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Recent developments of refrigeration technology in fishing vessels

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Abstract

Modern large and fast ocean fishing vessels include mechanical refrigeration, but all of them consume precious fuel or electricity to achieve refrigeration. Fishing vessels with tonnage at about 100 tons cannot attach compressor-icemaker onboard because of their small horsepower of diesel engine. These vessels always have to carry a lot of ice for caught fish preservation. At the same time, waste heat dissipated in the hot exhaust gases in most of the fishing vessels is rejected to the atmosphere. At present, some effort has been devoted to the utilization of the vast amount of the waste energy for refrigeration. In this paper, several types of refrigeration technology in fishing vessels are introduced, such as vapor-compression refrigeration systems, heat recovery systems to power absorption refrigeration plant, adsorption systems for producing chilled water, and adsorption icemaker systems, especially an adsorption icemaker prototype in our laboratory. The better perspectives of applications for the lattermost exist in fishing vessels.

Keywords: Fishing vessel; Refrigeration; Waste heat recovery; Adsorption icemaker

1. Introduction

Since natural ice was used from 1797 for carriage of fish by sailing ships to the UK [1], fishing vessels traditionally used crushed ice for caught fish preservation. The mechanical

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refrigeration system aboard tuna seiners had been developed in the late 1930s for use aboard bait boats [2] and some vessels, less than 30 m size, had been equipped with onboard mechanical refrigeration and freezing in 1960s [3]. A wide variety of the modern large and fast fishing vessels and mechanical refrigerating plants exists today, varying with fish species, size and processing methods [1]. All of these systems consume precious fuel or electricity to achieve refrigeration. However, the fishing vessels with tonnage at about 100 tons cannot carry compressor-icemaker onboard because of their small horsepower of diesel engine. Therefore, they always have to carry a lot of ice to keep their catches fresh when fishermen go fishing on the sea. Their internal combustion engines typically have a thermal efficiency of 40%. At present, most of the fishing vessels do not use any heat recovery system. The remaining energy is rejected to the atmosphere in the form of hot exhaust gases. Much work now in progress is directed to the improvement of the thermal efficiency by achieving better consumption of the fuel. Only a few of them employ an exhaust gas boiler to heat up water for cleaning purposes. Some effort has been devoted to the utilization of the vast amount of waste energy dissipated in the exhaust gases for refrigeration.

Absorption/adsorption systems are heat-operated units that need little electricity, so they can utilize waste heat or renewable energies. There are many possibilities for applications of sorption systems most of which, however, have not reached a significant state of maturity up to today. One of the evergreens, for instance, is the waste heat driven refrigeration system for fishing vessel application. Ziegler [4] discussed current trends as well as forthcoming applications in sorption heat pumping and cooling technologies. Srikhirin et al. [5] described a number of research options of absorption refrigeration technology and provided a comparison of the various types of absorption refrigeration systems. Meunier [6] claims solid sorption is very effective for low grade cooling, not only for air conditioning but also for deep freezing. By employing waste heat discharged from a fishing vessel's internal combustion engine to drive a sorption refrigeration system, the engine shaft can be relieved of the load required by the compressor of a conventional vapor-compression system for the larger vessels, and considerable fuel can be saved. Large space occupied for ice preservation can be avoided and the spoilage of ice may be negligible for the small fishing boats. Another attractive feature is that a sorption refrigeration system is almost noise-free and virtually maintenance-free.

The principal difference between the sorption and the vapor-compression cycles is the mechanism for circulating the refrigerant through the system and providing the necessary pressure difference between the vaporizing and condensing processes. The vapor-compressor employed in the vapor-compression cycle is replaced in the sorption cycle by a sorber and a generator, which compress the vapor as required. The energy input required by the vapor-compression cycle is supplied to the compressor in the form of mechanical work. In the sorption cycle, the energy input is mostly in the form of heat supplied to the generator. In the present case, the heat source is the exhaust heat of a fishing vessel internal combustion engine. Normally, solid sorption systems are preferred to liquid sorption systems. The reasons are mainly the flexibility in attainable temperatures of solid sorption, no need of a rectifying column, the corrosiveness of liquid sorption, the power requirement for the solution pump, and the difficulty for handling liquids in an accelerated, moving and reeling system.