CONCEPTUAL INVESTIGATIONS ON FULL OPTICAL ACCESSIBILITY TO LARGE BORE MEDIUM SPEED ENGINES

Author, co-author (Do NOT enter this information. It will be pulled from participant tab in MyTechZon)
Affiliation (Do NOT enter this information. It will be pulled from participant tab in MyTechZone)

Abstract

A clean, reliable and environmentally friendly solution for future mobility is not only a challenge concerning individual mobility but also concerning transportation issues. Ships using cost effective diesel engines accomplish most of the worlds' freight service. As the IMO TIER III takes effect, NOx emissions become strictly regularized in the ECAs (Emission Controlled Areas) and the ship propulsion systems not meeting the new requirements have to be improved.

One possibility to improve internal combustion engines is to optimize the combustion process to avoid the formation of emissions already in the cylinder. To investigate and understand the combustion process optically accessible engines are one possible tool. By using these types of engines optical and laser optical investigation methods can be applied to analyze the mixing formation, injection, combustion and emission formation in situ. Better understanding the combustion process results in new potentials to push them beyond existing limits. Optical engines are a common development tool for passenger car and truck size engines. Rather rare is the application of such an optically accessible engine for large bore engines driving ships or power plants due to their huge scale and size.

Therefore, this paper deals with concepts making large bore engines optically accessible. The following sections show conceptual possibilities according to the principle of Bowditch as well as alternatives to the principle according to Bowditch. One promising principle shown in the following is currently under investigation.

Introduction

The ongoing discussion about engine out emission and their regularization by laws lays its focus not only on passenger car or truck engines but also even more on ship vessels and stationary industry engines. A good example for this is the actual IMO Tier III regularization for ship vessels which stipulates the NOx reduction of 15 to 80% in ECAs compared to the IMO Tier I (cf. [1]). Therefore, available engines and especially their combustion processes have to be improved further to get an environmentally friendly propulsion system as required by the new laws. For passenger cars, light duty and heavy-duty commercial vehicles the use of optically accessible engines is already state of the art to investigate the processes from mixture formation to emission formation and the combustion process itself. Fully optically accessible engines provide the opportunity to get the maximum insight into the combustion chamber under conditions as close as possible resembling those of a normal all-metal engine. Due to the size of ship vessels fully optically accessible engines are not common at all. The following sections present design studies of optically accessible engines on a large bore scale. Furthermore, the present paper presents details of further investigations on one of the concepts.

Brief review of optical access to internal combustion engines

The main purpose of an optical access is to get visual insight in the combustion chamber using optical materials like quartz glass or sapphire with the potential to withstand the temperature and pressure of the combustion process. To take maximum advantage of the view into the combustion chamber, the use of different optical and laser optical measurement techniques is possible. These measurement techniques are used to characterize the combustion by improving visibility of the flame front and species as indicator for the combustion process and the emission formation, the charge distribution or the charge motion. Therefore, the following section presents a brief review of different embodiments for optical access to an engine's combustion. Therefore, two overall designs can be distinguished - the rapid compression machine (RCM) and the optically accessible engine.

RCMs focus only on the combustion and emission formation during a single combustion stroke and are a feasible way to derive and verify reaction kinetic models of the combustion under temperature and pressure (e.g. [2]). The main difference to the optically accessible engine is the missing mixture formation inside the combustion chamber due to the different engine run strategies and often different port channel geometries. RCMs mostly use homogeneous premixed air fuel mixtures to fill the combustion chamber via an appropriate valve. After filling the combustion chamber one stroke is carried out by impelling a piston with a e.g. hydraulic external drive. During the stroke the combustion process can be observed via lateral and top windows. Table 1 summarizes RCMs from a small size to medium speed large bore ship vessel's size.

Table 1 Overview on RCM

Bore/Stroke [mm]	Measurement technique	Source
50,8/254	PLIF	[3]
240/260	PIV, LIF, BDL, TCM	[4–6]

To overcome the disadvantages caused by the differences in behavior of the RCMs compared to combustion engines (missing charge motion, discontinuous engine run, pressure and temperature boundary conditions, external drive, etc.) it is possible to integrate an optical access directly into the combustion engine.