History and State of the Art in Commercial Electric Ship Propulsion, Integrated Power Systems, and Future Trends

ABSTRACT | Electric propulsion has emerged as one of the most efficient propulsion arrangements for several vessel types over the last decades. Even though examples can be found in the history at the end of 19th century, and further into the 20th century, the modern use of electric propulsion started in the 1980s along with the development of semiconductor switching devices to be used in high power drives (dc drives and later ac-to-ac drives). This development opened up for full rpm control of propellers and thrusters, and thereby enabling a simplification of the mechanical structure. However, the main reason for using electric propulsion in commercial ship applications is the potential for fuel savings compared to equivalent mechanical alternatives, except for icebreakers where the performance of an electric powered propeller is superior to a combustion engine powered propeller. The fuel saving potential lies within the fact that the applicable vessels have a highly varying operation profile and are seldom run at full power. This favors the power plant principle in which electric power can be produced at any time with optimum running of prime movers, e.g., diesel engines, by turning on and off units depending on the power demand for propulsion and other vessel loads. Icebreakers were among the first vessels to take advantage of this technology later followed by cruise vessel, and the offshore drilling vessels operating with dynamic positioning (DP). The converter technology was rapidly developing and soon the dc drives were replaced with ac drives. In the same period electric propulsion emerged as basic standard for large cruise liners, and DP operated drilling vessels, but also found its way into other segments as shuttle tankers, ferries, and other special vessels. At the same time podded propulsion were introduced, where the electric motor was mounted directly on the propeller shaft in a submerged 360° steerable pod, adding better efficiency, improved maneuvering, and reduced installation space/cost to the benefits of electric propulsion. The future trends are now focusing on further optimization of efficiency by allowing multiple energy sources, independent operation of individual power producers, and energy storage for various applications, such as power back up, peak shaving, or emission free operation (short voyages).

KEYWORDS | Commercial ships; cruise vessels; drilling vessels; frequency converter applications; icebreakers; LNG carriers; marine technology; podded propulsion; ship electric propulsion

I. INTRODUCTION

Electric ship propulsion has a long history going back more than 100 years (see [1] and [2]), however, in quite limited numbers. The main stream of propulsion machinery was steam turbine propulsion and later on followed by diesel engines. There are examples of early diesel-electric propulsion system as for the river tanker Vandal (see Fig. 1) launched in 1903, with a ship's power plant of 3 × 120 horsepower, with electric transmission to the propellers. The power plant was built in Sweden by Swedish