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Thesis Titel: OPTIMIZATION OF DUAL FUEL ENGINE UTILIZING FLEXIBLE VALVE TRAIN TECHNOLOGY

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Summary

In this study, a simulation model was developed for a dual fuel marine engine equipped with a flexible valve train strategy. The model aims to improve the engine performance and reduce its emissions through different valve timing. Two parts are included in this model, the first one is the flexible valve train model which was developed in MATLAB. It aims to predict the different valve timings taking into account the effect of the flexible camshaft technology (FCT) and the multisegment camshaft.

The second part is the phenomenological combustion model, which was developed in AVL CRUISE-M to predict the rate of heat release and the emissions formation in the engine depending on many submodels. The resulted valve timing positions from the first part were exported to the second one in order to investigate their influence on the engine performance. After reviewing the results, it can be concluded that the flexible valve train model can effectively predict the valve timing positions as the simulation results are in a very good agreement with the experimental data.

In terms of combustion model, the results of the in-cylinder parameters and exhaust emissions match well with the experimental tests on the engine test bench. Hence, the model was used for further investigations and four cam pairs (1, 2, 7, 8) with different valve timings were discussed in this study.

Results indicated that increasing the FCT angle has a positive effect on the knock intensity at the loads of 50%, 75% and 100% with the four cam pairs. Generally, as the FCT angle increased, more valve overlap period is attained. In cam pairs (1, 2), the higher FCT values are associated with mor NOx and total methane slip in the exhaust emissions. the reason behind that is the charge escaping through the exhaust valve as the overlap period increased. On the other hand, increasing the FCT value in cam pairs (7, 8) caused more $BSNO_x$ with slightly reduction in the total methane slip. The common factor between pairs (7, 8) is the EVC event, which indicates that not only the overlap value affects the emissions formation, but also the position of the overlap relative to the crank angle. brake thermal efficiency did not show major effect with the different FCT values.

Using the cam phase angle possibility, the effect of the intake valve timing is investigated. The results showed that advancing the IVO requires more intake air pressure to maintain the same power, which was very obvious with the four pairs. As the IVO is advanced, the IVC becomes earlier also which means strong Miller effect with lower compression ratio. Furthermore, with advancing the IVO, the overlap period is increased which allows more methane to escape out of the cylinder without participating in the combustion process. Knock intensity and $BSNO_x$ are reduced with advancing the IVO points with the all studied loads.

Regarding the EVC event, it showed lower effect on the engine performance and emissions in comparison with the IVO tuning. The progressive advancing of the EVC increased the knock intensity with the four cam pairs. Also, more methane slip is detected in the exhaust emissions with advancing the EVC as the exhaust valve is opened before the end of combustion. The $BSNO_x$ is affected positively with the earlier EVC with the four pairs.

In terms of the valve overlap value and position, results stated that too small valve overlap affected the exhaust emissions negatively as the valve overlap helps in the scavenge process. Moderate overlap values showed better performance and had more stable range for valve tuning which allows to optimize the other parameters without sacrificing. Results showed that, not only the amount of the valve overlap is significant, but also the position of the overlap relative to the TDC. The best performance with lower emissions were obtained when the valve overlap position is near to the TDC.