A Genetic Algorithm Assisted Model of a Scaled-up Ammonia-Diesel Dual-fuel Compression Ignition Engine

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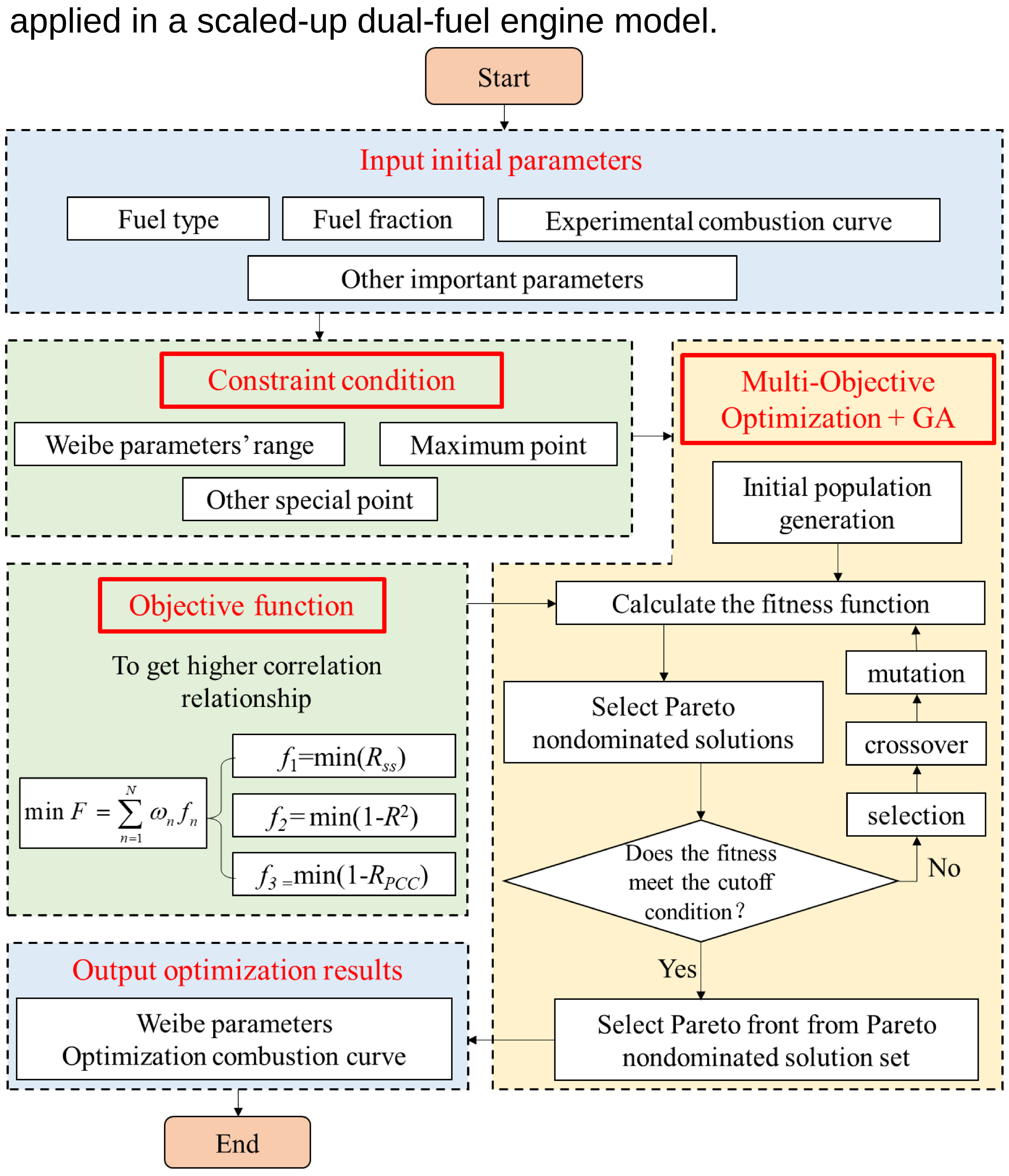
MariNH3
Clean, green ammonia engines for maritime

UNIVERSITY OF BIRMINGHAM

Introduction

Ammonia (NH3) shows promising potential as a marine fuel in both retrofitted conventional engines and disruptive novel-cycle engines. However, significant uncertainties persist regarding the lack of credible experimental results for a validated model of MW-scale engines commonly used in the maritime sector. Research is required to address the challenges through an innovative approach. In the current study, through employing the multi-objective optimization approach based on Genetic Algorithm, a parameterization method has been developed to extract combustion profiles of an ammonia-diesel Compression Ignition small engine before the combustion characteristics applied in a scaled-up dual-fuel engine model.



Experiment

- ***Combustion characterization on a small engine***

The small engine experiment is used to obtain the combustion characteristics of ammonia and diesel. The engine operation conditions including various the fuel ratio of ammonia and the injection timings for both fuel are measured.

Engine	Compression Ignition (CI) Direct Injection (DI)
Number of cylinders	1
Number of strokes	4
Bore (mm)	80
Stroke (mm)	69
Con-rod length (mm)	105.5
Compression ratio	17.5
TDC clearance height (mm)	0.5
Crank radius (mm)	34.5
Displaced volume (L)	0.3468
Speed (rpm)	1500

Verification and Optimization

- **Verification of the parameterization method**

Figure 1 shows the results related to pure diesel conditions, verifying the accuracy of the parameterization method. The pre-mixing, main and trail combustion phases are characterized in a triple Wiebe function. The in-cylinder pressure errors are within 5%.

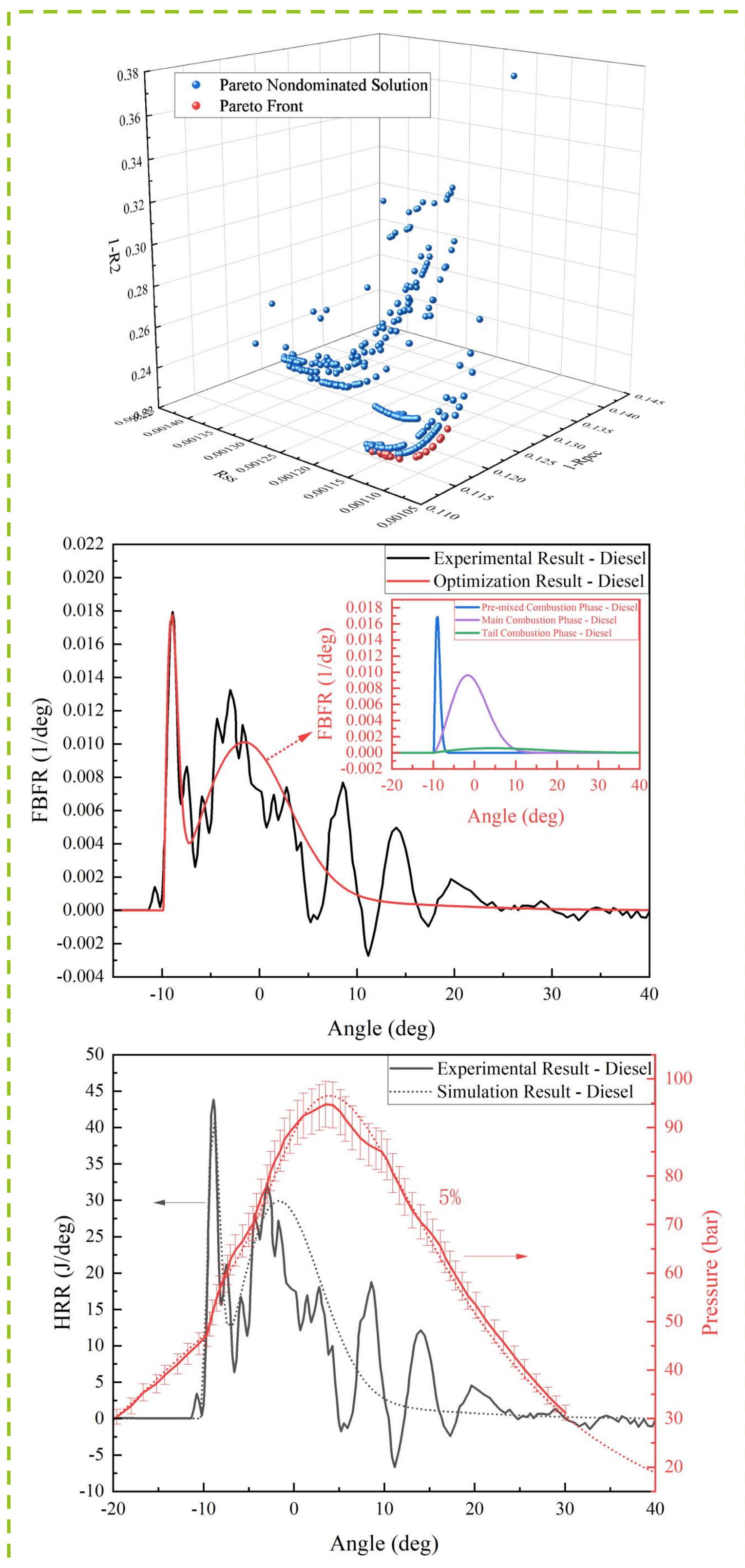


Figure 1

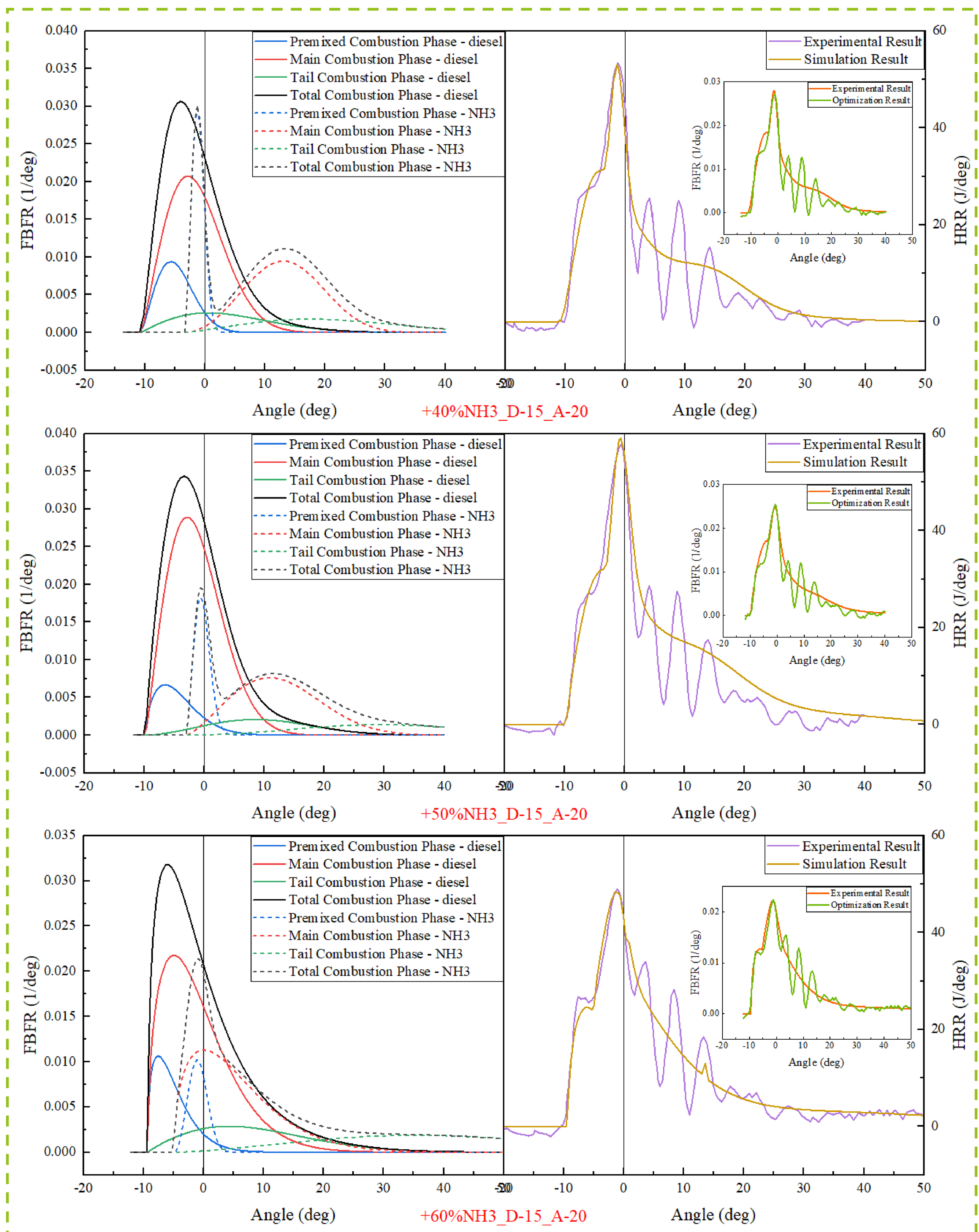


Figure 2

- **Application of the optimal method on dual fuel combustion**

Figure 2 shows with 60% NH3 addition (constant diesel amount), the HRR curve is wider and slightly lower than those of lower NH3 heat fractions, due to more liquid NH3 being present, requiring heat from the combustion for vaporization. In addition, it leads to obvious two stage combustion being observed before the peak of HRR.

Scaled-up Simulation

Based on the parameterization method derived dual fuel combustion characteristics, a scaled-up model of an MW-scale marine engine is built. The case engine specification and simulation results (Figure 3) are shown below. It indicates that increasing the heat fraction of NH3 in dual fuels leads to a significant decrease in temperature and pressure of the combustion in a large marine engine, which also exhibits the performance characteristics (such as power, speed) similar to the published results of smaller dual fuel engines.

Engine	Marine CI engine
Number of cylinders	16
Number of strokes	4
bore (mm)	159
stroke (mm)	159
con-rod length (mm)	289.6
compression ratio	13.9
Engine shape	V
Mixture type	Spray Guided (DI)
Engine speed (rpm)	1500
Firing order	1-9-3-11-2-10-5-12-8-16-6-14-7-15-4-13

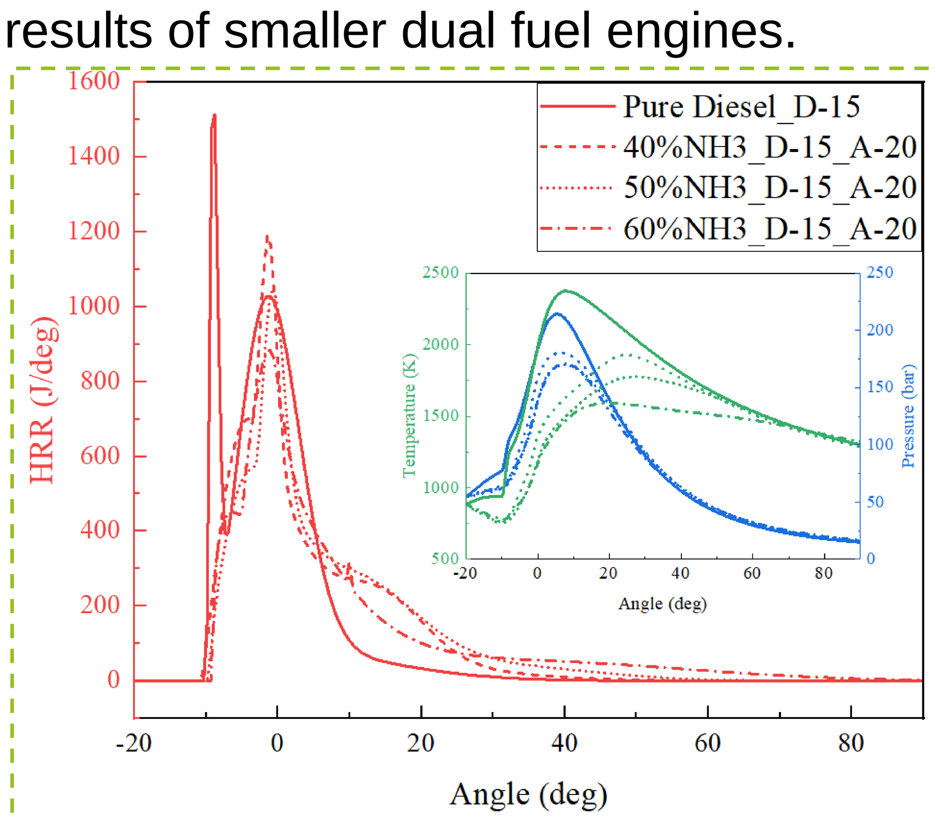


Figure 3

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