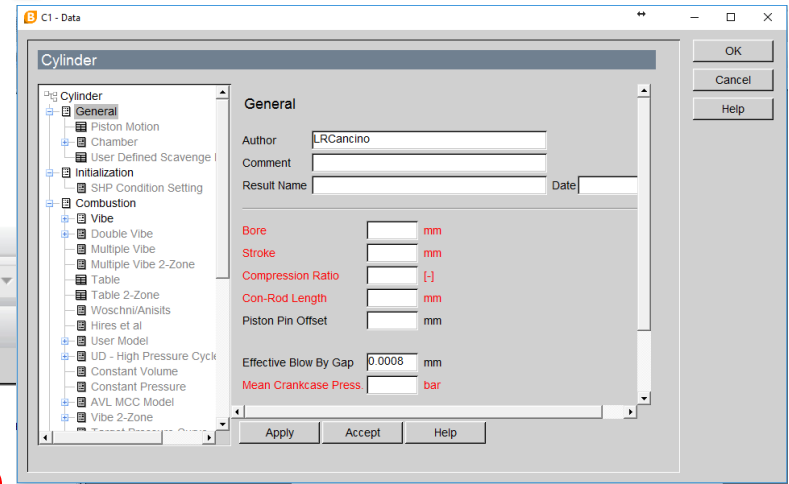
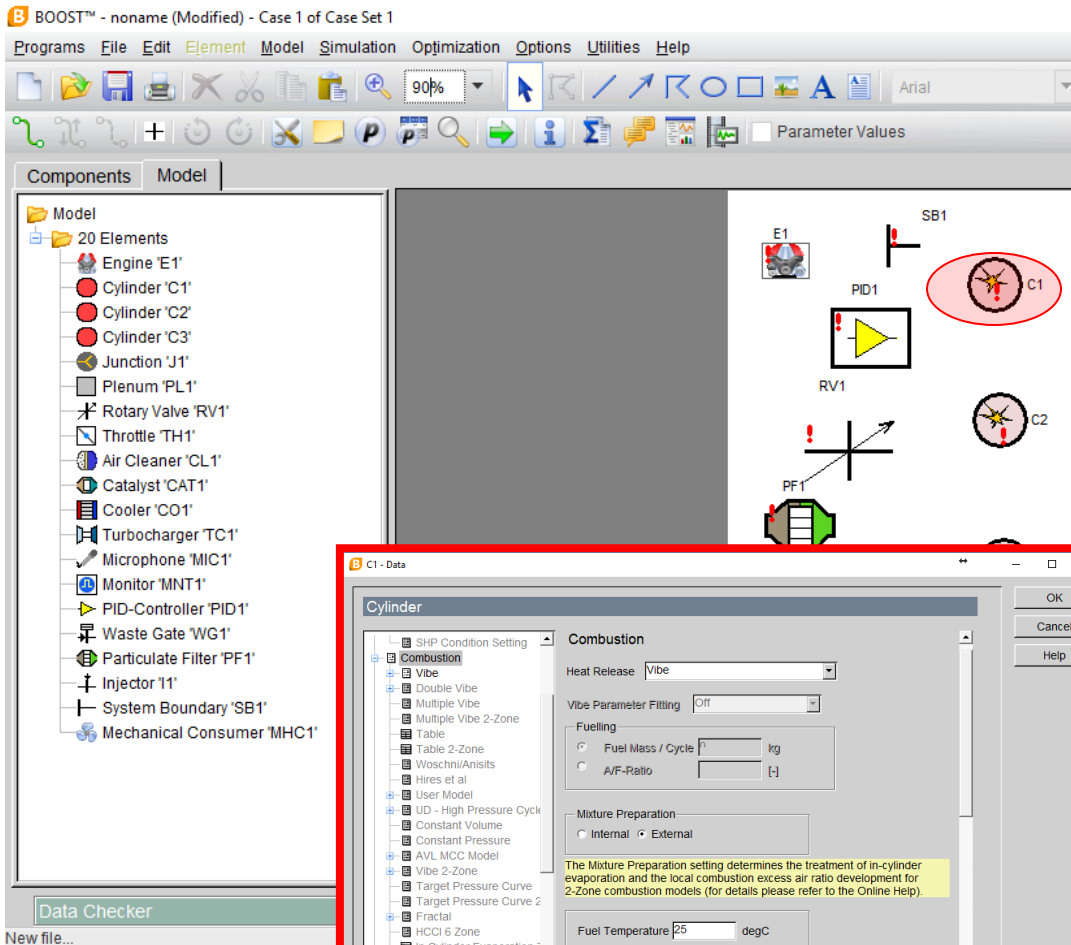
Estrutura do AVL-BOOST

Working place do BOOST

The screenshot displays the AVL-BOOST software interface. The main workspace is divided into three sections: a component tree on the left, a schematic diagram in the center, and a data checker at the bottom. The component tree lists 20 elements including Engine 'E1', three Cylinders ('C1', 'C2', 'C3'), a Junction 'J1', a Plenum 'PL1', a Rotary Valve 'RV1', a Throttle 'TH1', an Air Cleaner 'CL1', a Catalyst 'CAT1', a Cooler 'CO1', a Turbocharger 'TC1', a Microphone 'MIC1', a Monitor 'MNT1', a PID-Controller 'PID1', a Waste Gate 'WG1', a Particulate Filter 'PF1', an Injector 'I1', a System Boundary 'SB1', and a Mechanical Consumer 'MHC1'. The schematic diagram shows these components connected, with cylinder 'C1' highlighted in red. Two configuration windows are open: 'Cylinder - General' and 'Cylinder - Initialization'. The 'General' window shows fields for Author (L.R. Cancino), Comment, Result Name, Date, Bore, Stroke, Compression Ratio, Con-Rod Length, Piston Pin Offset, Effective Blow By Gap (0.0008 mm), and Mean Crankcase Press. The 'Initialization' window shows fields for Initial Conditions at EO (Pressure, Temperature), Initial Gas Composition (Ratio Type: A/F - Ratio, Ratio Value, Fuel Vapour, Combustion Products), and a checkbox for SHP Condition Setting.

Estrutura do AVL-BOOST

Working place do BOOST



Estrutura do AVL-BOOST

Working place do BOOST

BOOST™ - noname (Modified) - Case 1 of Case Set 1

Programs File Edit Element Model Simulation Optimization Options Utilities Help

90%

Parameter Values

Components Model

Model

- 20 Elements
 - Engine 'E1'
 - Cylinder 'C1'

C1 - Data

Cylinder

- UD - High Pressure Cycle
- Constant Volume
- Constant Pressure
- AVL MCC Model
- Vibe 2-Zone
- Target Pressure Curve
- Target Pressure Curve 2
- Fractal
- HCCI 6 Zone
- In Cylinder Evaporation 1
- Open Chamber Gas Eng
- AVLMZCM
- Flame Tracking Model
- Pollutants
- Knock
- Heat Transfer
 - Piston Calibration Factor
 - Head Calibration Factor
 - Liner Calibration Factor
 - Variable Wall Temperat
 - Liner Layer Wall Temper
 - Valve Port Specifications

Heat Transfer

Cylinder: Woschni 1978

Ports: Zapf None

Piston: Surface Area [] mm², Wall Temperature [] degC, Piston Calibration Factor 1 [-]

Cylinder Head: Surface Area [] mm², Wall Temp [] degC, Head Calibration Factor 1 [-]

Liner: Layer Discretization [], Surface Area (Piston at TDC) [] mm²

Mixture Preparation: Internal External

The Mixture Preparation setting determines the treatment of in-cylinder evaporation and the local combustion excess air ratio development for 2-Zone combustion models (for details please refer to the Online Help).

Fuel Temperature 25 degC

In Cylinder Evaporation []

Data Checker

New file...

C1 - Data

Cylinder

General

Author: LRCancino

Comment: []

Result Name: [] Date: []

Bore: [] mm

Stroke: [] mm

Compression Ratio: [] [-]

Con-Rod Length: [] mm

Piston Pin Offset: [] mm

Effective Blow By Gap: 0.0008 mm

Mean Crankcase Press: [] bar

Apply Accept Help

C1 - Data

Cylinder

Initialization

Initial Conditions at EO

Pressure: [] bar

Temperature: [] degC

Initial Gas Composition

Ratio Type: A/F - Ratio

Ratio Value: [] [-]

Fuel Vapour: [] [-]

Combustion Products: [] [-]

SHP Condition Setting []

Apply Accept Help

Estrutura do AVL-BOOST

Working place do BOOST

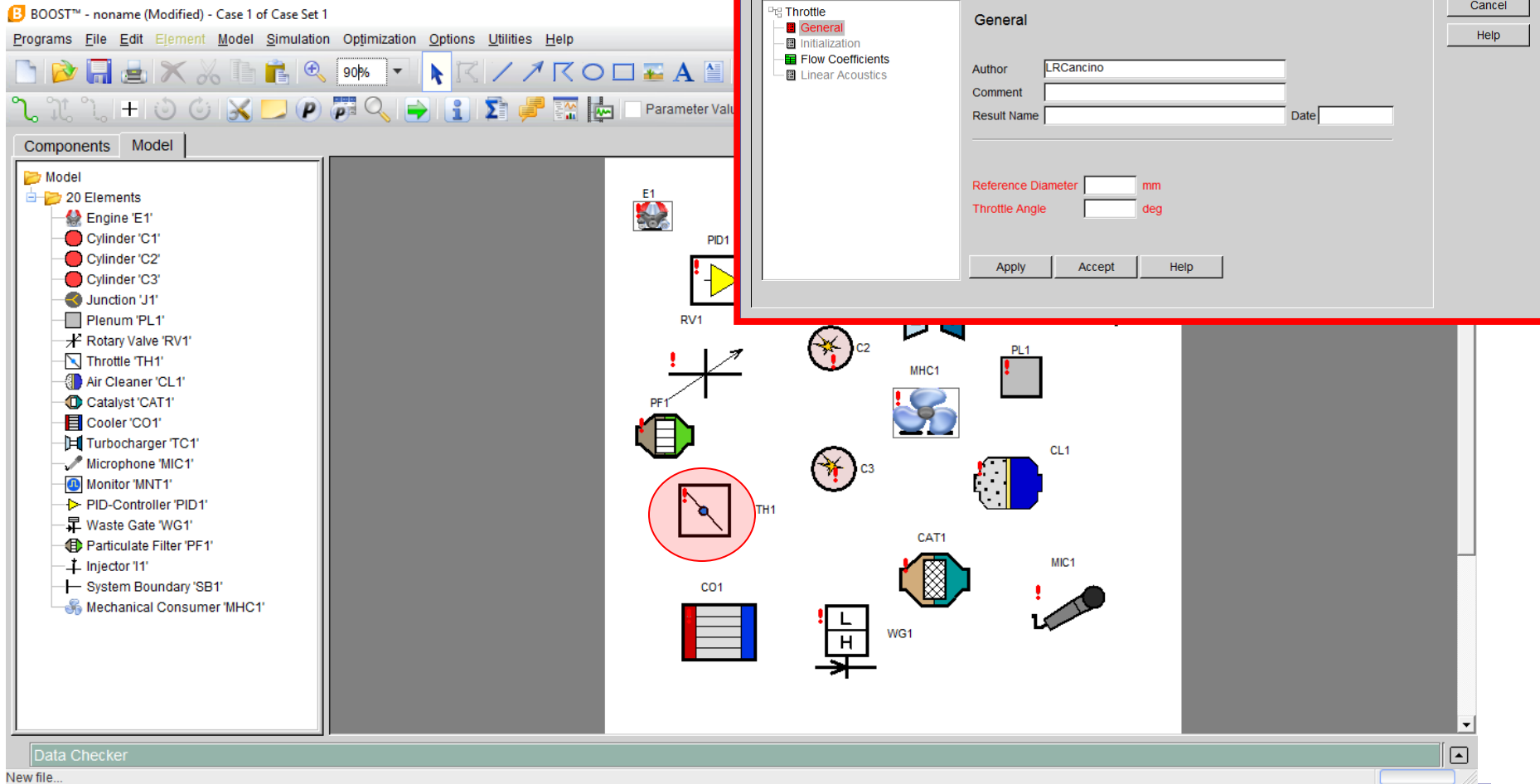
The image displays several overlapping windows from the AVL-BOOST software interface:

- Cylinder (Red Border):** Shows a tree view on the left with 'Heat Transfer' selected. The main area contains 'Valve Port Specifications' with tables for 'Controlled By', 'Port', and 'Variable Wall Temperature'.

Pipe	Control	Surf Area	W. Temp	W.Thick	Conduct	Heat Cap
		mm ²	degC	mm	W/(m.K)	kJ/(m ³ .K)
- Valve Port Specifications:** Contains fields for 'Surface Area', 'Wall Temperature', and 'Piston Calibration Factor' for both 'Piston' and 'Cylinder Head'.
- Mixture Preparation:** Shows 'Internal' and 'External' options, with a note: "The Mixture Preparation setting determines the treatment of in-cylinder evaporation and the local combustion excess air ratio development for 2-Zone combustion models (for details please refer to the Online Help)." It also includes 'Fuel Temperature' and 'In Cylinder Evaporation' checkboxes.
- Initialization:** Shows 'Initial Conditions at EO' for Pressure and Temperature, and 'Initial Gas Composition' for Ratio Type, Ratio Value, Fuel Vapour, and Combustion Products.
- Data Checker:** A window at the bottom left with a 'New file...' button.

Estrutura do AVL-BOOST

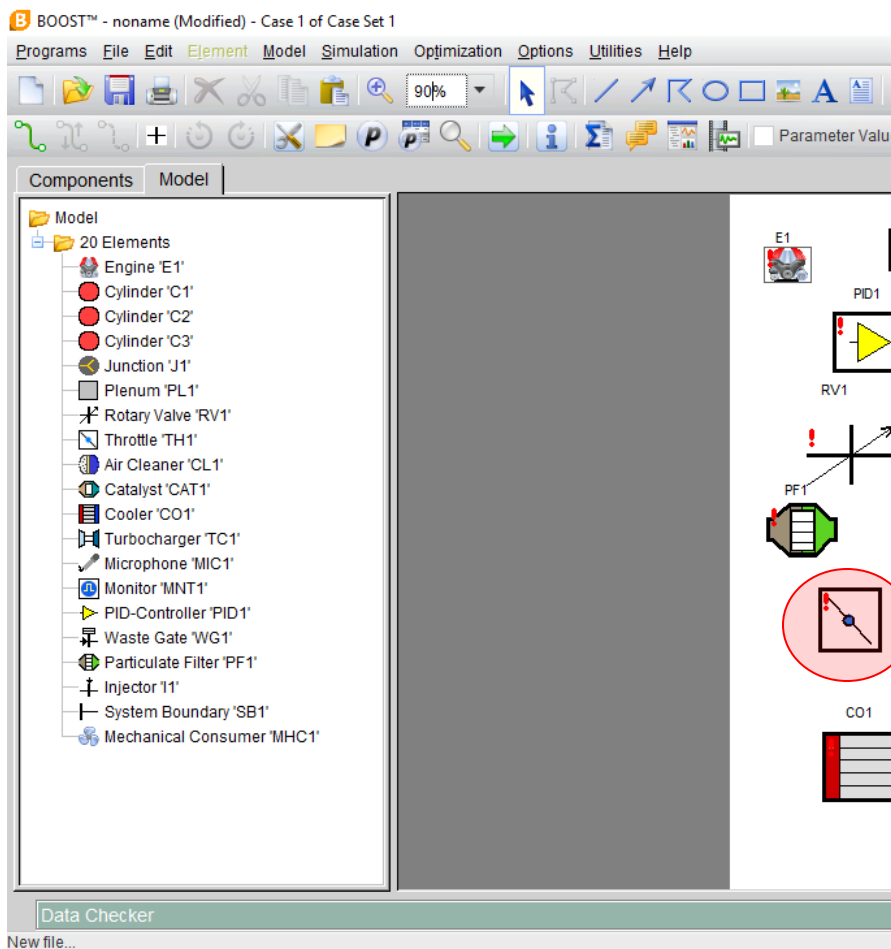
Working place do BOOST



The screenshot displays the AVL-BOOST software interface. On the left, a 'Components' tree lists 20 elements including Engine 'E1', three Cylinders ('C1', 'C2', 'C3'), Junction 'J1', Plenum 'PL1', Rotary Valve 'RV1', Throttle 'TH1', Air Cleaner 'CL1', Catalyst 'CAT1', Cooler 'CO1', Turbocharger 'TC1', Microphone 'MIC1', Monitor 'MNT1', PID-Controller 'PID1', Waste Gate 'WG1', Particulate Filter 'PF1', Injector 'I1', System Boundary 'SB1', and Mechanical Consumer 'MHC1'. The central workspace shows a schematic diagram of these components, with the Throttle 'TH1' highlighted by a red circle. On the right, a 'Throttle' data dialog box is open, showing the 'General' tab with fields for Author (LRCancino), Comment, Result Name, Date, Reference Diameter (mm), and Throttle Angle (deg). Buttons for 'Apply', 'Accept', 'Help', 'OK', 'Cancel', and 'Help' are visible.

Estrutura do AVL-BOOST

Working place do BOOST

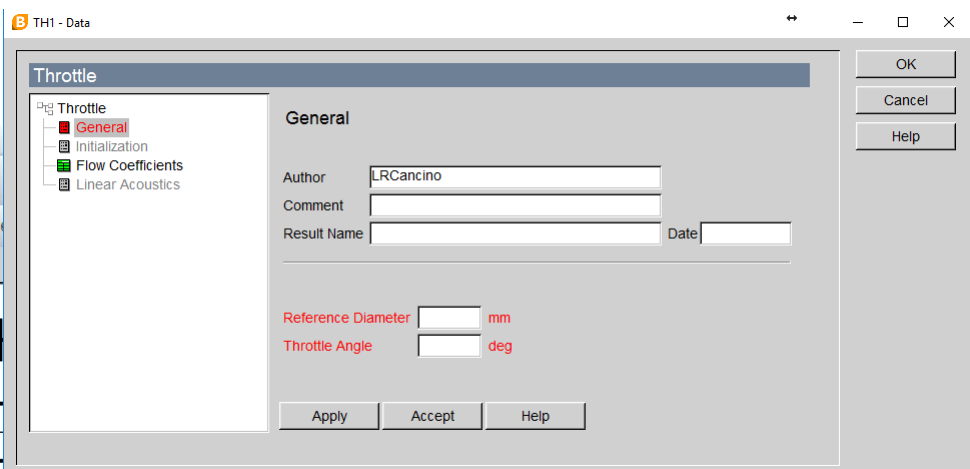


BOOST™ - noname (Modified) - Case 1 of Case Set 1

Programs File Edit Element Model Simulation Optimization Options Utilities Help

Components Model

- Model
 - 20 Elements
 - Engine 'E1'
 - Cylinder 'C1'
 - Cylinder 'C2'
 - Cylinder 'C3'
 - Junction 'J1'
 - Plenum 'PL1'
 - Rotary Valve 'RV1'
 - Throttle 'TH1'
 - Air Cleaner 'CL1'
 - Catalyst 'CAT1'
 - Cooler 'CO1'
 - Turbocharger 'TC1'
 - Microphone 'MIC1'
 - Monitor 'MNT1'
 - PID-Controller 'PID1'
 - Waste Gate 'WG1'
 - Particulate Filter 'PF1'
 - Injector 'I1'
 - System Boundary 'SB1'
 - Mechanical Consumer 'MHC1'



TH1 - Data

Throttle

- General
- Initialization
- Flow Coefficients
- Linear Acoustics

General

Author: LRCancino

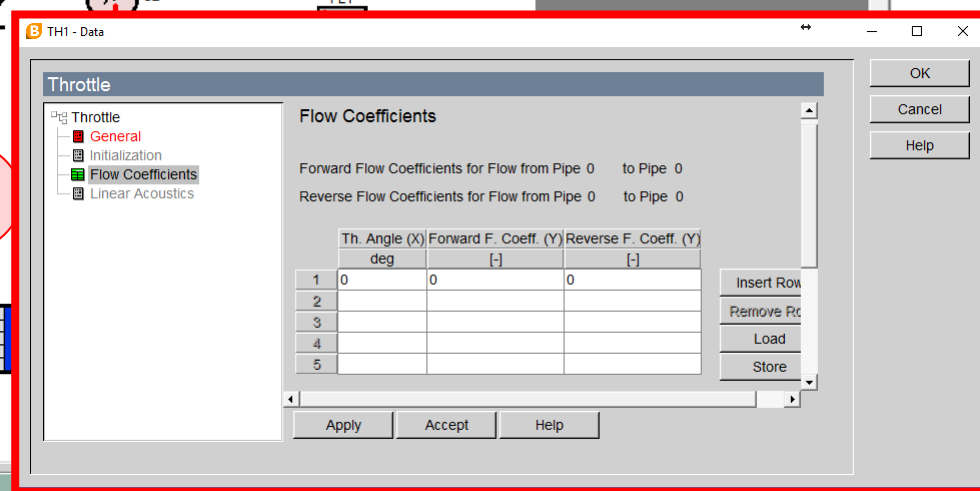
Comment:

Result Name: Date:

Reference Diameter: mm

Throttle Angle: deg

Apply Accept Help



TH1 - Data

Throttle

- General
- Initialization
- Flow Coefficients
- Linear Acoustics

Flow Coefficients

Forward Flow Coefficients for Flow from Pipe 0 to Pipe 0

Reverse Flow Coefficients for Flow from Pipe 0 to Pipe 0

	Th. Angle (X) deg	Forward F. Coeff. (Y) [-]	Reverse F. Coeff. (Y) [-]
1	0	0	0
2			
3			
4			
5			

Insert Row Remove Row Load Store

Apply Accept Help

Estrutura do AVL-BOOST

Working place do BOOST

The screenshot displays the AVL-BOOST software interface. On the left, a 'Components' tree lists 20 elements including Engine 'E1', three Cylinders ('C1', 'C2', 'C3'), Junction 'J1', Plenum 'PL1', Rotary Valve 'RV1', Throttle 'TH1', Air Cleaner 'CL1', Catalyst 'CAT1', Cooler 'CO1', Turbocharger 'TC1', Microphone 'MIC1', Monitor 'MNT1', PID-Controller 'PID1', Waste Gate 'WG1', Particulate Filter 'PF1', Injector 'I1', System Boundary 'SB1', and Mechanical Consumer 'MHC1'. The central workspace shows a schematic diagram of these components connected in a system. On the right, a red-bordered dialog box titled 'Air Cleaner' is open, showing configuration options for 'CL1'. The dialog includes a 'General' section with fields for Author, Comment, and Result Name. It also has sections for 'Geometrical Properties' (Total Air Cleaner Volume, Inlet Collector Volume, Outlet Collector Volume, Length of Filter Element) and 'Hydraulic Setting of Filter Element' (Hydraulic Setting, Hydraulic Unit, Hydraulic Diameter, Hydraulic Area).

Estrutura do AVL-BOOST

Working place do BOOST

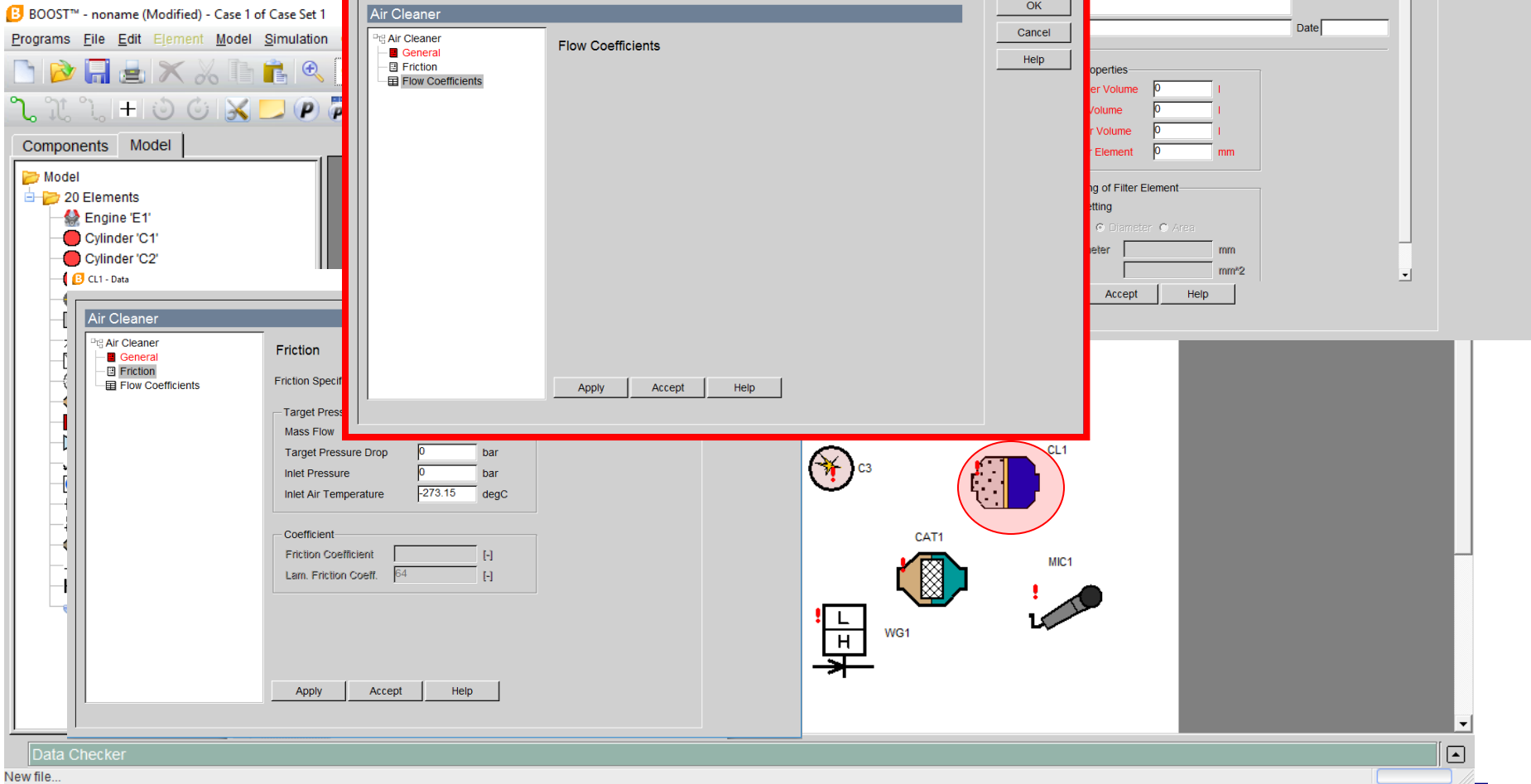
The screenshot displays the AVL-BOOST software interface. The main window shows a model with 20 elements, including Engine 'E1', Cylinder 'C1', and Cylinder 'C2'. A red box highlights the 'Air Cleaner' data entry window, which is currently set to the 'Friction' tab. This window contains the following fields:

- Friction Specification:** Target Pressure Drop (selected), Coefficient.
- Target Pressure Drop:** Mass Flow (0 kg/s), Target Pressure Drop (0 bar), Inlet Pressure (0 bar), Inlet Air Temperature (-273.15 degC).
- Coefficient:** Friction Coefficient ([-]), Lam. Friction Coeff. (54 [-]).

Other visible windows include 'Air Cleaner' (General tab) with fields for Author (LRCancino), Comment, Result Name, Date, and Geometrical Properties (Total Air Cleaner Volume, Inlet Collector Volume, Outlet Collector Volume, Length of Filter Element). The main model view shows components like MHC1, PL1, C2, C3, CAT1, WG1, and MIC1.

Estrutura do AVL-BOOST

Working place do BOOST



The screenshot displays the AVL-BOOST software interface. The main window shows a project titled "BOOST™ - noname (Modified) - Case 1 of Case Set 1". The "Components" pane on the left lists the model elements: Engine 'E1', Cylinder 'C1', Cylinder 'C2', and CL1 - Data. The "Air Cleaner" configuration window is open, showing the "Flow Coefficients" tab. A red box highlights this window. Below it, the "Friction" configuration window is also visible, showing fields for "Target Pressure Drop", "Inlet Pressure", "Inlet Air Temperature", "Friction Coefficient", and "Lam. Friction Coeff.". To the right, a schematic diagram shows the engine components: C3 (Cylinder), CL1 (Air Cleaner), CAT1 (Catalytic Converter), WG1 (Water Separator), and MIC1 (Microphone). The "Data Checker" window is visible at the bottom left.

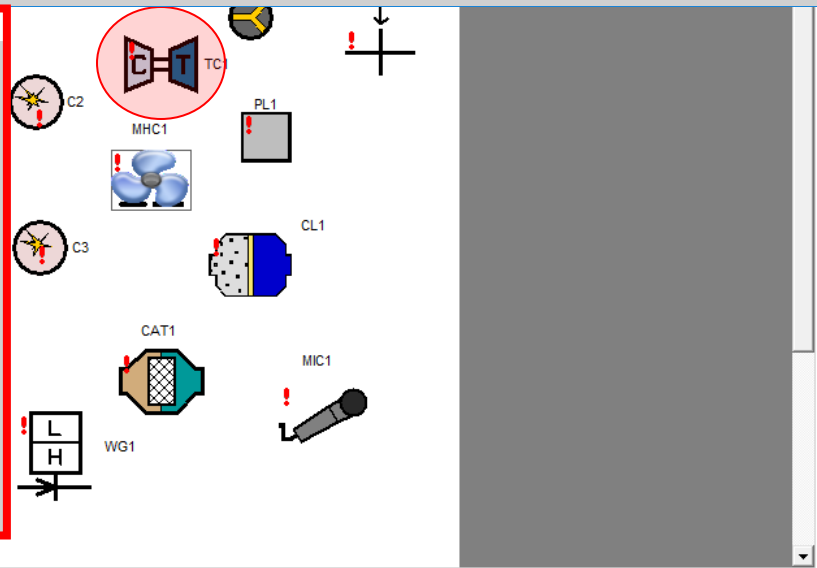
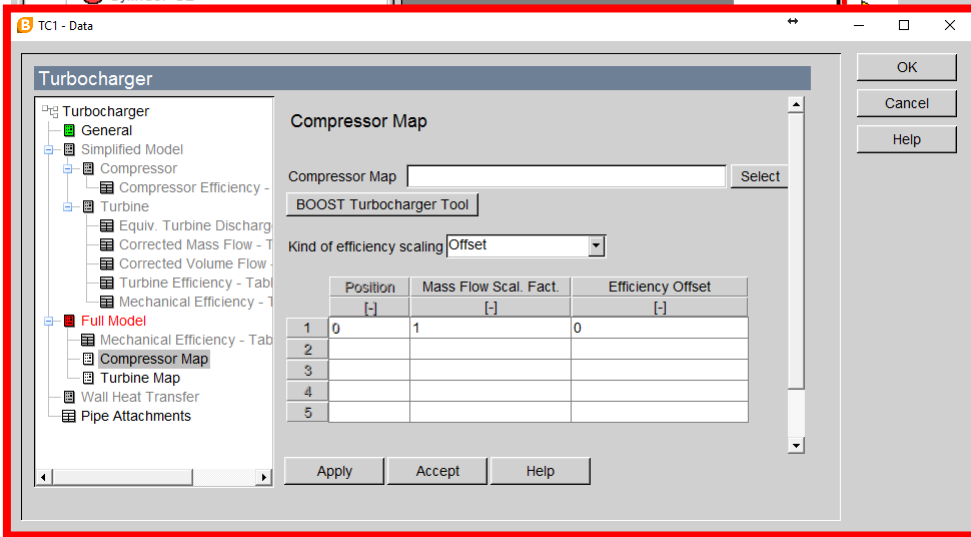
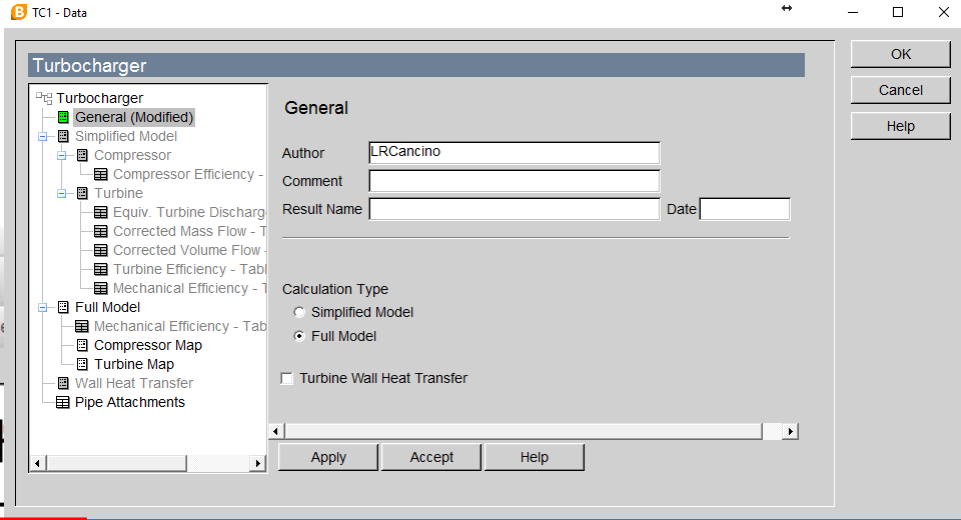
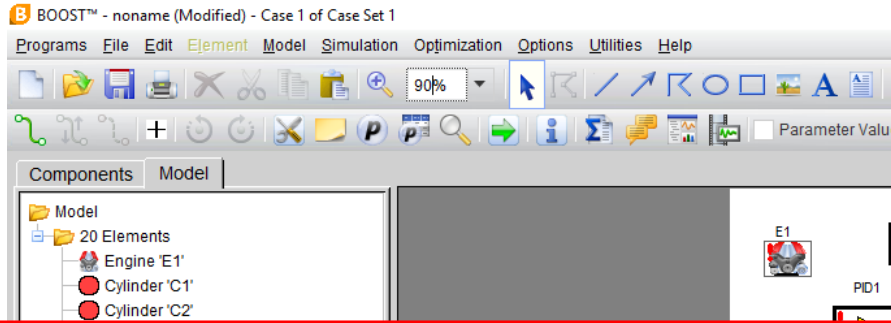
Estrutura do AVL-BOOST

Working place do BOOST

The screenshot displays the AVL-BOOST software interface. On the left, a 'Components' tree lists 20 elements including Engine 'E1', three cylinders (C1, C2, C3), a junction (J1), plenum (PL1), rotary valve (RV1), throttle (TH1), air cleaner (CL1), catalyst (CAT1), cooler (CO1), turbocharger (TC1), microphone (MIC1), monitor (MNT1), PID-controller (PID1), waste gate (WG1), particulate filter (PF1), injector (I1), system boundary (SB1), and mechanical consumer (MHC1). The main workspace shows a 3D schematic of the engine with various components labeled: E1, PID1, RV1, PF1, TH1, CO1, TC1 (circled in red), MHC1, PL1, CL1, CAT1, WG1, and MIC1. An inset window titled 'TC1 - Data' is open, showing the configuration for the Turbocharger. The 'General' tab is active, with fields for Author (LRCancino), Comment, Result Name, and Date. Under 'Calculation Type', 'Full Model' is selected. Buttons for 'Apply', 'Accept', and 'Help' are at the bottom of the dialog.

Estrutura do AVL-BOOST

Working place do BOOST



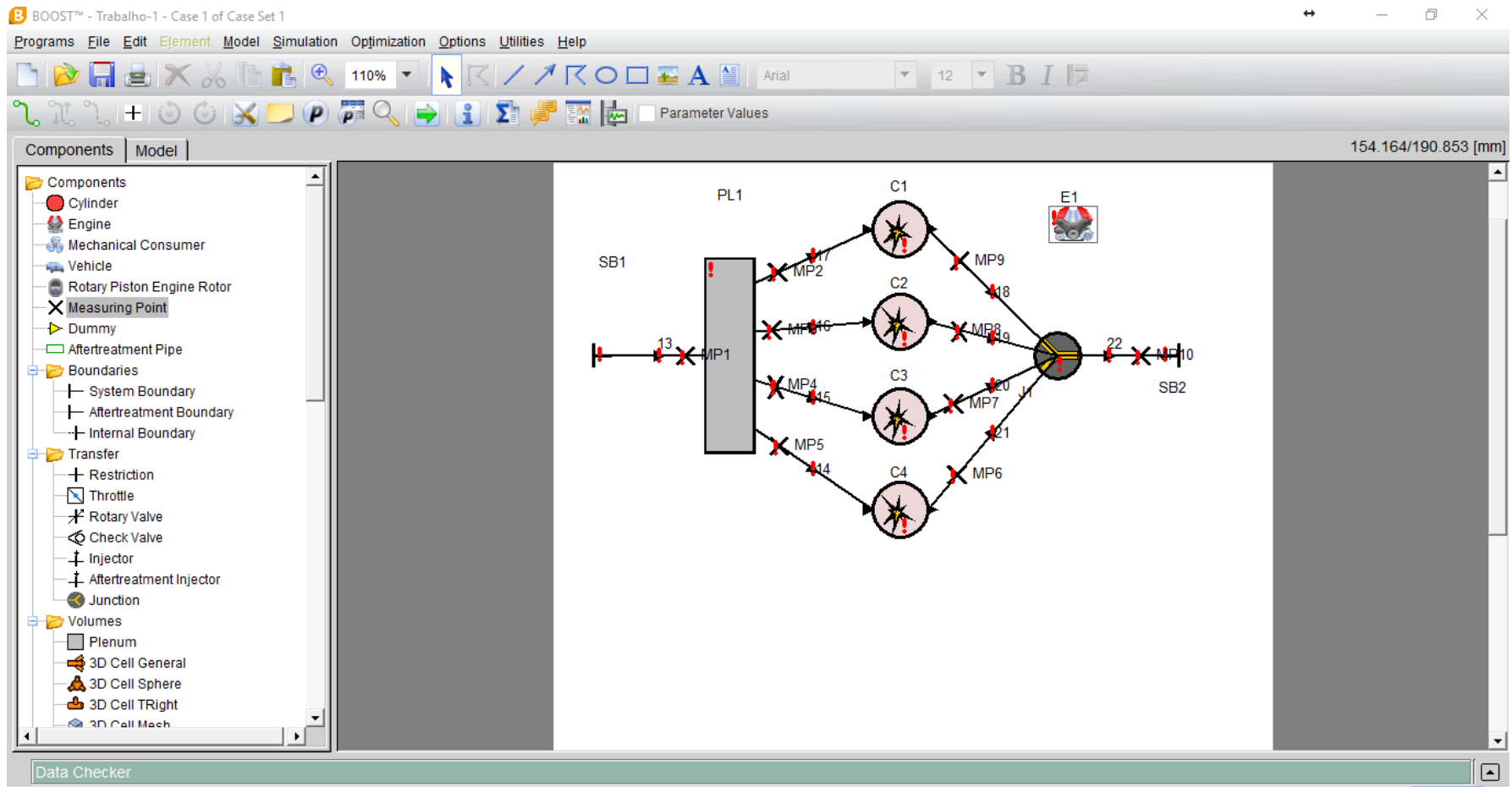
Data Checker

New file...

Modelagem de componentes

Trabalho #1 em sala de aula

Configurar o seguinte sistema MCI para simular

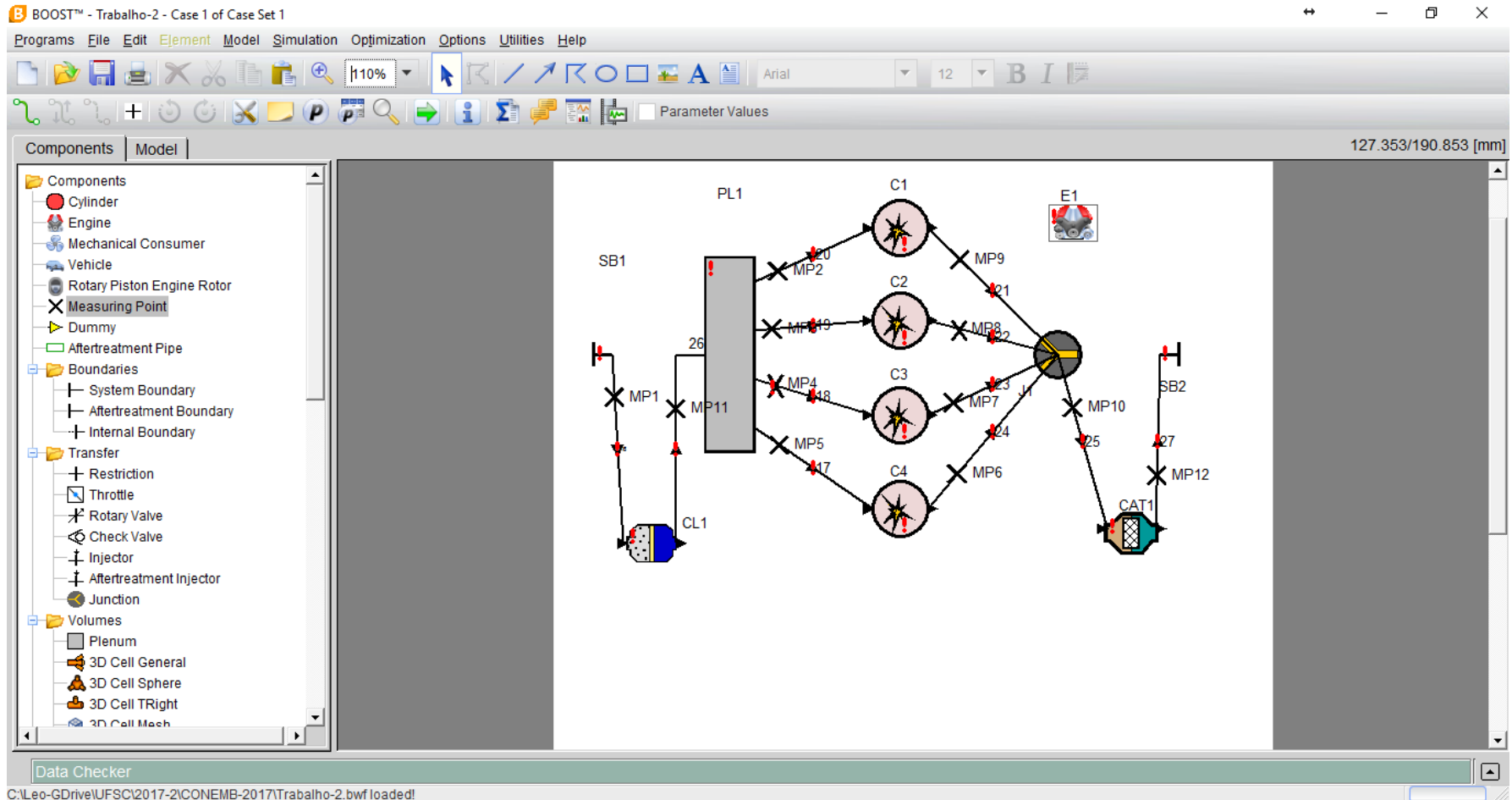


The screenshot displays the AVL BOOST software interface for a simulation case titled "BOOST™ - Trabalho-1 - Case 1 of Case Set 1". The main workspace shows a schematic diagram of a multi-cylinder engine system. The diagram includes a plenum (PL1) on the left, four cylinders (C1, C2, C3, C4) in the center, a junction (J1) on the right, and two system boundaries (SB1, SB2). Measuring points (MP1-MP10) are distributed throughout the system. A 'Components' tree on the left lists various parts like Cylinder, Engine, and Throttle. The software title bar indicates "BOOST™ - Trabalho-1 - Case 1 of Case Set 1".

Modelagem de componentes

Trabalho #2 em sala de aula

Configurar o seguinte sistema MCI para simular



The screenshot displays the AVL BOOST software interface for a simulation case titled "Trabalho-2 - Case 1 of Case Set 1". The main window shows a 3D schematic of an engine system. Key components include:

- Engine (E1):** A four-cylinder engine (C1, C2, C3, C4) connected to a plenum (PL1).
- Plenum (PL1):** A central chamber with four measuring points (MP2, MP3, MP4, MP5) leading to the cylinders.
- Aftertreatment:** A catalytic converter (CAT1) is connected to the system via a junction (J1) and measuring points (MP6, MP7, MP8, MP9, MP10, MP11).
- Boundaries:** The system is bounded by SB1 and SB2.
- Other Components:** A cylinder (CL1) is also present in the system.

The left sidebar shows a "Components" tree with categories like Cylinder, Engine, Mechanical Consumer, Vehicle, Rotary Piston Engine Rotor, Measuring Point, Dummy, Aftertreatment Pipe, Boundaries, Transfer, Volumes, and 3D Cell. The bottom status bar indicates the file path: "C:\Leo-GDrive\UFSC\2017-2\CONEMB-2017\Trabalho-2.bwf loaded!".

Modelagem de componentes

Trabalho #3 em sala de aula

Configurar o seguinte sistema MCI para simular

The screenshot displays the AVL BOOST software interface for a simulation. The main workspace shows a schematic diagram of a mechanical system. The components list on the left includes: Cylinder, Engine, Mechanical Consumer, Vehicle, Rotary Piston Engine Rotor, Measuring Point, Dummy, Aftertreatment Pipe, Boundaries (System Boundary, Aftertreatment Boundary, Internal Boundary), Transfer (Restriction, Throttle, Rotary Valve, Check Valve, Injector, Aftertreatment Injector), Junction, and Volumes (Plenum, 3D Cell General, 3D Cell Sphere, 3D Cell TRight, 3D Cell Mesh). The schematic diagram shows a plenum (PL1) connected to four cylinders (C1, C2, C3, C4). A compressor (CO1) and a turbine (TC1) are also shown, along with a catalytic converter (CAT1). Various measuring points (MP1-MP15) and boundary types (SB1, SB2) are indicated throughout the system.