Cooling System Simulation for New Tractor Engine Platform

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Objective:

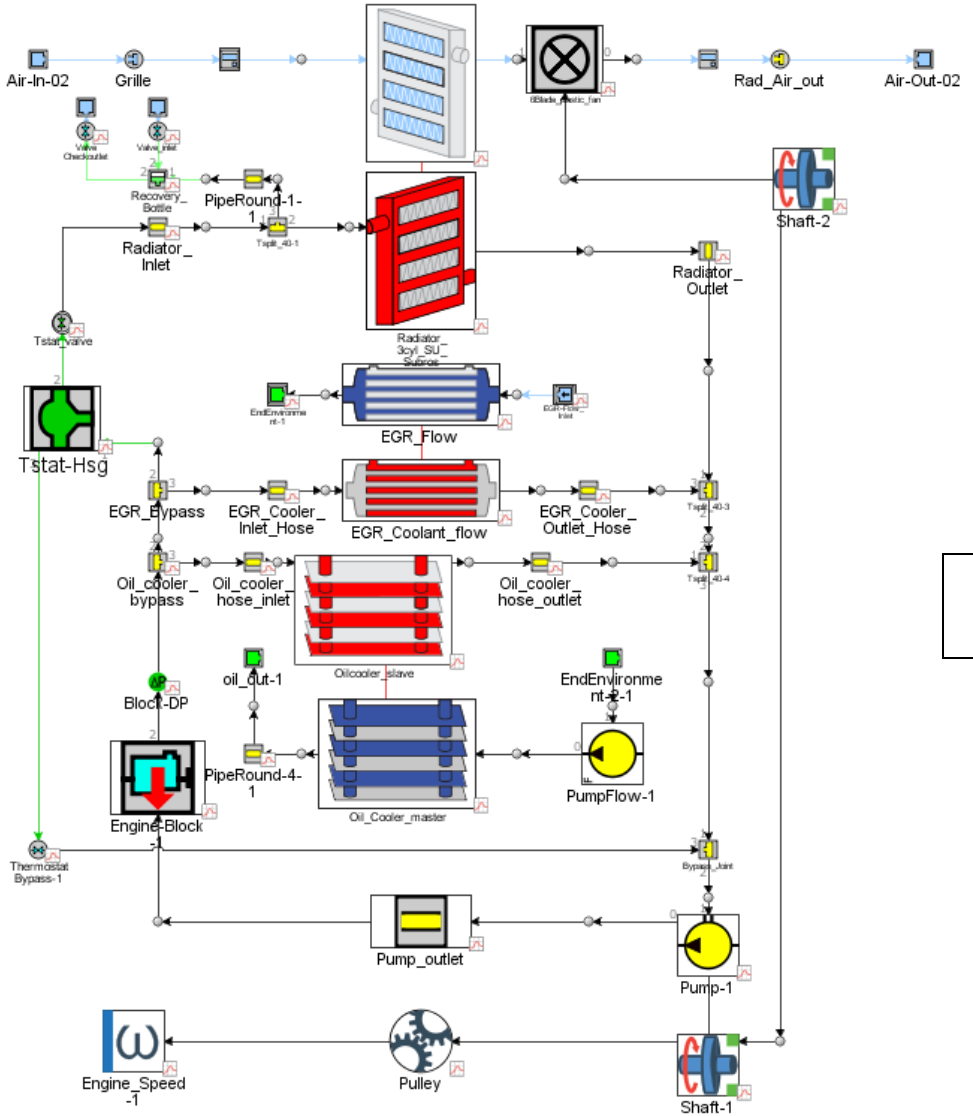
For a New Tractor Engine Platform which contains Engines from 32HP to 70HP the following parameters are to be predicted

- Water Pump flow rate
- Engine Water Outlet temperature
- EGR Cooler Heat transfer
- Oil cooler Heat Transfer

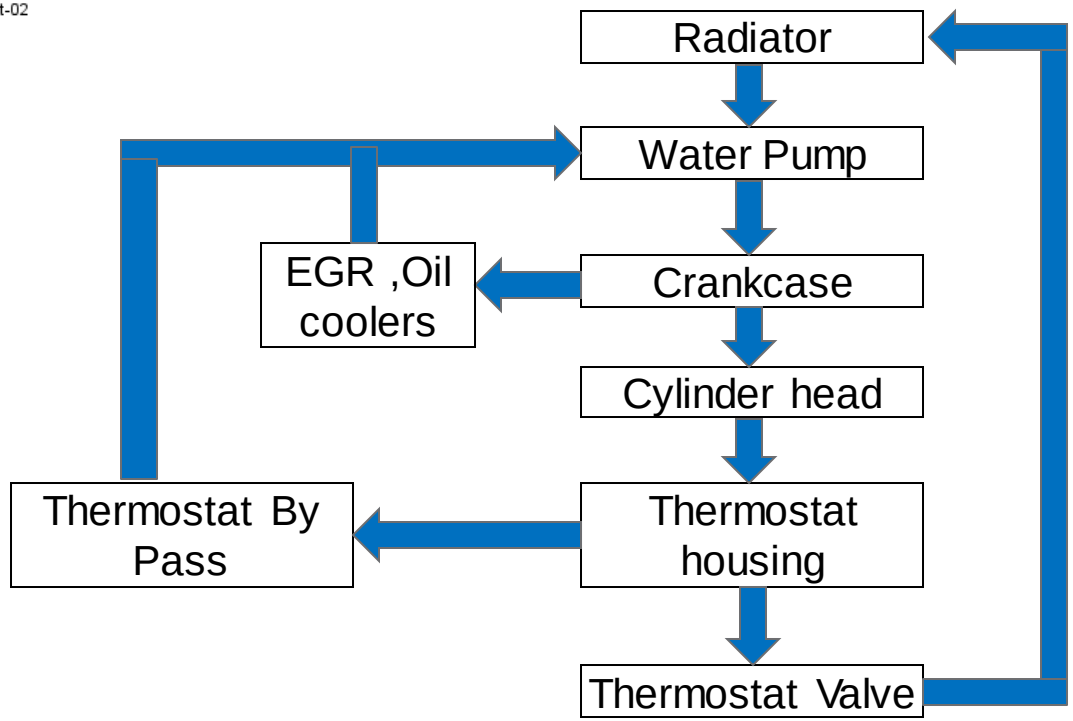
Introduction:

- Optimization of Cooling system is a challenging task in Tractor particularly when the Engine Platform is entirely new
- Cooling system analysis using GT suite was used to finalize the Radiator, Water pump, Drive pulley diameter and Fan
- Water pump flow rate and Engine water inlet and outlet temperatures are predicted at High ambient (45Deg C) for Engine power range from 32HP to 70HP
- EGR Cooler and Oil cooler Heat transfer capacity and Coolant flow rates through them were also predicted.

GT Model

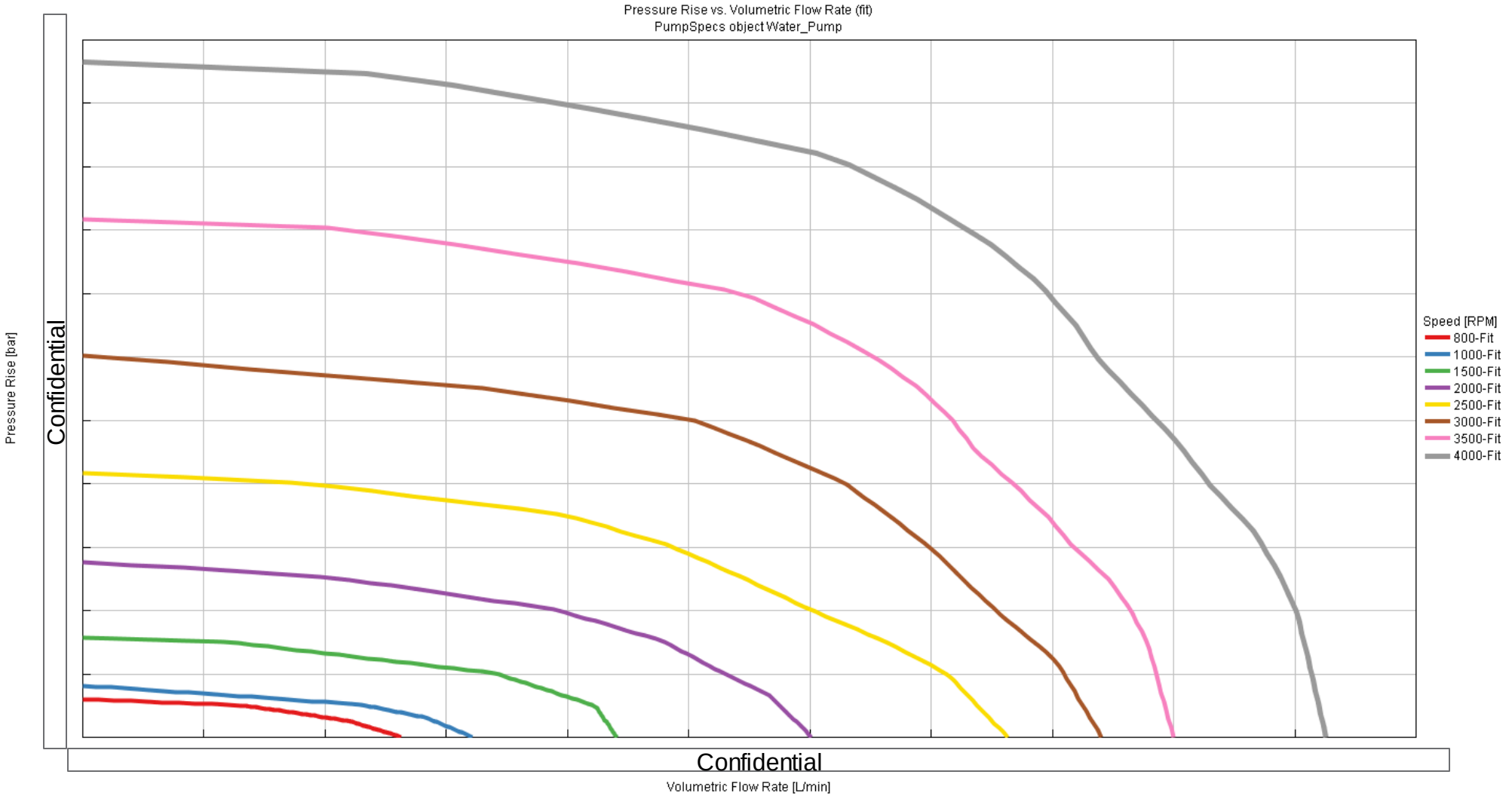


Flow Diagram



Input Parameters

Water Pump Flow rate



Water Pump Test rig data

Input Parameters Radiator, EGR Cooler , Oil cooler

Reference Conditions | Data | Output | Advanced

Attribute	Unit	Object Value
Type of Performance Input		heat-rate
Main (Internal) Flow Rate Input		Volume_Flow_Rate
Secondary (External) Flow Rate Input		Volume_Flow_Rate

Attri...	Main Volume Flow Rate	Main Inlet Temperature	Main Inlet Pressure (static)	Main Outlet Pressure (static)	Secondary Volume Flow Rate	Secondary Inlet Temperature	Secondary Inlet Pressure (static)	Secondary Outlet Pressure (static)	Heat Transfer Rate

Test data provided by supplier

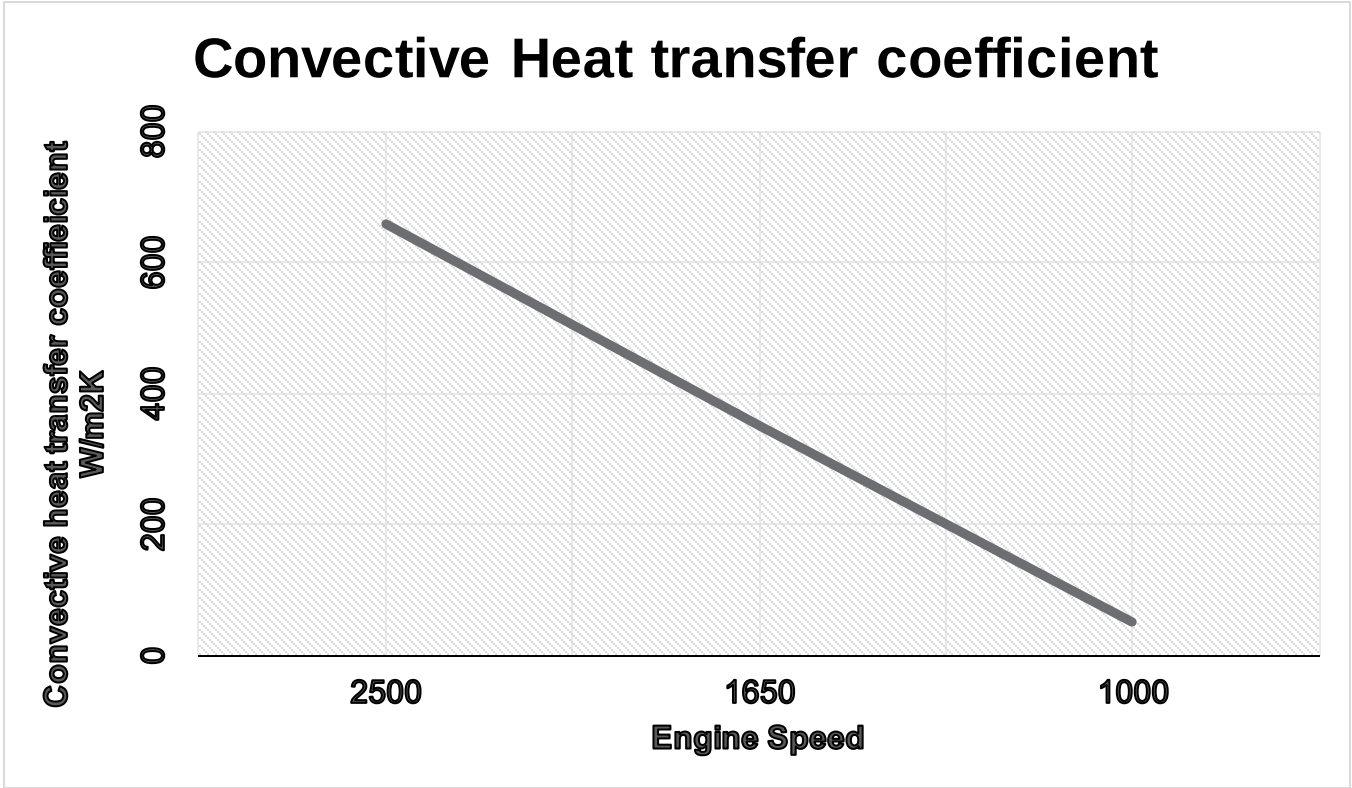
Input Parameters

Convective Heat transfer coefficient Values

Convective Heat Transfer co efficient Values of Engine Block can have major impact on the results
This Value also depends on the restriction to the Fan air flow . For Initial analysis the benchmark values of similar Engines can be used .
The calibrated model for 40HP Engine Model is used for all other models in this Analysis .

Main | Fluid | Ext. Convection | GT-POST Output | Plots

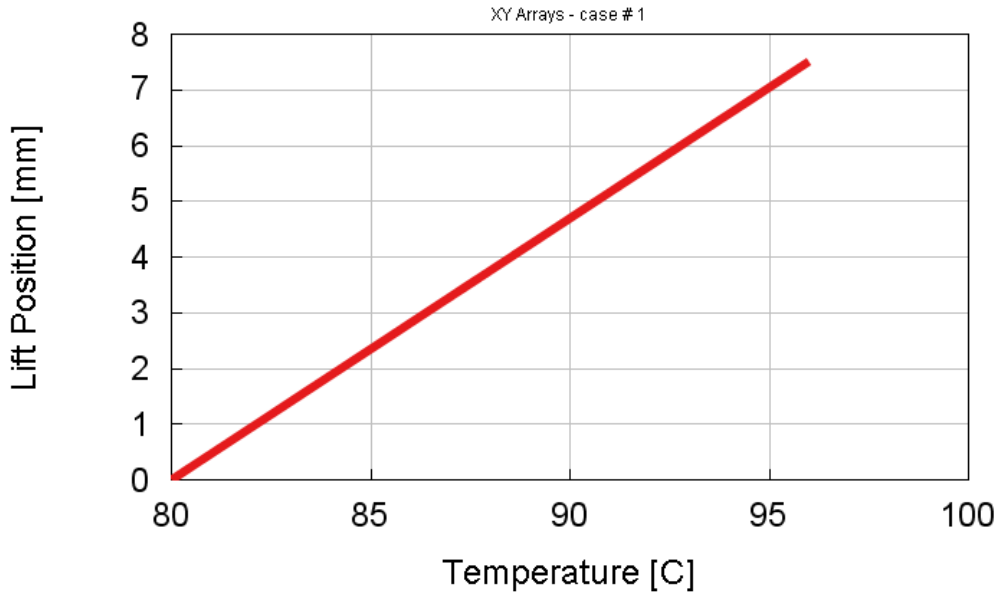
Attribute	Unit	Object Value
Temperature for External Convection to Ambient	See Case S...	[AMBIENT_TEMP]
Convective Heat Transfer Coefficient to Ambient	See Case S...	[convective_heat_coeff]
Area for External Convection to Ambient	mm^2	549492
Block Average Thickness	mm	5



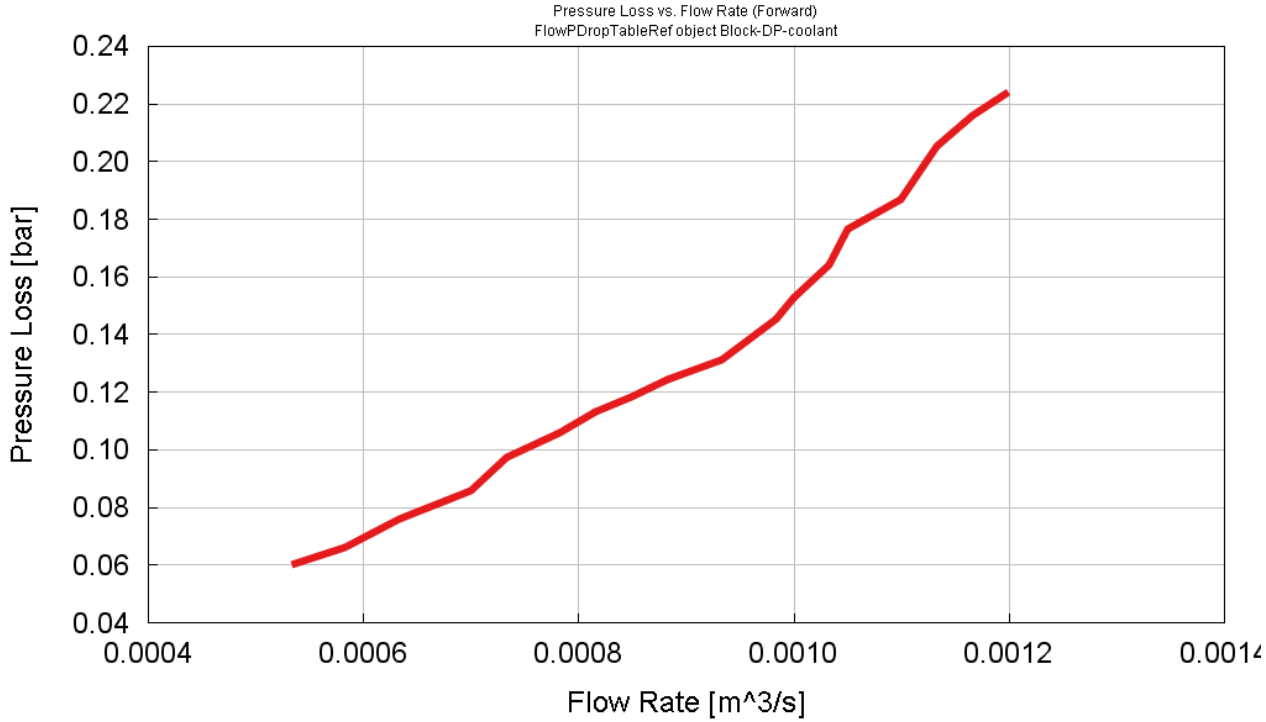
Input Parameters

Other Input

Thermostat Valve Opening VS Temperature



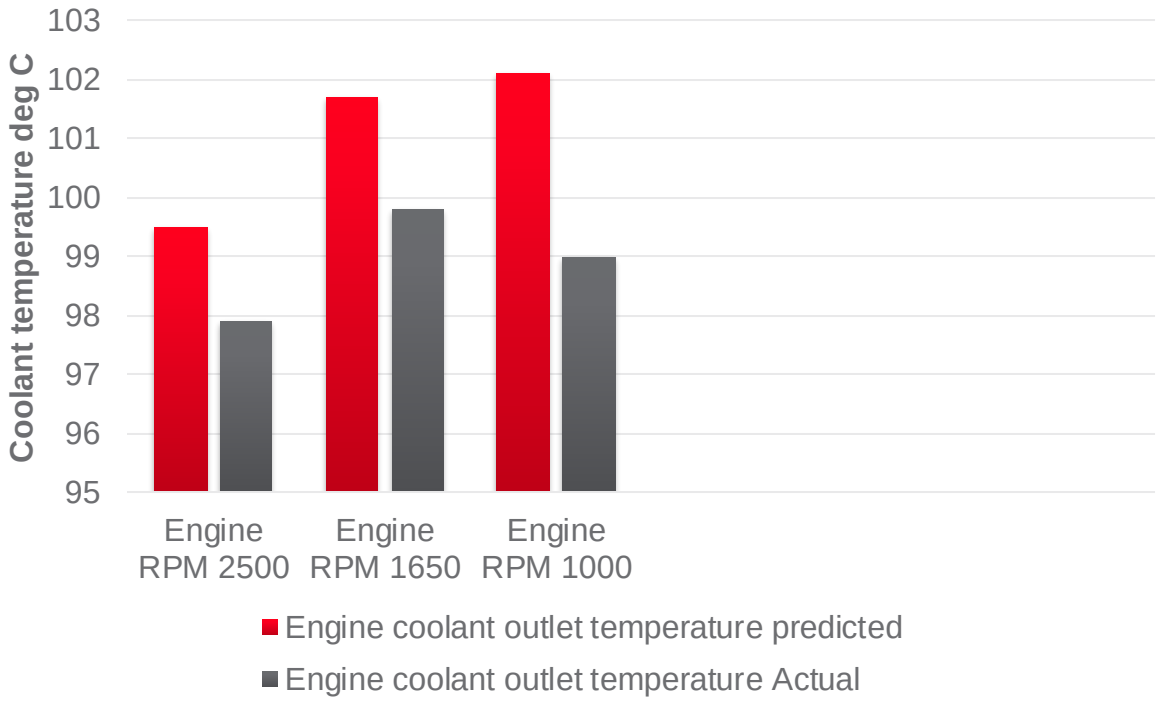
Crankcase Back pressure vs Flow Rate

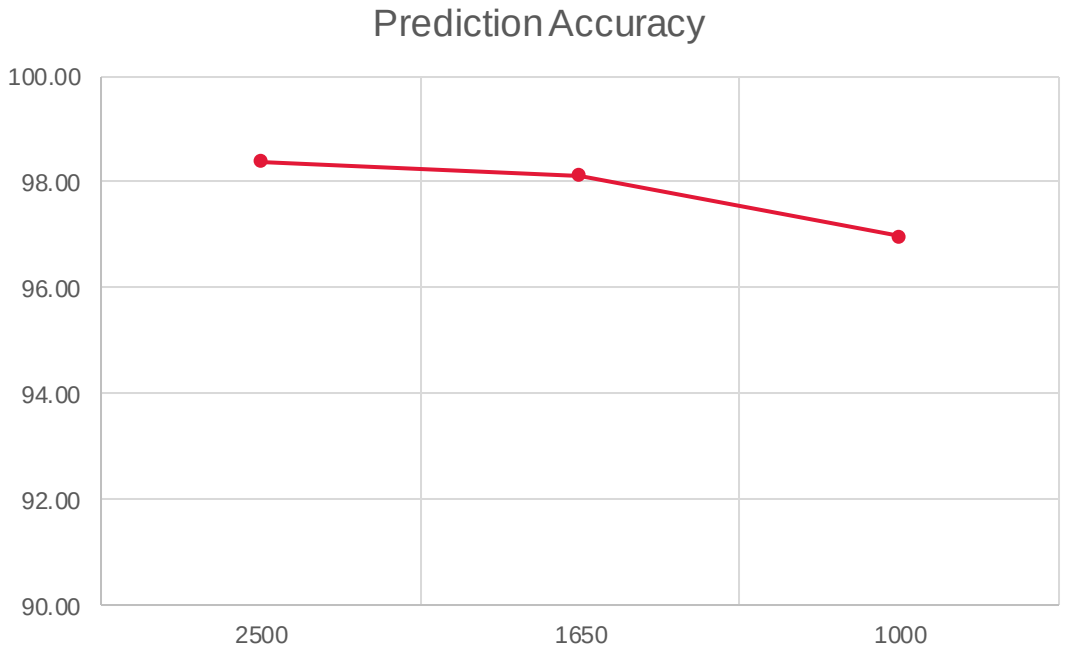


Crankcase Restriction vs Flow is measured data in the Engine

Simulation Results 32-40HP

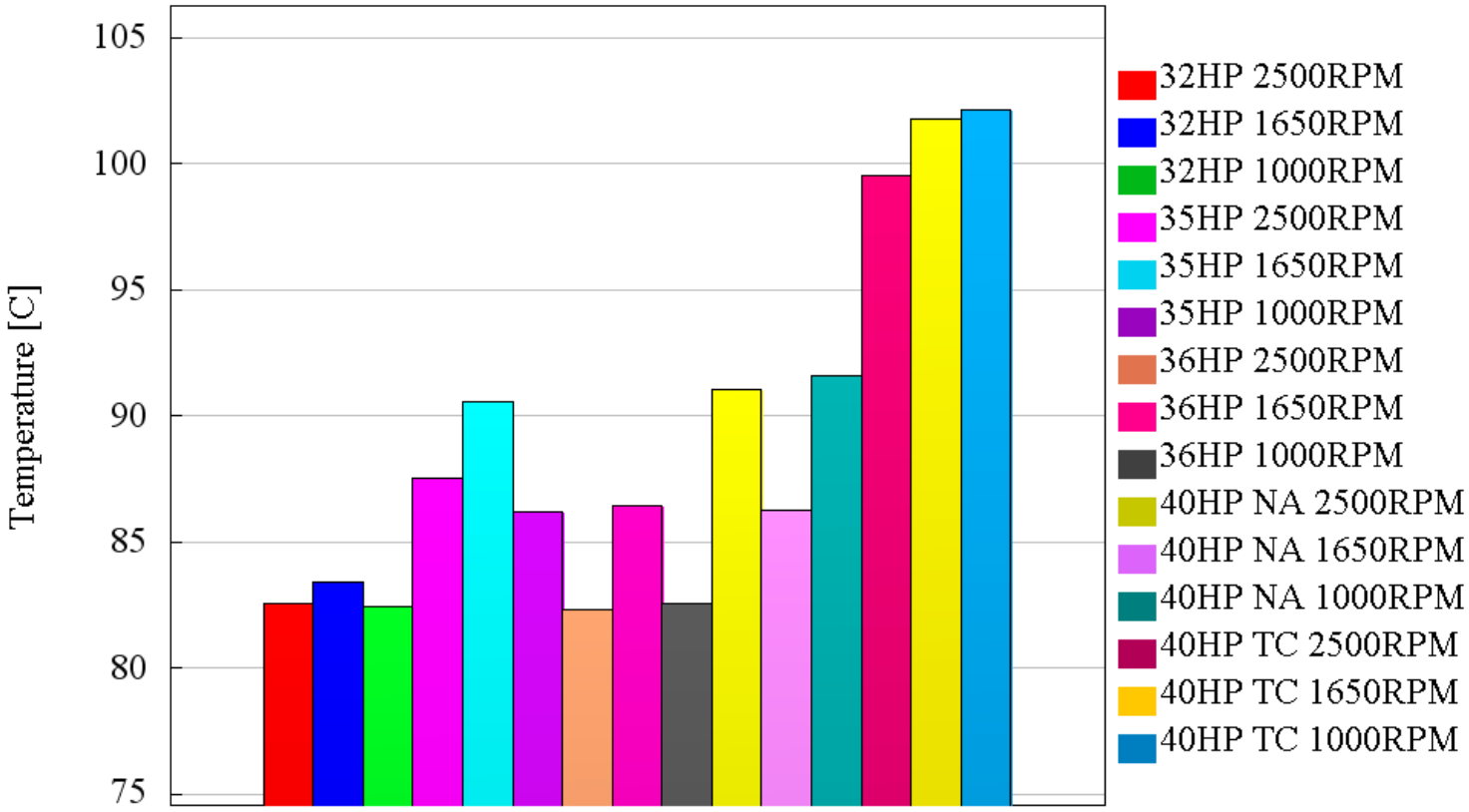
Engine coolant Outlet Temperature 40HP Predicted vs Measured





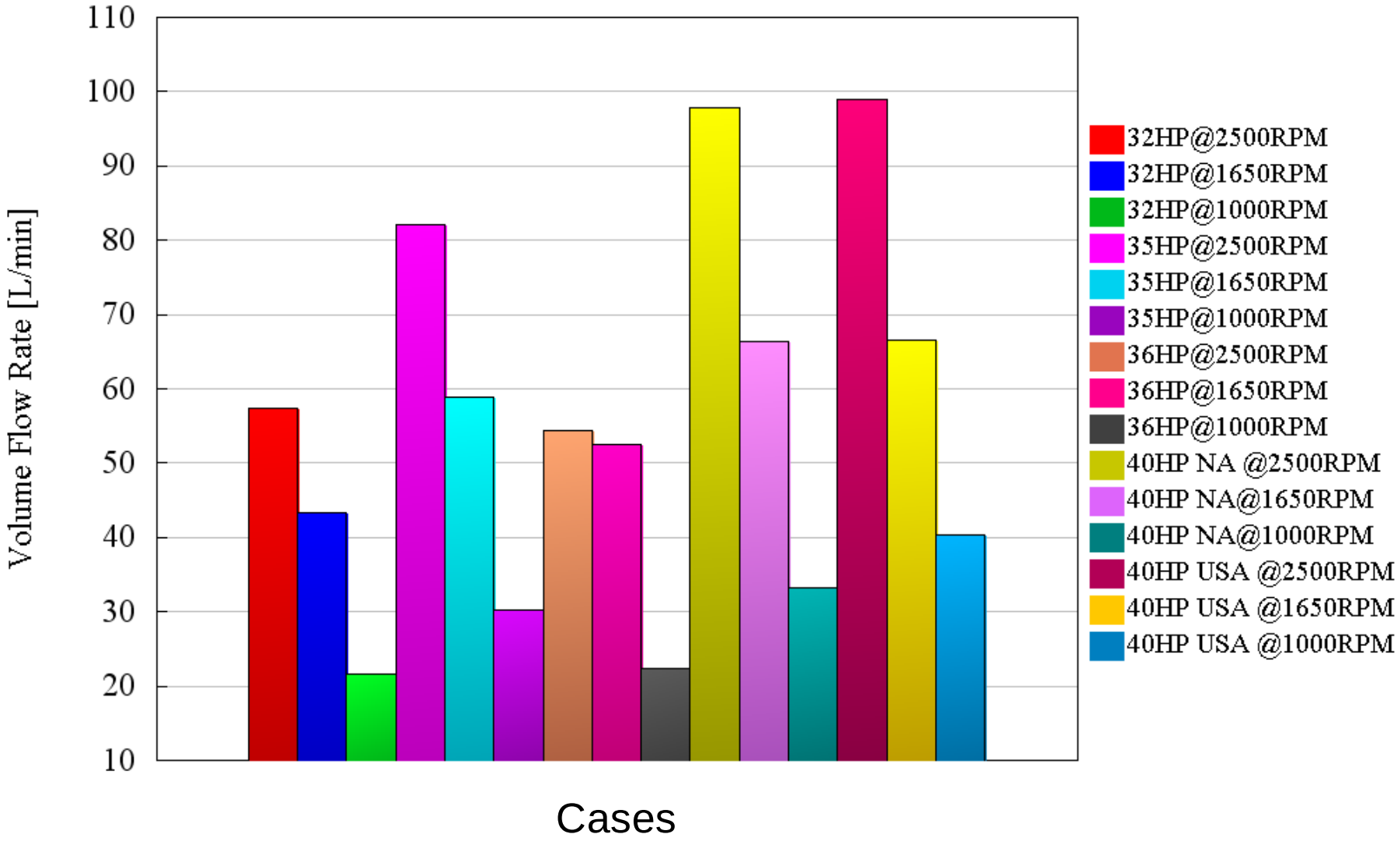
Simulation Results 32-40HP

Engine coolant Outlet Temperature

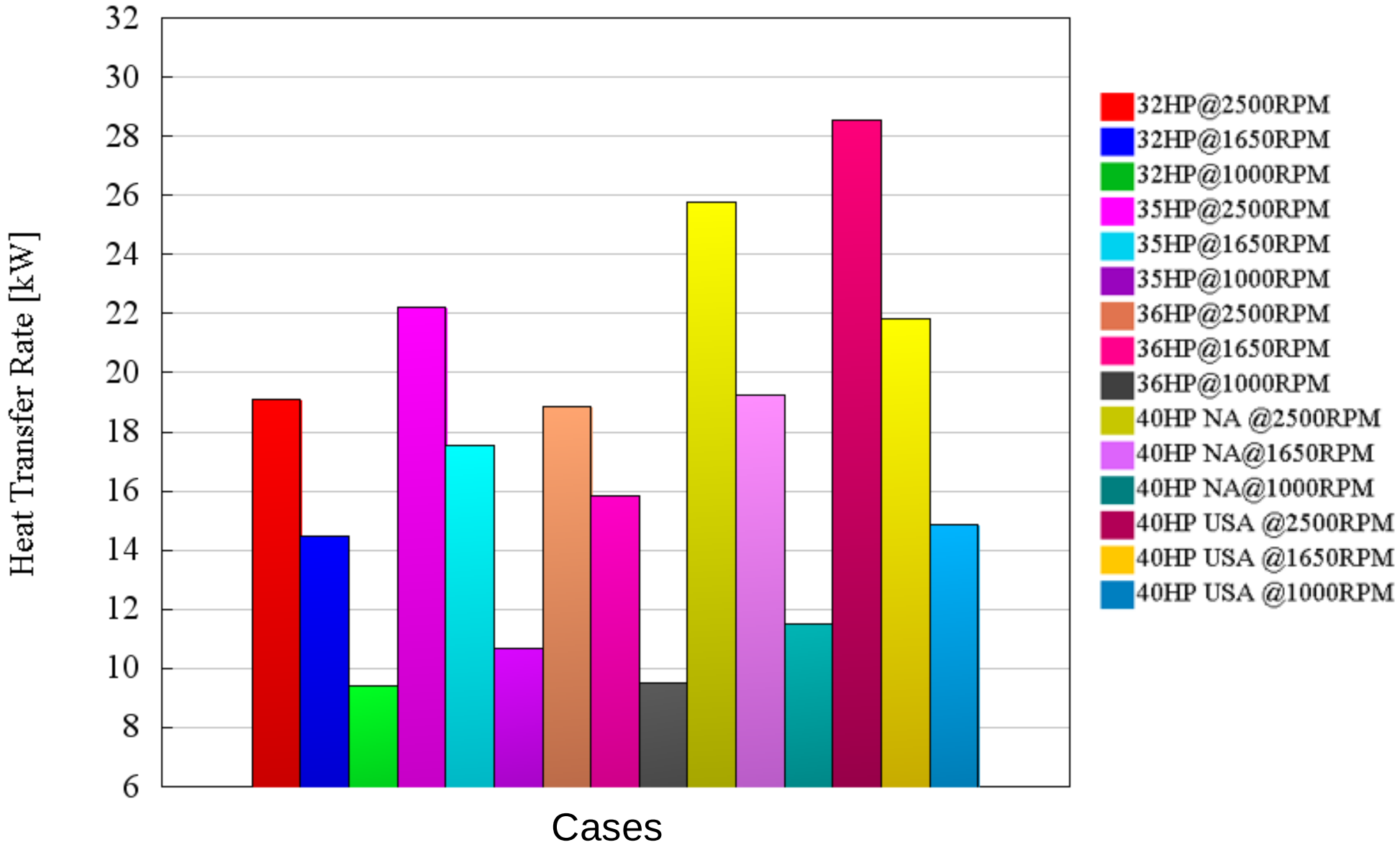


Simulation Results 32-40HP

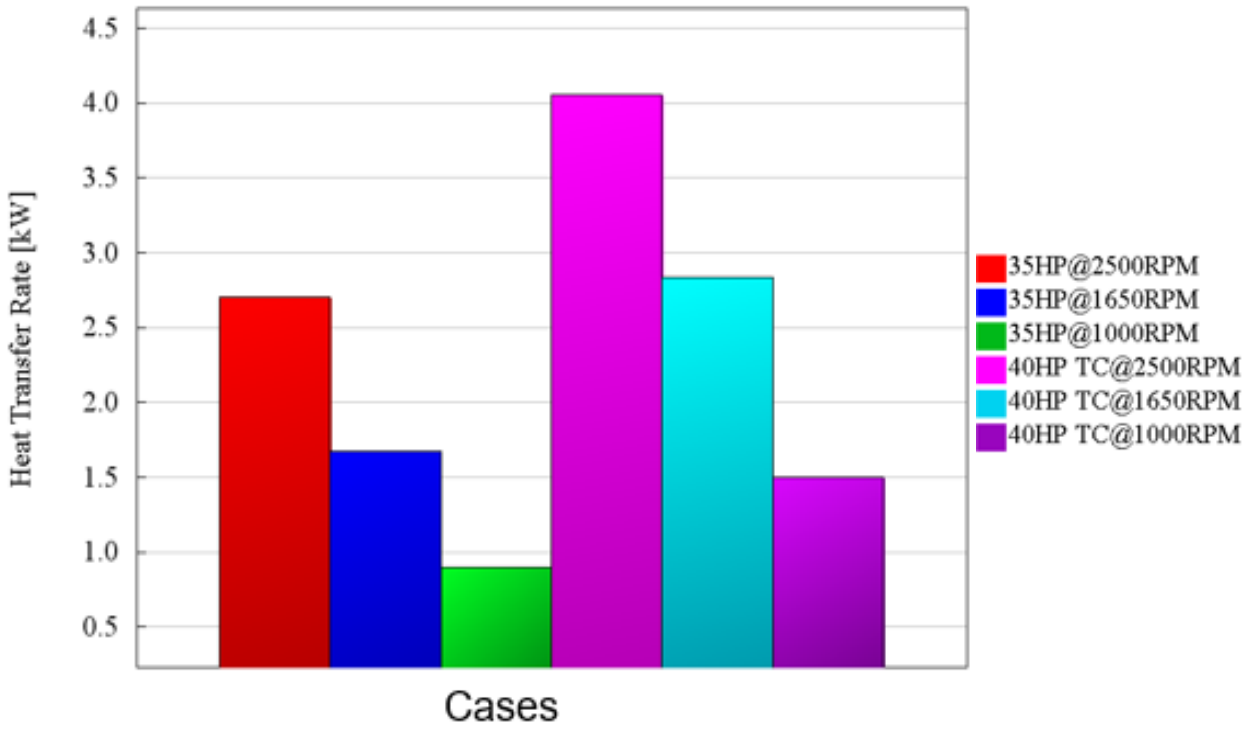
Coolant flow rate through radiator LPM



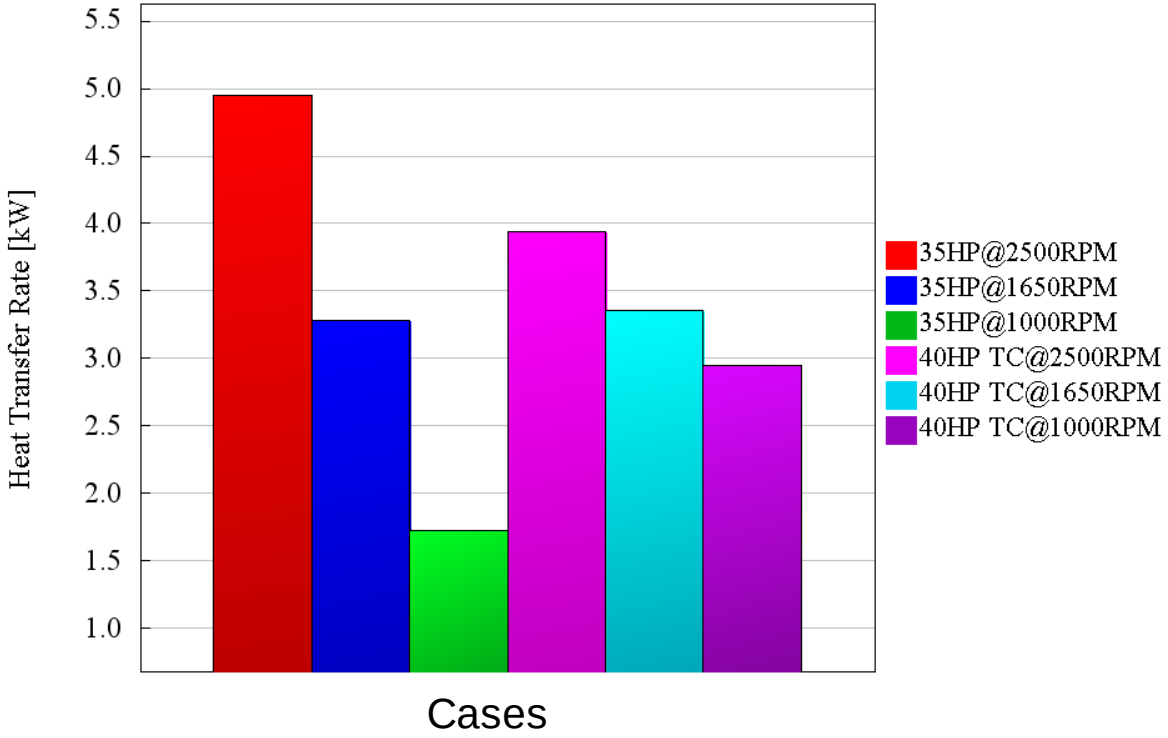
Simulation Results 32-40HP
Heat Transferred by Radiator



Simulation Results 32-40HP
Heat Transferred by EGR Cooler & Oil Cooler



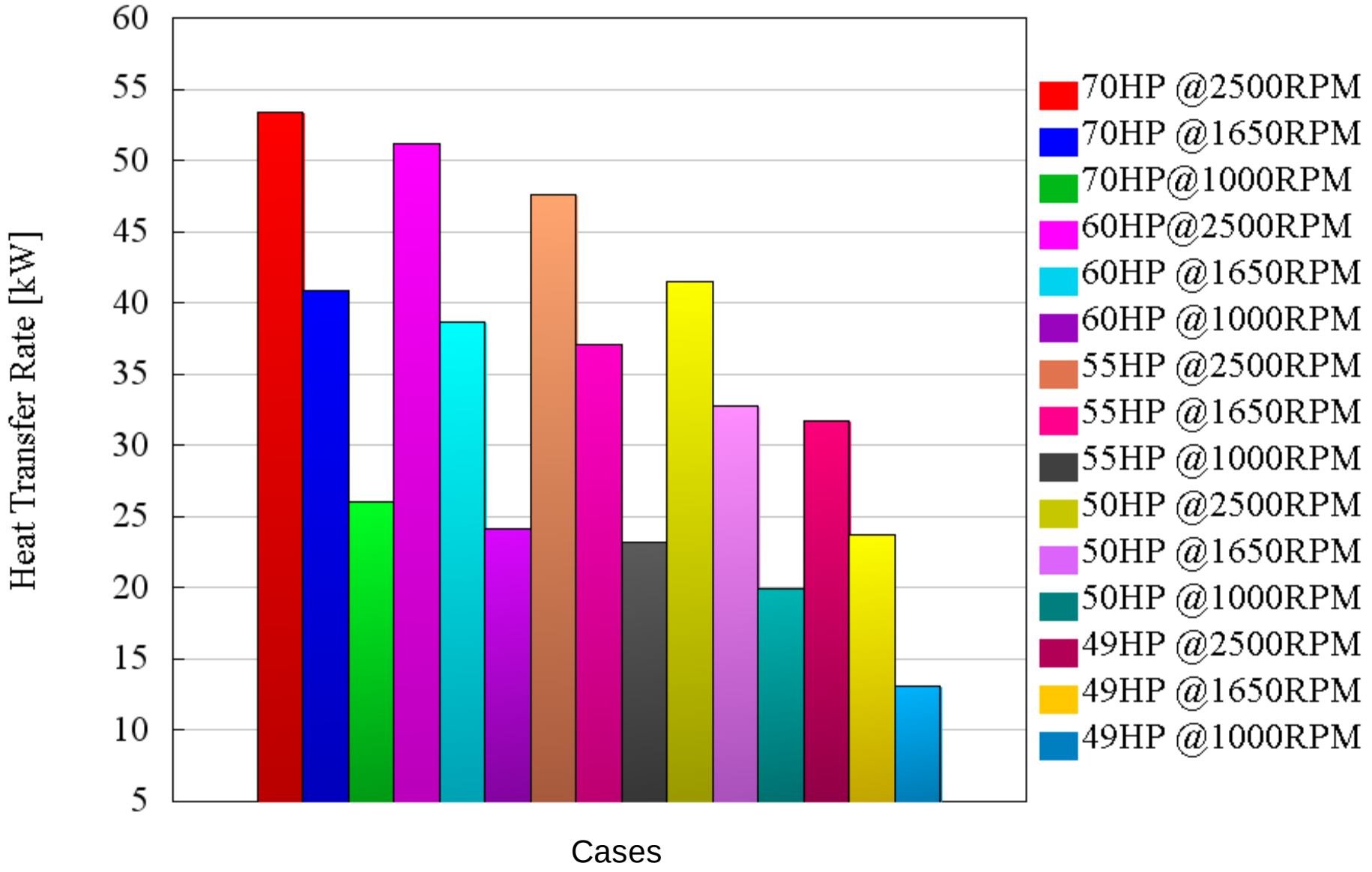
EGR Cooler Heat Transfer



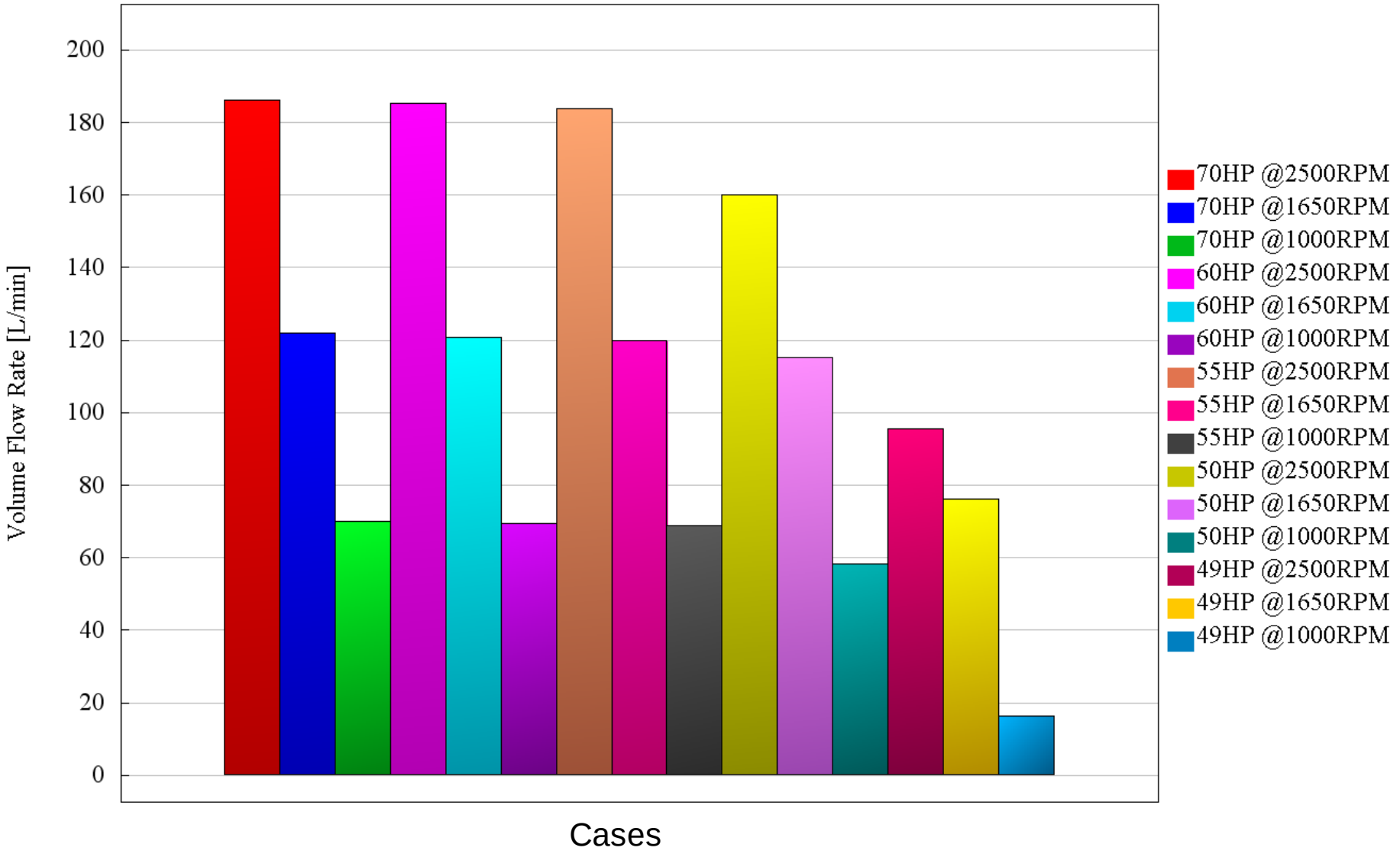
Oil Cooler Heat Transfer

EGR Cooler and Oil cooler Heat transfer varies from ~1KW to 5KW over the Engine Operation

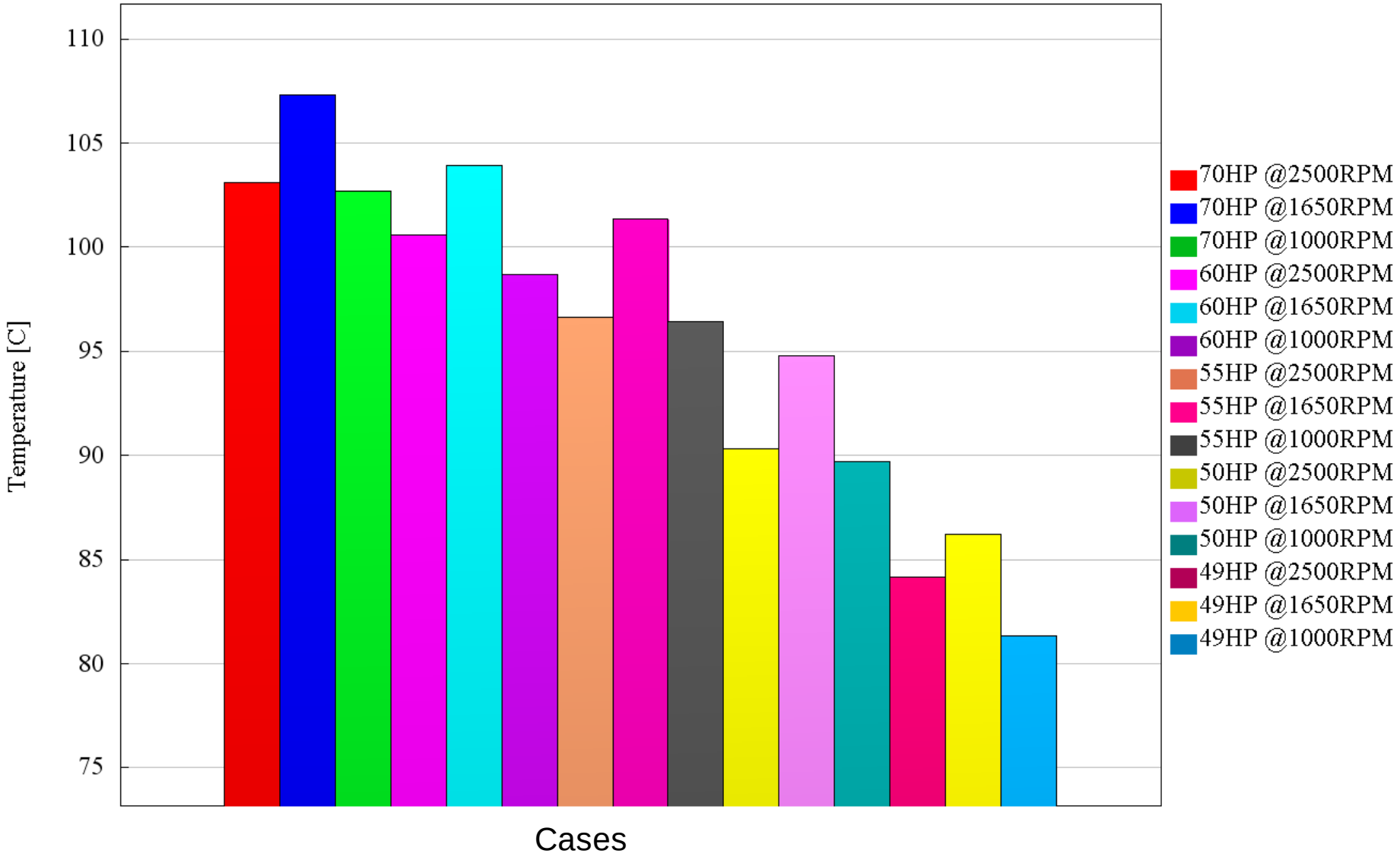
Simulation Results 4 Cylinder 49-70HP
Heat Transferred by Radiator



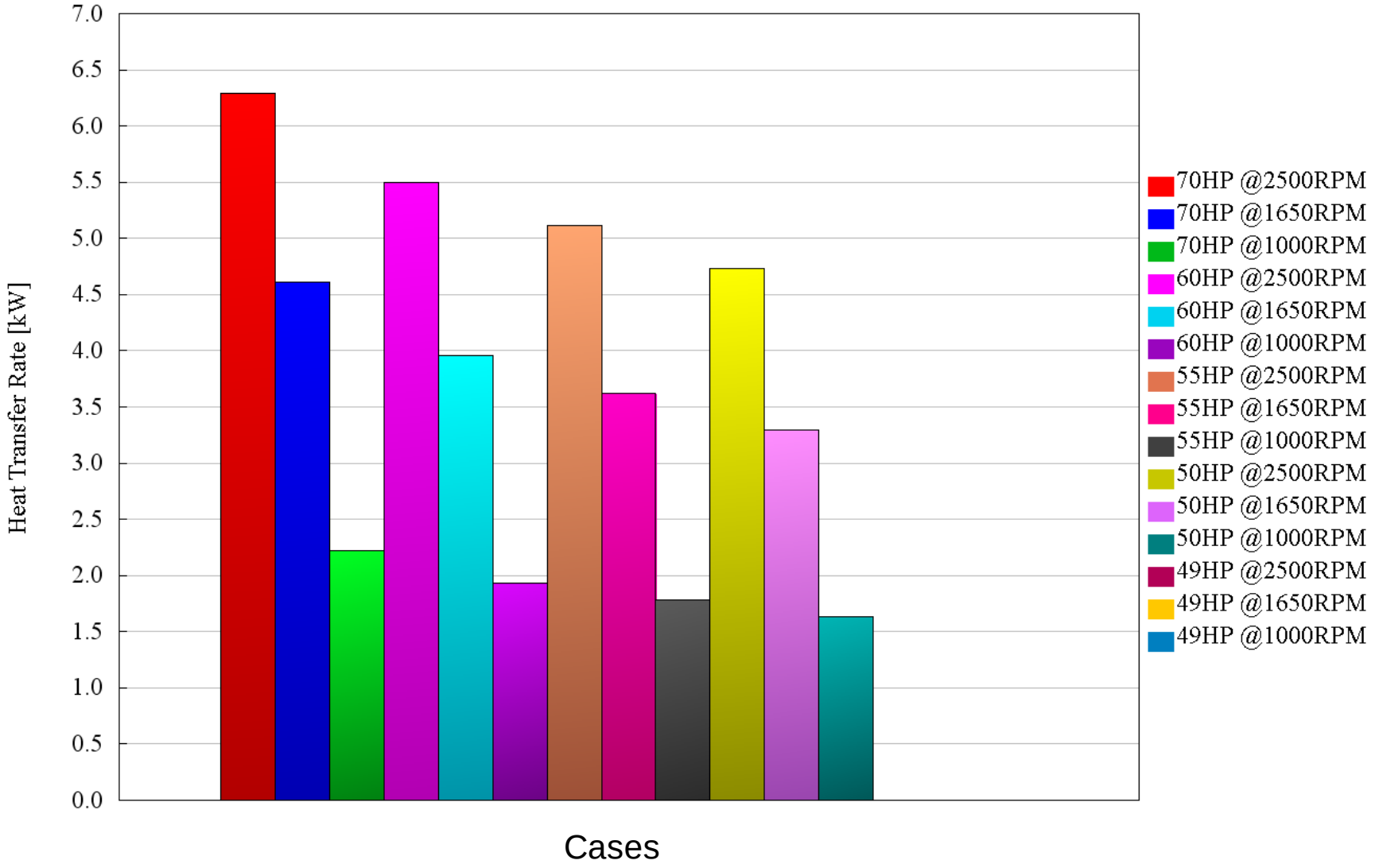
Simulation Results 4 Cylinder 49-70HP
Coolant Flow through Radiator



Simulation Results 4 Cylinder 49-70HP
Water Outlet Temperature from Engine



Simulation Results 4 Cylinder 49-70HP
EGR Cooler Heat Transfer



Simulation Results 32-70HP

Water Pump and Fan Speed ratio

Engine Power	Number of cylinder	Drive Speed ratio
70HP	4	Confidential
60HP	4	
55HP	4	
50HP	4	
49HP	4	
32HP	3	
35HP	3	
36HP	3	
40HP NA India	3	
40HP USA	3	

Drive speed Ratio of water pump and varies from 1-1.4 .
The speed ratio for each model is optimised using GT-Suite

Conclusion

- The accuracy of the simulation predicted coolant temperature with respect to the actual measurement is ~98%
- The Radiator and fan selected are meeting the cooling system requirements for all the conditions thereby minimising testing
- The 1D simulation output was used as a input in 3D simulation of crankcase & cylinder head cooling jackets which improved the quality of 3D simulation output
- As the fan , Radiator and Water pump drive pulley ratios are finalised in the simulation there was no further optimisation trials in the test lab . The simulation has reduced the timeline ~30days for all models

Acknowledgements

I would like to thank Mr. T. Senthil and Mr. Ramwarun for reviewing the simulation and providing prominent feedback

Thank You