MARMARA
UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL ENGINEERING

ME4084
INTERNAL COMBUSTION ENGINES II
FINAL EXAM PROJECT

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List of Figures

List of Tables

ENGINE SPECIFICATIONS

First of all, I choose 2JZ-GTE engine to analyze. It is used in Supra MK-4 and my version is without VVT.

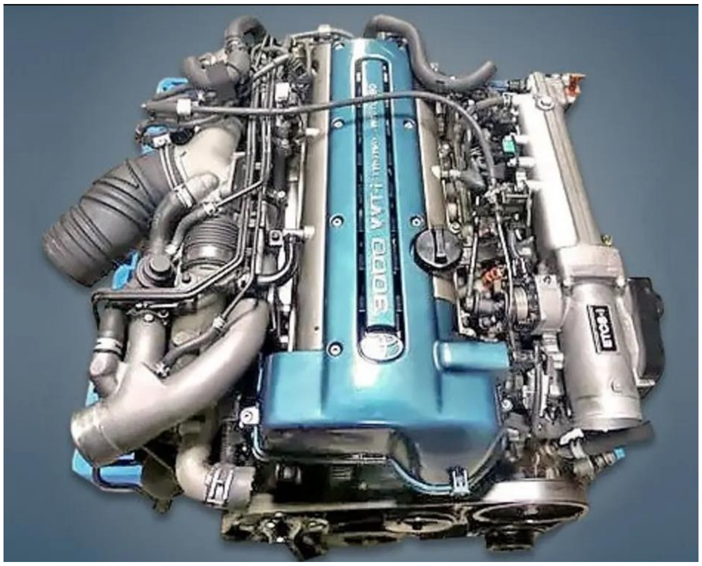

Figure 1: 2JZ engine

- 4 stroke, inline
- 6 cylinders, 3L SI engine

Table 1: Cylinder geometry

Bore (mm)	86
Stroke (mm)	86
Connecting Rod (mm)	142
Compression Ratio	10.0
Pin offset (mm)	35.75

Total of 24 valves with 12 intake and 12 exhaust valves, total of 4 valves per cylinder

Table 2: Valve parameters

	Intake Valves	**Exhaust Valves**
Valve Lift (mm)	8.26	8.41
Valve Open (deg)	3 deg bTDC	53 deg bBDC
Valve Close (deg)	50 aBDC	3 deg aTDC

Valve Throat Diameter (mm)	33.6	29
Runner Diameter (mm)	36	36

SIMULATION

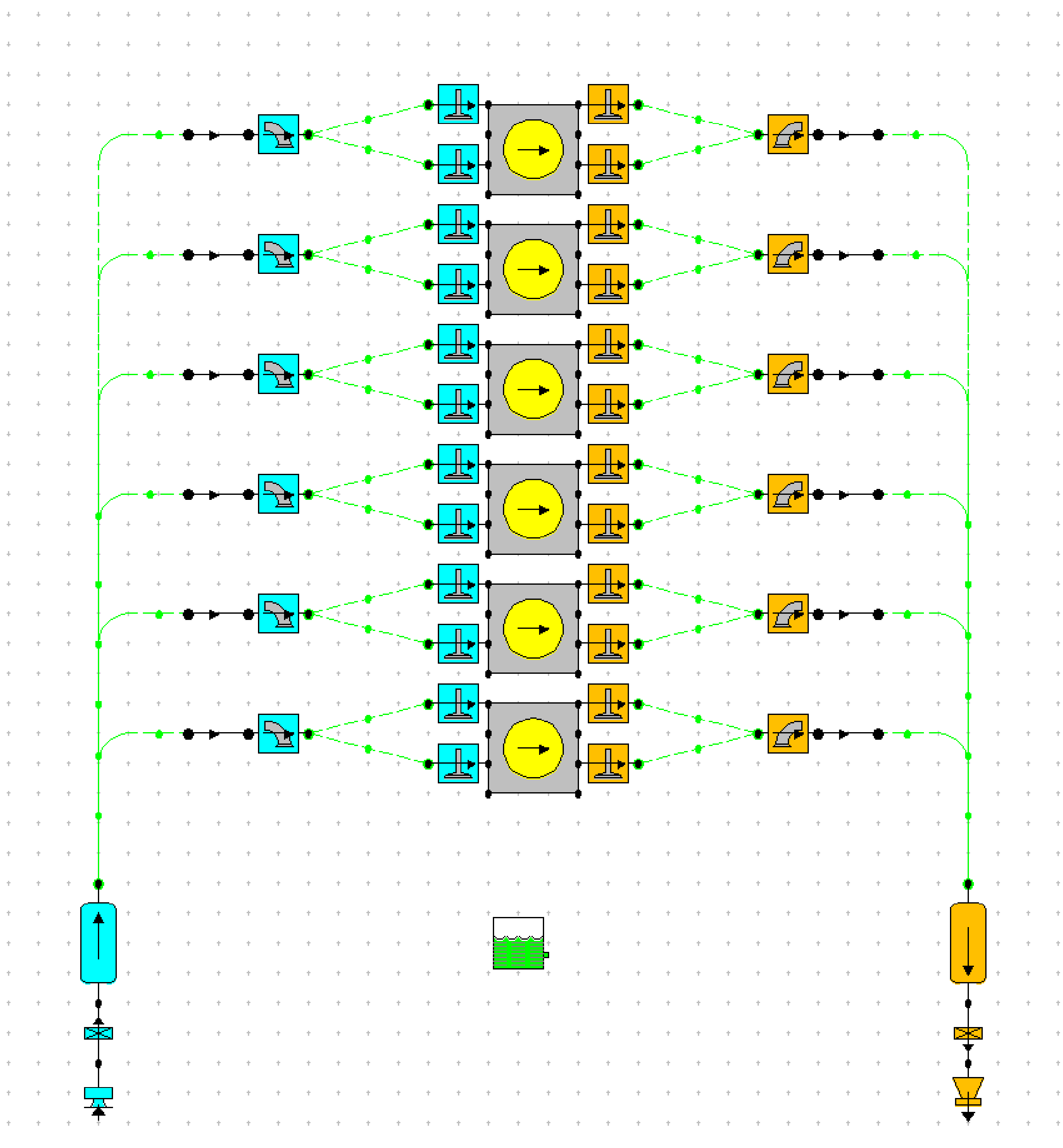

Figure 2: Lotus Engine Model

After placing components of my model, I set the followings as shown.

Label	
Fuel System	Direct Injection
Fuel Type	Gasoline
Calorific Value (kJ/kg)	43000.0
Density (kg/litre)	0.7500
H/C Ratio Fuel (molar)	1.8000
O/C Ratio Fuel (molar)	0.0000
Molecular Mass (kg/k.mol)	114.230
Maldistribution Factor	1.000
Conversion Tool	

Figure 3: Fuel Data

	Bore (mm)	Stroke (mm)	Rod Length (mm)	Pin Offset (mm)	Compression Ratio	Phase (ATDC)
Cyl 1	86.0000	86.0000	142.00	1.00	10.00	0.00
Cyl 2	86.0000	86.0000	142.00	1.00	10.00	480.00
Cyl 3	86.0000	86.0000	142.00	1.00	10.00	240.00
Cyl 4	86.0000	86.0000	142.00	1.00	10.00	600.00
Cyl 5	86.0000	86.0000	142.00	1.00	10.00	120.00
Cyl 6	86.0000	86.0000	142.00	1.00	10.00	360.00

Figure 4: Cylinder Geometric Data

Intake Poppet Valve Data:

	Valve Open (deg)	Valve Close (deg)	Dwell at Max (deg)	Max Lift (mm)	MOP (deg)	Lift Option	Data Action	Opening Lash	Closing Lash
Pval 2	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 3	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 6	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 7	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 10	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 11	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 14	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 15	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 18	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 19	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 22	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000
Pval 23	3.00	50.00	15.00	8.260	106.00	Def. Fast	Scale	0.00000	0.00000

Exhaust Poppet Valve Data:

	Valve Open (deg)	Valve Close (deg)	Dwell at Max (deg)	Max Lift (mm)	MOP (deg)	Lift Option	Data Action	Opening Lash	Closing Lash
Pval 1	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 4	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 5	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 8	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 9	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 12	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 13	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 16	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 17	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 20	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 21	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000
Pval 24	53.00	3.00	10.00	8.410	-120.00	Def. Fast	Scale	0.00000	0.00000

Figure 5: Intake and Exhaust Valve Data

Intake Port Data:

	No of Valves	Valve Throat Dia (mm)	Port Type	CF at 0.3 L/D
Port 2	2	33.60	Default Good Port	0.6400
Port 3	2	33.60	Default Good Port	0.6400
Port 5	2	33.60	Default Good Port	0.6400
Port 7	2	33.60	Default Good Port	0.6400
Port 9	2	33.60	Default Good Port	0.6400
Port 11	2	33.60	Default Good Port	0.6400

Exhaust Port Data:

	No of Valves	Valve Throat Dia (mm)	Port Type	CF at 0.3 L/D
Port 1	2	29.00	Default Good Port	0.7800
Port 4	2	29.00	Default Good Port	0.7800
Port 6	2	29.00	Default Good Port	0.7800
Port 8	2	29.00	Default Good Port	0.7800
Port 10	2	29.00	Default Good Port	0.7800
Port 12	2	29.00	Default Good Port	0.7800

Figure 6: Intake and Exhaust Port Data

Intake Pipes (Ports) Data:

	Length (mm)	Diameter (mm)	No. of Meshes	Wall Thickness (mm)	Cooling Type	Wall Material	Wall Factor	Label
Pipe 2	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	Inlet port 1 (copied)
Pipe 3	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	Inlet port 1 (copied)
Pipe 5	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	Inlet port 1 (copied)
Pipe 7	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	Inlet port 1 (copied)
Pipe 9	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	Inlet port 1 (copied)
Pipe 11	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	Inlet port 1 (copied)

Exhaust Pipes (Ports) Data:

	Length (mm)	Diameter (mm)	No. of Meshes	Wall Thickness (mm)	Cooling Type	Wall Material	Wall Factor	Label
Pipe 1	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	exhaust port 1 (copied)
Pipe 4	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	exhaust port 1 (copied)
Pipe 6	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	exhaust port 1 (copied)
Pipe 8	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	exhaust port 1 (copied)
Pipe 10	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	exhaust port 1 (copied)
Pipe 12	0.000 250.000	36.000 36.000	20	1.00	Water Cooled	Aluminium	Def Surface Roughness (mm)	exhaust port 1 (copied)

Figure 7: Figure 6: Intake and Exhaust Pipe Data

For calculations, I created 8 test points from 800 to 7800 that increase by 1000. Also, I set following parameters as shown.

Steady State Test Data - Summary

Test Points | Heat - Phase | Heat - Period | Heat - Two-Zone | Fuelling | Boundary Conditions | Friction | Solution | Plotting | Actuators

Test Point	Speed (rpm)	Combustion Option	Combustion Efficiency (0-1)	Maldistribution Factor	Fuelling Option	Cylinder Data	Cylinder No.	Trapped Air Fuel Ratio
1	800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743
2	1800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743
3	2800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743
4	3800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743
5	4800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743
6	5800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743
7	6800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743
8	7800	Efficiency + Maldistribution	1.0000	0.0100	Trapped Air Fuel Ratio	Common	All	13.743

Figure 8: Test Points

Steady State Test Data - Summary

Test Points | Heat - Phase | Heat - Period | Heat - Two-Zone | Fuelling | Boundary Conditions | Friction | Solution | Plotting | Actuators

Test Point	Speed (rpm)	Humidity Option	Specific Humidity (kg/kg)	Relative Humidity (0-1)	Ambient Air Pressure (bar-abs)	Ambient Air Temperature (C)	Inlet No.	Inlet Boundary Pressure (bar-abs)	Inlet Boundary Temperature (C)	Exit No.	Exit Boundary Pressure (bar-abs)	Exit Temp Initialisation
1	800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO
2	1800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO
3	2800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO
4	3800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO
5	4800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO
6	5800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO
7	6800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO
8	7800	Specific Humidity (kg/kg)	0.0130000	0.8745018	1.00000	20.00	1	1.00000	20.00	1	1.10000	Use Cyl 1 at EVO

Figure 9: Boundary Conditions

For combustion modelling, single wiebe function with parameters of 10 and 2 is used to predict burning rate and Annand heat release model with parameters of 0.2 and 0.8 is used to calculate convective and radiative heat transfer coefficients.

RESULTS

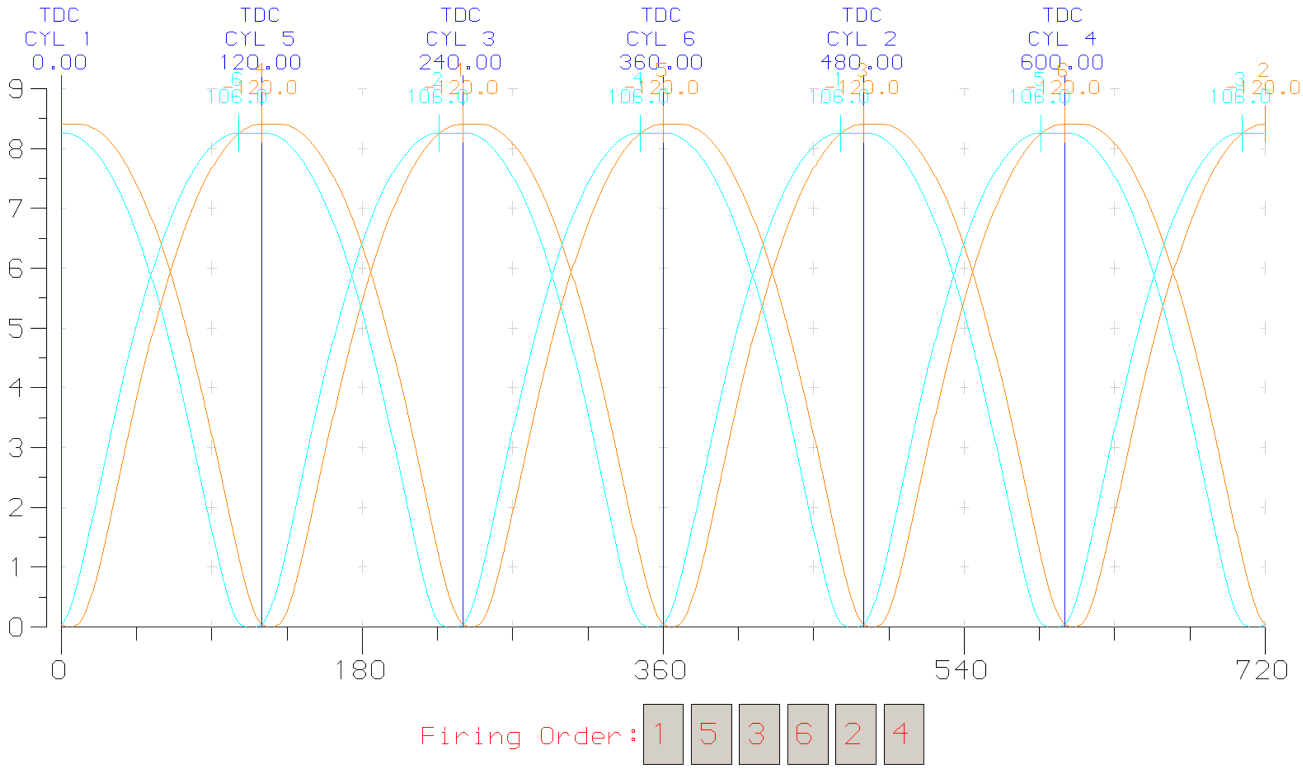

Figure 10: Valve Timings

Firing order of cylinders is 1-5-3-6-2-4 as we can see from Figure-10.

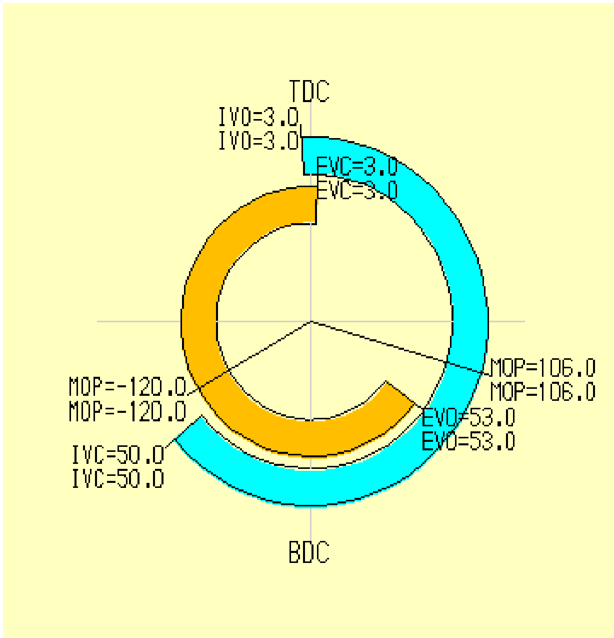

Figure 11: Valve Timing Diagram

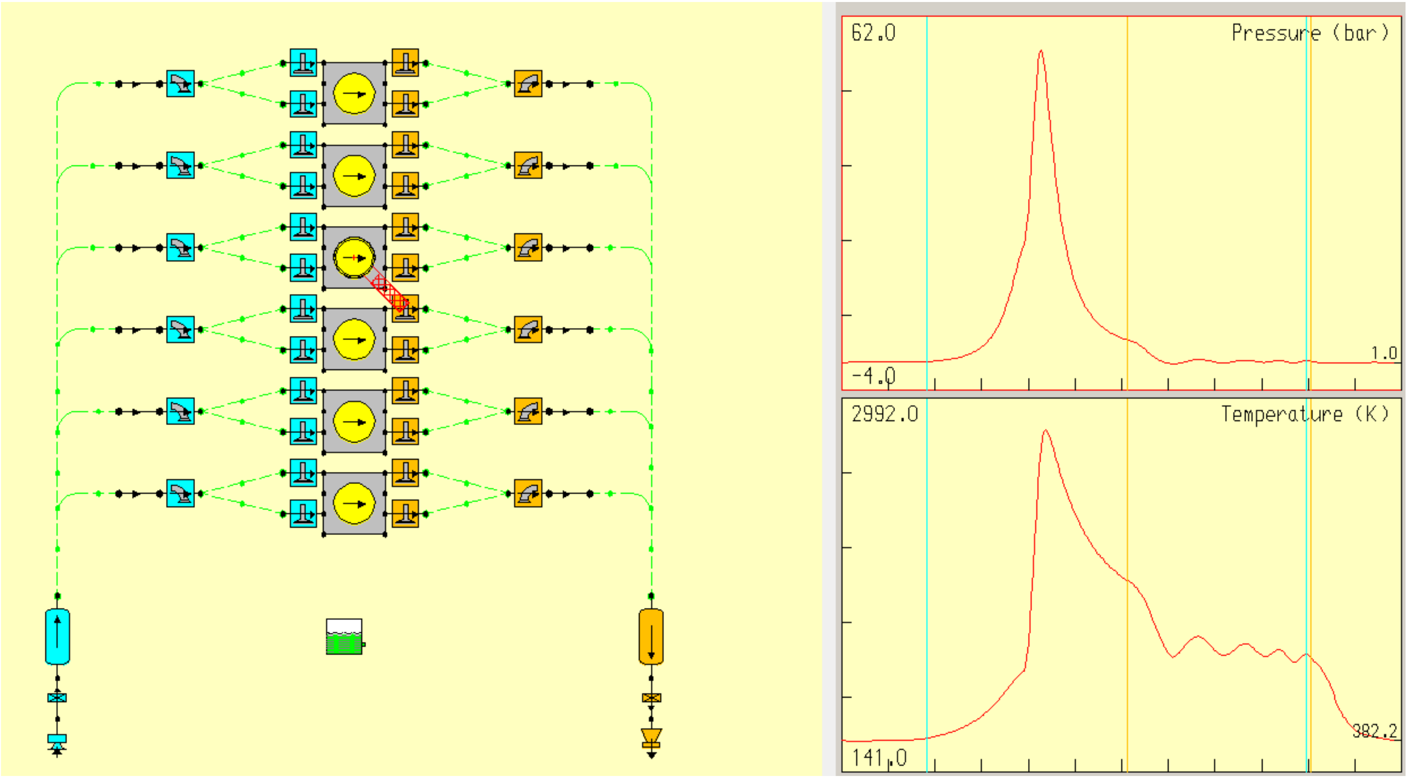

Figure 12:Pressure and Temperature vs CA for 3rd Cylinder at 2800 rpm

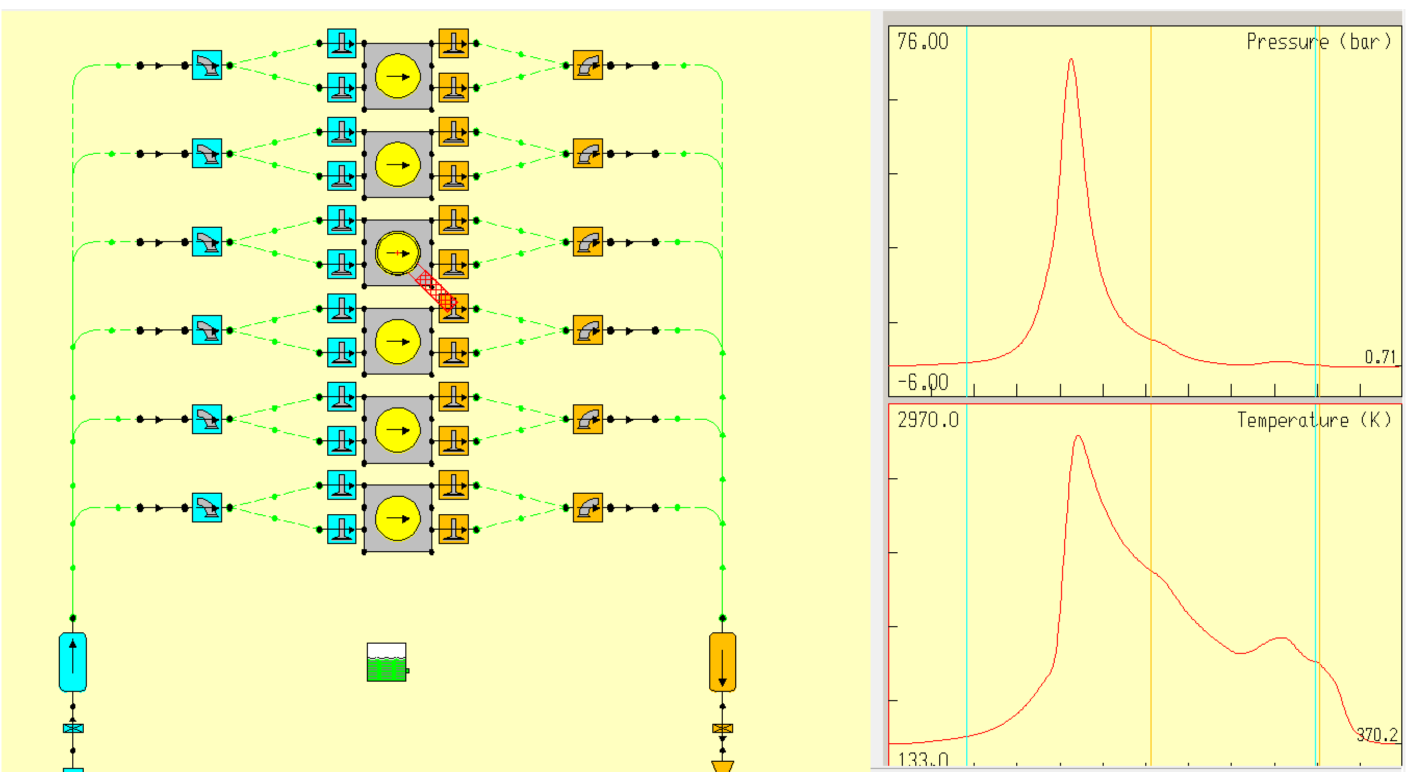

Figure 13: Pressure and Temperature vs CA for 3rd Cylinder at 6800 rpm

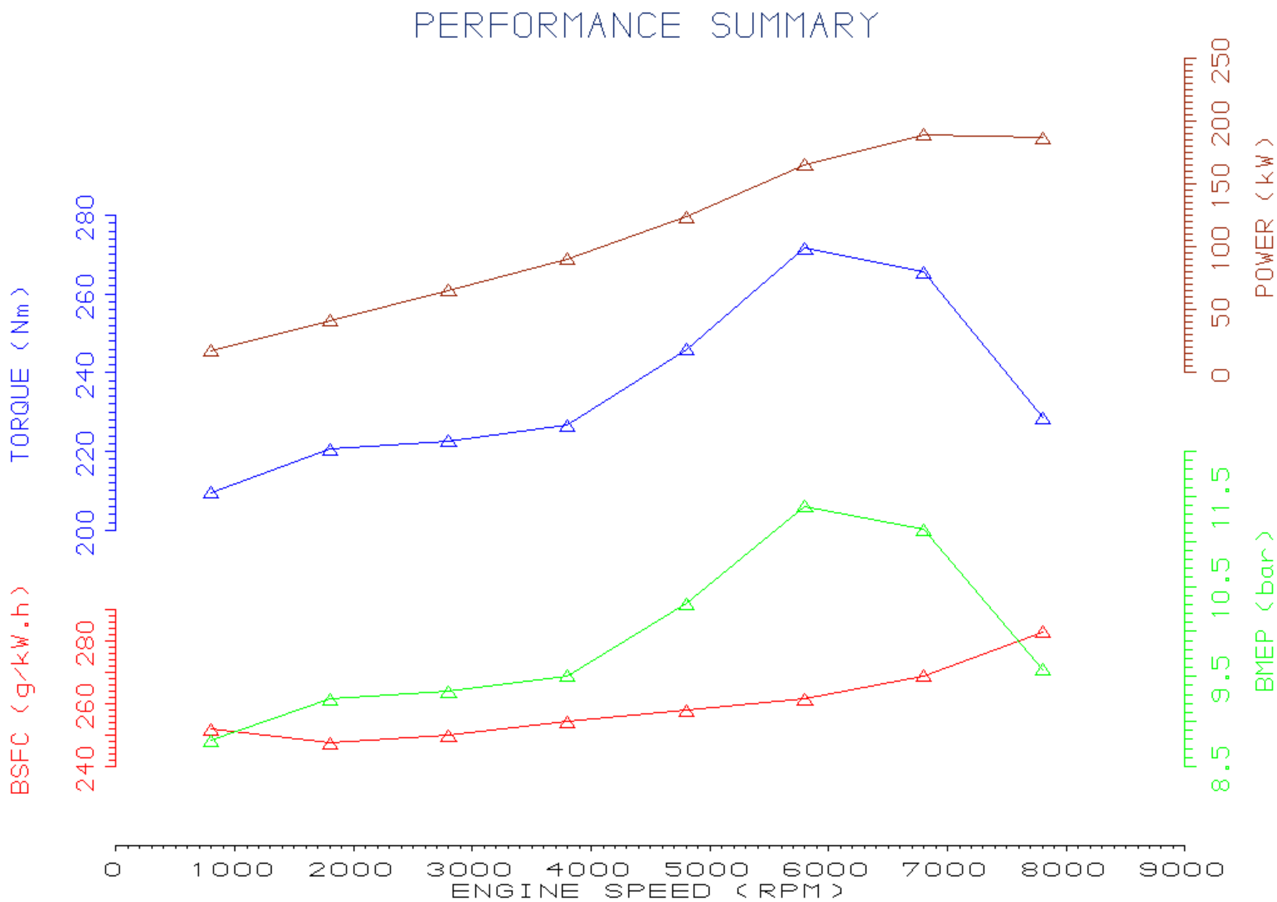

Figure 14: Simulated Performance Curves of 2JZ engine

REFERENCES

1. https://www.engine-specs.net/toyota/2jz-gte.html
2. https://australiancar.reviews/2jz-ge-toyota-engine/
3. https://lotusproactive.wordpress.com/wp-content/uploads/2013/08/getting-started-with-lotus-engine-simulation.pdf