

DESIGN OF REFRIGERATED SEA WATER PLANT FOR PRESERVATION OF FISH

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To study the feasibility of employing refrigerated sea water on board fishing vessels for the preservation of fish, a pilot model has been designed, the details of which are presented in this paper.

INTRODUCTION

It has been established that lowering the temperature of fish retards the activity of the enzymes and bacteria which bring about the spoilage. For short time storage, say up to a maximum of seven days, fish can be kept in fresh condition by chilling with ice immediately after catch in the ratio of 1:1 with subsequent replenishment of ice and this method has come to stay in the Indian fishing industry. The same result can be achieved if the fish can be stored in refrigerated sea water (RSW) maintained at 0 to -1°C with added advantage that the fish can be cooled much more rapidly and efficiently compared to ice storage. Another important advantage in using RSW storage is that fish held in this medium have buoyancies almost equal to their weights and hence to whatever heights the tanks may be filled, the fish do not get pressed or crushed, whereas in ice storage if the depth of fish and ice stored in a container exceeds about half to one metre, the bottom layers of fish get crushed and more often pitted by the pieces of ice. There is better

control of temperature in R S W storage which is maintained generally at -1.1°C (30°F) where as in ice storage it is very difficult to bring the temperature below 1.5°C and uniform temperature conditions throughout the material are seldom obtained. R S W storage eliminates the difficult task of icing and hence there is considerable saving of labour and ice storage space on board fishing vessels. Moreover, there is no question of the ice getting exhausted and hence the fishing trip can be prolonged without the catch getting spoiled (Govindan, 1969).

MATERIALS AND METHODS

Three separate refrigerated sea water storage tanks maintained at -1.1°C (30°F) were designed with the intention that simultaneously three sets of experiments could be carried out under identical conditions for collecting maximum data. The storage tanks were chosen in such a way that at a time a maximum of 150kg. of fish can be stored in each tank. The storage capacity in terms of fish may be taken as 800kg. of fish per cubic metre of tank

volume (50 lbs./cft.) (Roach *et al.* 1961). It has been found that even when 80% by weight of the seawater is displaced by fish in a loaded tank, adequate passage still remains between the fish for circulating sea water for cooling.

RESULTS AND DISCUSSION

The size of the storage tank chosen was 61 cm. x 61 cm. x 76 cm. height (2' x 2' x 2'6"). Excluding head space of 15cm. and another 10cm. below the perforated bottom the actual space available for fish to occupy is 0.1898cu.m. and hence the weight of fish in each tank is 150kg. The weight of sea water will be the weight of water occupied between the fish and that occupied below the perforated bottom

$$\begin{aligned} \text{which is } & \frac{150}{4} + 0.61^2 \times 0.1 \times 1000 \\ & = 37.5 + 37.21 \\ & = 74.71 = \text{Say } 75 \text{ kg.} \end{aligned}$$

From the above calculations, it is seen that the cooling load on the refrigeration machinery for one storage tank is to cool 150 kg. of fresh fish from an initial temperature, say 32.2°C to -1.1°C within one hour by submerging it under continuous flow of chilled water. It is assumed that the temperature of chilled sea water after cooling fish would be increased by about 2°C. Thus the heat load calculations are based upon cooling 150 kg. of fresh fish from 30°C to -1.1°C and to cool 75 kg. of sea water from 1.1°C to -1.1°C in one hour for each tank.

Calculation of Refrigeration Load

Sp. gravity of sea water	=	1.028 (3.5% salinity)
Freezing point of sea water	=	-2.2°C (28°F)
Sp. heat of fish	=	0.75 kcal./kg./°C
Freezing point of fish	=	-1.7°C (29°F)
Entering fish temperature	=	32.2°C (90°F)
Inside temperature to be maintained	=	-1.1°C (30°F)

The cooling load in each tank will work out as follows:

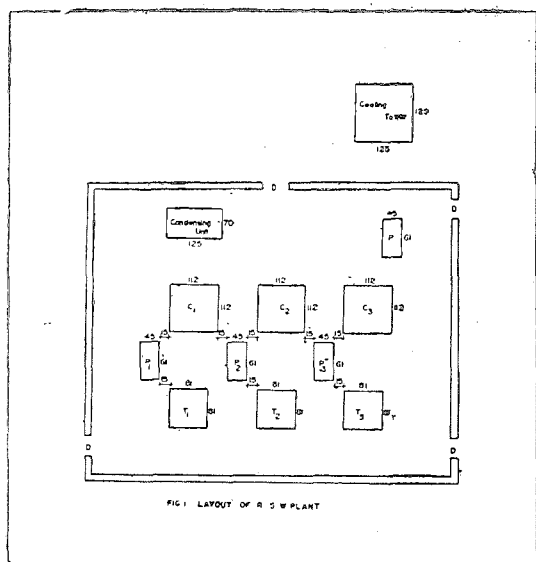
For cooling fish	=	150 x 0.75 [32.2-(-1.2)] = 3746.25 kcal./hr.
For cooling sea water	=	75 [2.1-(-1.1)] = 240 kcal./hr.
Total cooling load for each tank	=	3746.25 + 240
	=	3986.25 kcal/hr.

The total refrigeration load for removing heat from three similar tanks = 3986.25 x 3 = 11,958.75kcal./hr.

In order to satisfy the above conditions a low pressure Freon-12 water cooled condensing unit was selected which is a 3 cylinder reciprocating compressor, shell and tube water cooled condenser receiver having capacity of 15,000 kcal./hr. at 40°C condensing temperature and -9°C suction temperature.

The arrangements of the various com-

ponents of the RSW Plant are as shown in Figures 1 & 2. T1, T2 and T3 are the three fish storage tanks each with internal dimensions 61 cm. x 61 cm. x 76 cm. (2' x 2' x 2' - 6") made out of 18 gauge stainless steel and exterior constructed out of 16 gauge m.s. sheet. The tanks are insulated with 100mm. thick thermocole and provided with insulated doors at the



top. C1, C2 and C3 are the corresponding chilling tanks also made out of 18 gauge stainless steel interior and 16 gauge m. s. plate outside with 100mm. thermocole

insulation. Evaporator coils are made out of 16mm. cupro-nickel tubing. P1, P2 and P3 are the circulating pumps. In order to reuse the cooling water, a natural draught forced spray atmospheric type cooling tower also has been provided and the same water is being recirculated by using pump P.

Several experiments have been conducted with different fishes and the results will be presented in subsequent paper. The results are very much encouraging and there are many advantages of installing the RSW Plant on board fishing vessels.

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