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# Spray Combustion Chamber: History and Future of a Unique Test Facility

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**Abstract**
Large marine two-stroke diesel engines still represent the major propulsion system for merchant shipping. With steadily increasing transport demands, rising operational costs and stricter environmental legislations, the global marine shipping industry finds itself facing the challenge to future-proof its fleet. In order to comply with international maritime organizations emission standards (TIER II and TIER III), highly sophisticated and flexible combustion systems are demanded. With the help of spray and combustion research such systems can be developed and continuously improved. A highly valuable tool to investigate sprays of large marine diesel injectors under engine relevant conditions is the Spray Combustion Chamber (SCC). This paper reviews the history of the SCC, shows todays possibilities and looks into the near future of research involving large marine two-stroke engines. The SCC was built during the first Hercules project (I.P.-HERCULES, WP5, [1]). The initial setup focused on fundamental investigations comprising the application of highly flexible thermodynamic conditions. During follow-up projects (Hercules beta [2] and Hercules C [3]) the SCC was continuously developed, and a variety of influences on spray and combustion were experimentally assessed. The initial SCC design focused on maximum optical access as well as the applicability of a wide span of optical techniques. Single-hole nozzles were utilized to generate reference data to optimize existing spray and combustion simulation models. Different fuel types and fuel qualities were investigated and effects of the in-nozzle flow on spray morphology was identified. A sound set of results was achieved and published in several (internal and public) reports. Over the years, spray research at Winterthur Gas & Diesel has turned its focus from basic spray investigations to more detailed cavitation and in-nozzle flow examinations [4], [5]. Future research on the SCC will focus on investigations of more engine related topics, as, for example, the application of a fuel flexible injection system as is currently developed in the HERCULES-2 project [6]. Significant design modifications of the initial setup were necessary, as the injector positions and therefore exposure of the spray relative to the swirl were not fully congruent with real engine conditions. As a consequence, the new setup includes some minor drawbacks, e.g. the optical access of the nozzle tip is only visible from one side of the chamber. This means that line-of-sight methods are currently only possible at selected positions in the centre of the chamber. Therefore, a new setup was installed to illuminate the spray, consisting of a high speed, high energy laser (100 kHz, 100 W) and special optics. In order to obtain enhanced optical access, tangential windows were re-arranged, now pointing directly at the nozzle. With this setup, a first set of images was realized, showing a real spray as it occurs in large marine two-stroke diesel engines.

**Keywords**
Large marine diesel engines, spray, combustion, high pressure high temperature conditions, heavy fuel oil, residual fuel

**Introduction**
Due to their high thermal efficiency and reliability, Diesel engines are still relied upon extensively for seaborne freight transport. With steadily increasing transport demands, rising operational costs and increasing environmental restrictions, the global marine shipping industry finds itself facing the challenge to *future-proof* its fleet. Ship owners and operators are looking for alternative fuels in order to remain economically competitive while complying with strict environmental regulations. Today's injection systems already are capable of handling a variety of fuel qualities, ranging from light fuel oils to residual fuels of very high viscosity and density. Nevertheless, in order to provide even higher fuel flexibility, injection systems are designed to facilitate the injection of fuels with for example very poor self-ignition properties or poor lubricity.

To develop such an injection system, Winterthur Gas & Diesel Ltd. is making use of highly sophisticated tools: From state of the art injection- and component test rigs up to full scale test engines (e.g. RTX-6, located in Winterthur, Switzerland).

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