UNIVERSITI TEKNOLOGI MARA

ASSESSMENT OF CURRENT CARRYING CAPACITY FOR SHORE POWER CABLE VIA MULTI-PHYSICAL FIELD COUPLING MODEL UNDER VARIOUS AMBIENT CONDITIONS

YOU FEI

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ABSTRACT

Shore power cables are directly laid in the air, in a humid port, and are directly exposed to sunlight. It will be affected by the sea breeze and tide. The special working conditions of shore power cables expedite the aging process of the insulation and lead to a decrease in the ampacity of these cables. Moreover, shore power cables are significantly influenced by factors such as ambient temperature, wind speed, water flow velocity, and solar radiation. The IEC 60287 standard does not elaborate the calculation method of ampacity under the influence of wind, water and solar radiation. There is no unified national or enterprise standard has been proposed. Based on the current situation and existing problems of shore power cable, firstly, an electromagnetic-thermal-flow-force multi-physics coupling model of shore power cables CEU94 - 8.7/10 kV - 3×120 mm2 is established suitable for ports, and the coupling form between each field is analysed, and the multi-physical field is solved by ANSYS software. Also, the correctness of the simulation model is verified by comparison with analytical calculation and experimental measurement. The following conclusion can be drawn that the average errors between the simulation results and the experimental data were 5.85% and 7.2%, respectively, which were relatively small. Secondly, the influence law of environmental temperature, wind speed, water flow velocity, and solar radiation on the temperature distribution of multi-circuit shore power cables were studied, and it comes to the result that when the ambient temperature increases by 10°C, the average temperature of the cable conductor increases by about 11.66°C; when the wind speed rises to 10 m/s from still, the maximum conductor temperature decreases by 13.84°C; under extremely high temperature and radiation conditions, the shore power cable's maximum temperature can reach 117.6°C. Finally, based on the Heat Balance Equation of the cable, an analytical calculation method of current carrying capacity of shore power cable based on Newton iteration was proposed and implemented by MATLAB programming. The analytical calculation method and finite element calculation method were used to compare and analyse the law of current carrying capacity affected by ambient temperature, wind speed, water flow velocity and solar radiation during the laying of air and water. The result obtained is that compared to the still state, the wind speed and water flow velocity significantly increase the current carrying capacity of the shore power cable: the current carrying capacity of the shore power cable increases with higher wind or water flow speed, showing a greater improvement when laid in water (23.4%) compared to air (22.5%). Additionally, higher ambient temperature and solar radiation significantly reduce the capacity, with the largest decrease (171.1 A) observed at high temperature and radiation levels. When laying in water, water has a certain absorption effect on solar radiation, and the increase in cable current carrying capacity is better; When laid in the air, solar radiation greatly reduces the current carrying capacity of shore power cables. And measures to improve the current carrying capacity of shore power cables were proposed, providing reference for the revision of the standard for calculating the current carrying capacity of shore power cables.

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CHAPTER 1
INTRODUCTION

1.1 Research background

With the increasingly frequent economic, trade and cultural exchanges among countries around the world, the number of ships traveling between countries is steadily rising. Ships arriving at ports have significantly contributed to environmental pollution in port cities. The primary source of pollution from ships is the exhaust gases emitted by onboard generators during power generation [1], and the gas discharged mainly includes particulate matter (PM2.5). Nitrogen oxides and sulfur oxides will not only cause environmental pollution, but also produce many respiratory and cardiovascular diseases after inhalation [2]. Shore power transmission technology can provide clean energy for ships arriving at the port. In order to meet the requirements of high-power and graded load of the port, high-voltage shore power cables are used for ship shore interactive transmission [3].

In order to solve the pollution problem caused by shore ships to coastal and riverside cities, countries began to adopt shore power transmission technology. In 2006, the European Union issued "EU directive EC2010", which requires ships stopping at the port to use shore power [4] from 2010; IMO, WHO, EC, LR and other organizations have also formulated an international convention (MARPOL 73/78 ANNEX VI), which proposes that ships arriving at the port should use direct power supply [5]. Due to the attention paid by countries all over the world to the pollutant emission from port ships, the development and application of shore power transmission technology have been accelerated. With the advancement of shore power technology, shore power cables are being increasingly utilized in shore power transmission systems.