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DATA DETERMINATION OF AN INTERNAL COMBUSTION ENGINE FOR MODEL SET-UP

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To make the model of the vehicle power train modelling firstly we have to make the engine (uncharged, 4-cylindrical, 8 valve four stroke engine) model with the help of GT Suite software. In terms of building and identification of the model we need to define several geometrical and mechanical values. Some of mentioned values are not given in available mending directive of the car. Some of them (e.g. the intake and exhaust-system) are too complex they can't be exactly defined with simple measurement-technique. To define these geometries a computer tomography and methods with limited-element have been used. In the lecture we are introducing some interesting examples.

Keywords: GT Suite, model, intake pipe, valve lift, Computer Tomography, straight pipe, bent pipe, Y-connector

Introduction

The research and development project set target to build the vehicle power train. The first important step is to build the internal combustion engine model. To build this model important data of the chosen engine are required. There are only a few of these as base data available. Therefore most of the geometrical sizes have to be defined by measurements. The engine chosen for modelling is a 1.6-liter 8-valve gasoline engine.

Table 1: The main dates of chosen engines are as it follows:

Construction	4-cylinder line engine
Engine capacity	1595 cm^3
Bore	Ø81.0 mm
Stroke	77.4 mm
Compression ratio	10.3:1
Max. power	75 kW, 5600 min^{-1}
Max. torque	148 Nm, 3800 min^{-1}

The characteristic curves are shown on *Fig. 1* and *Fig. 2.*

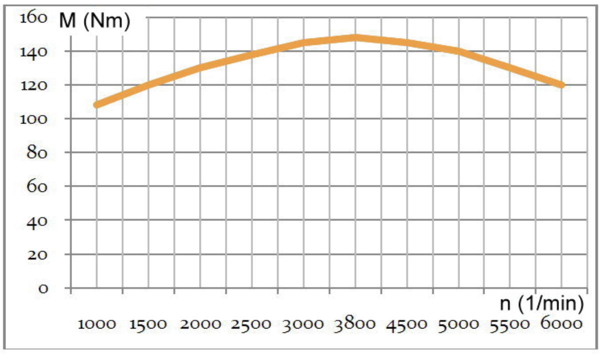


Figure 1: Engine torque

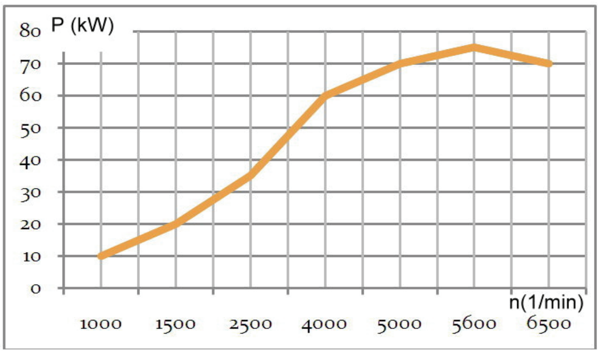


Figure 2: Engine power

Data validation for the model

For the modelling it is necessary to know the elements of the intake and exhausting system details. Hereinafter we show the method of the measuring process.

Defining the valve-lift chart

We measured the valve moving chart with disassembled cylinder head. For this measuring we use inductive way and angle signaller. With this measuring technique we get the chart which is based on camshaft rotation.

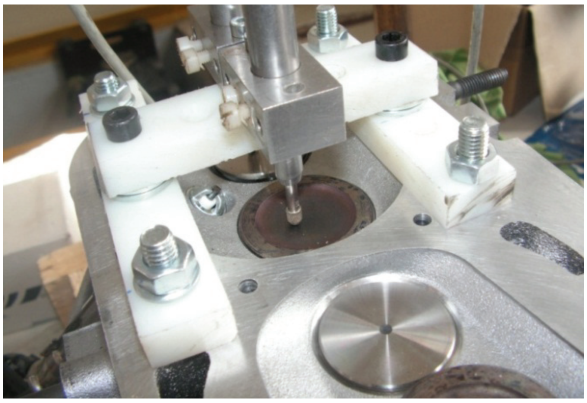


Figure 3: Measuring the valve movement chart (movement measure)

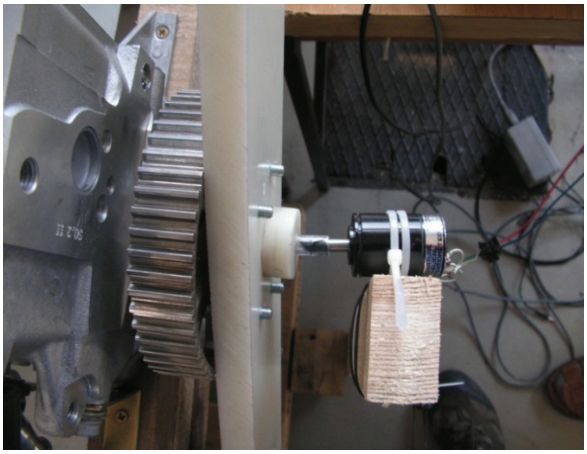


Figure 4: Measuring the valve movement chart (angle signaller)

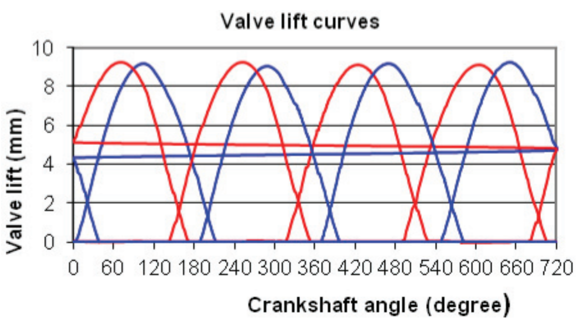


Figure 5: The valve movement chart from the measure

Definition of the mass data of the crank gear

As an example, measurements of the mass of the piston are presented:

Table 2: Results of the measurements

Connecting-rod mass	539.63 g
Mass without pin	286.6 g
Mass with pin	348.7 g
Piston + pin + connecting rod mass	886.86 g

Figure 6: Measuring the piston mass

Definition of geometrical data of the crank gear

We present the measurements of the data of the piston and combustion chamber measured on the components of the given engine.

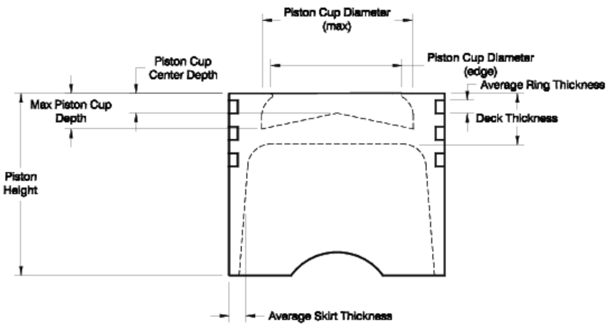


Figure 7: Piston geometrical dimensions

- Piston Cup Diameter Ø 62.4 mm
- Maximum Piston Cup Depth 2.5 mm
- Piston Cup Diameter (Edge) Ø 62.4 mm
- Piston Cup Centre Depth 2.5 mm
- Piston Height 51 mm
- Deck Thickness 9.7 mm
- Average Ring Thickness 3 mm

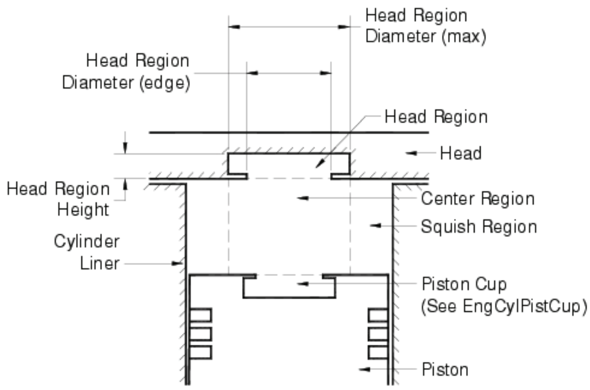


Figure 8: Piston and combustion chamber dimensions

• Head Region Diameter (max.)	Ø80.6 mm
• Head Region Diameter (edge)	Ø 80.6 mm
• Head Region Height	8 mm

Data of the intake system

With the computer tomography we can control the outside and inside geometries with high accuracy. The external profile can be measured with ATOS optical measuring system, and the 3D digitalizing system is creating a polygon-mesh with high resolution. The system converts these data to CAD data using reverse engineering method. The steps of this process are:

- cloud-model
- STL file(*.stl) only the surface is described with the help of 923.196 triangle elements
- Making the 3D model using the computer tomography geometries of lower part of the intake system
- Fitting the guideline to intake system and defining the length of the axis and the angle between the two connecting surfaces
- Using the section guideline we can measure the diameter of the intake system shown on *Fig. 10*

Figure 9: Lower intake system

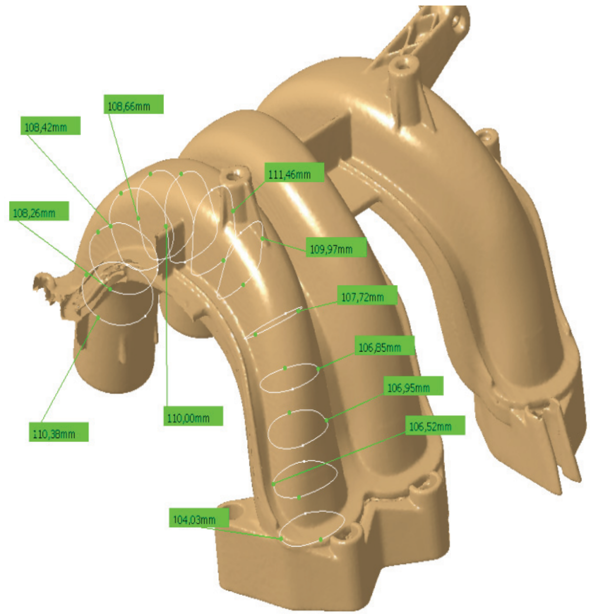


Figure 10: Dimensions of the lower intake system

Data of exhaust system

The geometric measures of the exhaust system have to be defined exactly. According to this the exhaust system pipes can be set up from the following model elements:

1.	straight	D=Ø45.4 mm	l=40 mm	
2.	bent	D=Ø45.4 mm	38°45’	r=45.4 mm
3.	straight	D=Ø45.4 mm	l=530 mm	
4.	Y connector with 90° angle			
5.	straight	D=Ø45.4 mm	l=80 mm	
6.	D=Ø45.4 mm → Ø130 mm		l=47 mm	
7.	straight	D=Ø130 mm	l=158 mm	
8.	D=Ø130 mm → Ø 54.4 mm		l=47 mm	
9.	straight	D=Ø54.4 mm	l=960 mm	
10.	bent	D=Ø54.4 mm	10°	r=54.4 mm
11.	straight	D=Ø54.4 mm	l=230 mm	
12.	bent	D=Ø54.4 mm	55°	r=54.4 mm
13.	straight	D=Ø54.4 mm	l=210 mm	
14.	bent	D=Ø54.4 mm	55°	r=54.4 mm
15.	straight	D=Ø54.4 mm	l=40 mm	
16.	catalyst			
17.	straight	D=Ø54.4 mm	l=40 mm	
18.	bent	D=Ø54.4 mm	30°	r=54.4 mm
19.	straight	D=Ø54.4 mm	l=150 mm	
20.	bent	D=Ø54.4 mm	45°	r=54.4 mm
21.	straight	D=Ø54.4 mm	l=260 mm	
22.	bent	D=Ø54.4 mm	45°	r=54.4 mm
23.	muffler			
24.	exhaust pipe end			

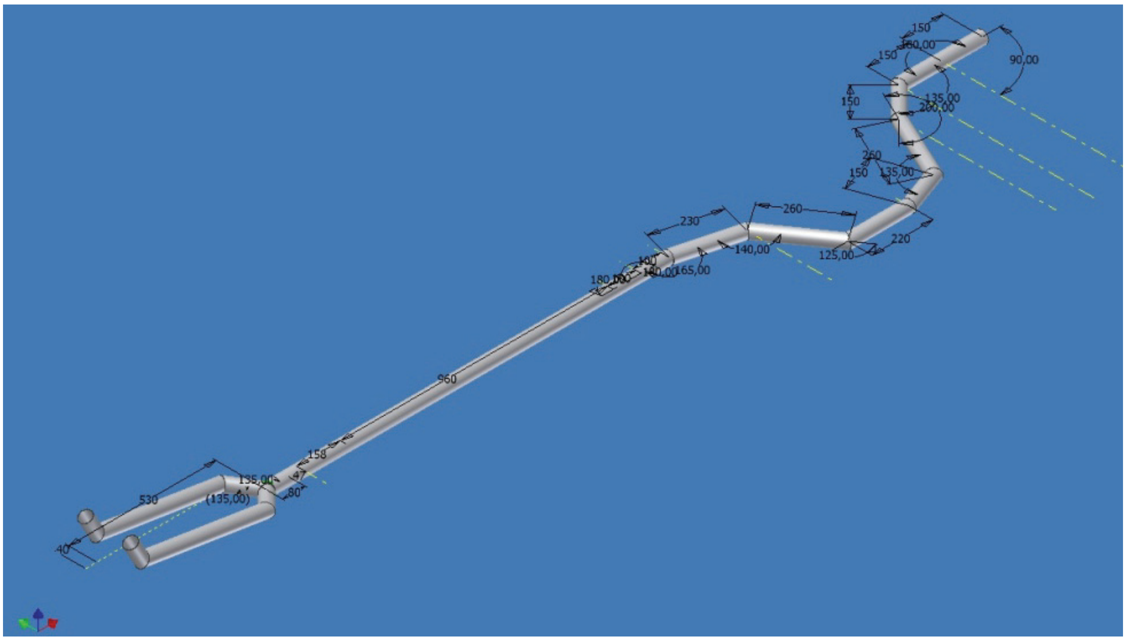


Figure 11: Dimensions of the exhaust system

It is quite simple to model the straight sections if we know the geometric data.

The bent pipe length can be defined with the measured angle (length of arc):

$$i = 2 \cdot R \cdot \pi \cdot \frac{\alpha}{360} \qquad (1)$$

Where:

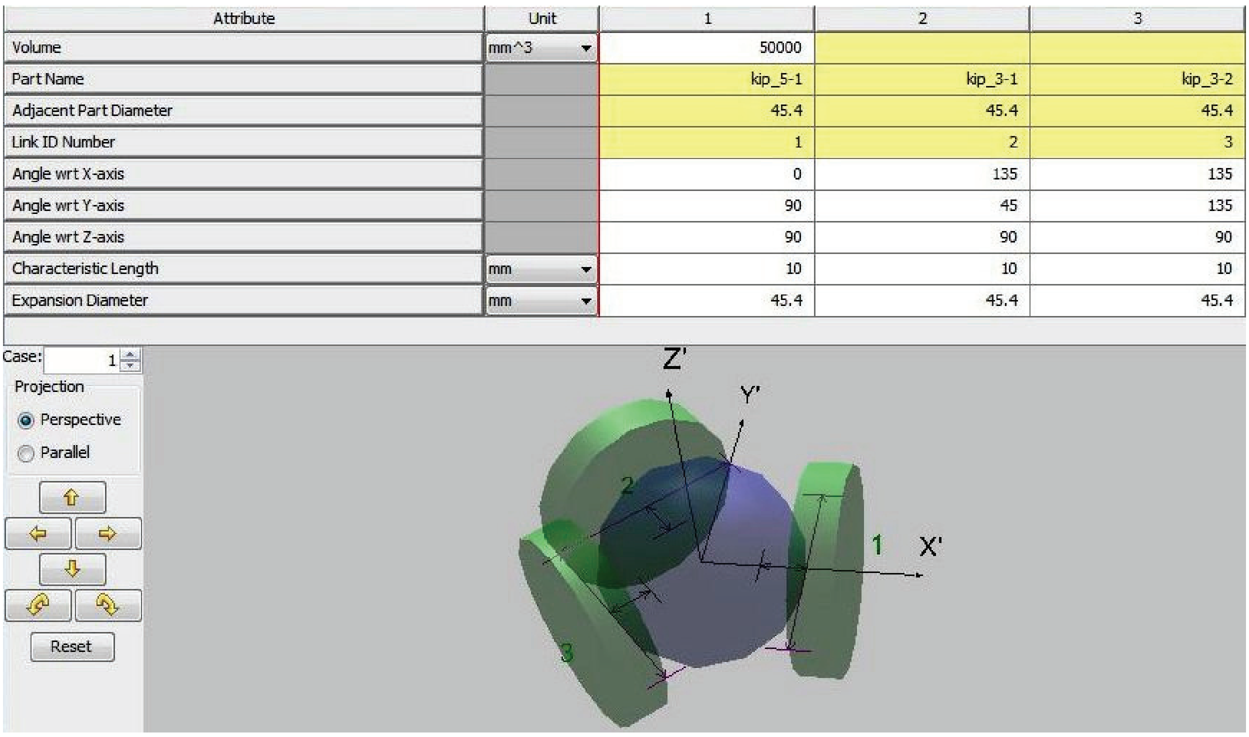
- i – pipe length (mm)
- R – radius (mm)
- α – angle [°]

To model the Y-connector we have to give the dimensions precisely. Beside this the volume has to be given according to changing size of the blue sphere on the model shown on *Fig. 12.*

We have to measure the following dimensions to define the catalytic system:

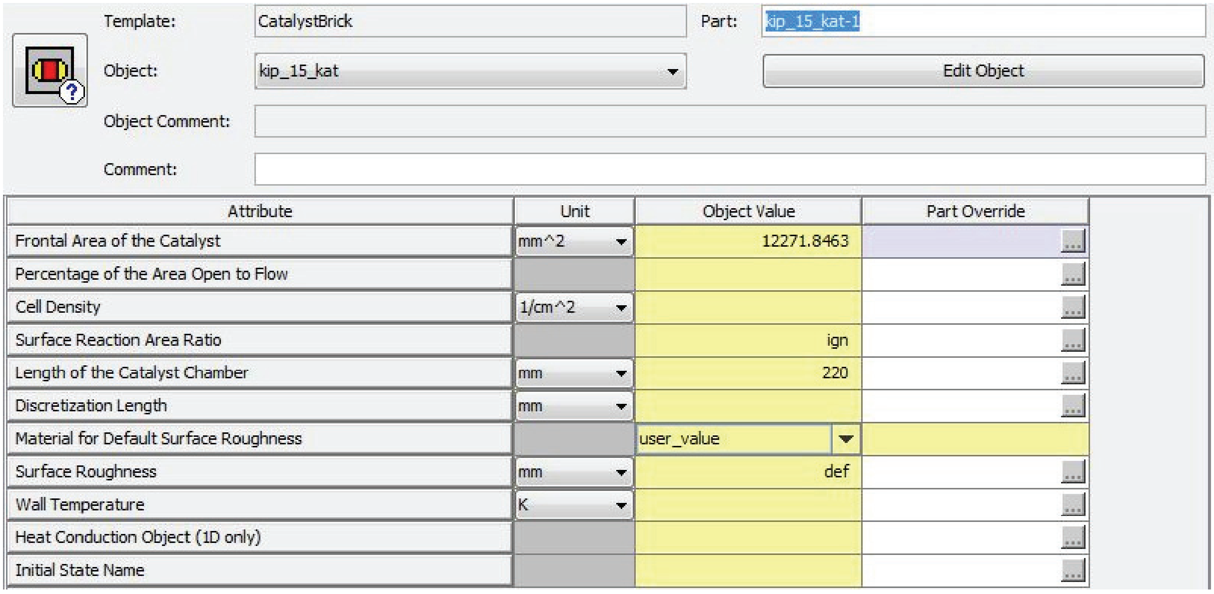
- The section of the catalytic system (11959 mm^2)
- Flow section (flow factor) from GT Suite, value 70%
- We choose the following parameters for cell density which is 400 cpsi (cells per square inch) = 62 $cells/cm^2$ (this value is used for passenger car)

For modelling the silencer we use the GT Suite sample model because we cannot disassembly the exhaust system. The silencer has a lot of parts like pipe and T connector, etc. which is shown on *Fig. 14*.



Attribute	Unit	1	2	3
Volume	mm^3	50000		
Part Name		kip_5-1	kip_3-1	kip_3-2
Adjacent Part Diameter		45.4	45.4	45.4
Link ID Number		1	2	3
Angle wrt X-axis		0	135	135
Angle wrt Y-axis		90	45	135
Angle wrt Z-axis		90	90	90
Characteristic Length	mm	10	10	10
Expansion Diameter	mm	45.4	45.4	45.4

Figure 12: Modelling the Y connector



Template:	CatalystBrick	Part:	kip_15_kat-1
Object:	kip_15_kat		Edit Object
Object Comment:			
Comment:			

Attribute	Unit	Object Value	Part Override
Frontal Area of the Catalyst	mm^2	12271.8463	...
Percentage of the Area Open to Flow			...
Cell Density	1/cm^2		...
Surface Reaction Area Ratio		ign	...
Length of the Catalyst Chamber	mm	220	...
Discretization Length	mm		...
Material for Default Surface Roughness		user_value	
Surface Roughness	mm	def	...
Wall Temperature	K		...
Heat Conduction Object (1D only)			...
Initial State Name			...

Figure 13: Model of the catalytic system

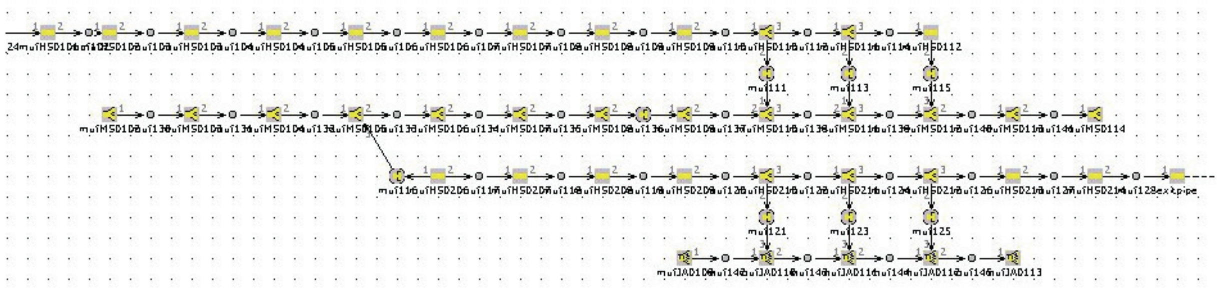


Figure 14: Model of the silencer

Summary

To carry out the model of the chosen four-cylinder, 8-valved, four stroke engine we have to get the rest of the dimensions. In this presentation we highlighted only some significant elements.

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