Mechanical Refrigeration for Shrimp Trawlers

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Abstract

Over the past few years, the shrimp industry has witnessed a dramatic improvement in trawler configuration, but the continued employment of ice as the storage medium has negated, to a great extent, the very benefits to be derived from the vessel improvements.

Is vessel refrigeration the panacea which will finally eliminate all of the productivity and quality problems inherent in the ice-boat operation? An effective vessel refrigeration system should deliver a "pearl" quality product to the processor; that is, the shrimp must remain in essentially the same state of freshness as when captured and headed at sea.

Two storage problems must be overcome: dehydration and spoilage. To accomplish this, an effective system must glaze and quick-freeze the shrimp in a single operation, prior to storage in a dormant area, or dead air space such as the hold. No system, no matter how well it processes shrimp while it is working, is of any value unless it possesses the reliability to consistently go to sea, and stay at sea for extended periods, without malfunctions. The manufacturer should design redundancy into all critical components.

The reliable performance of a vessel refrigeration system is also dependent upon the ability and willingness of the vessel operator to provide effective preventive maintenance. Westinghouse provides free training to customer personnel.

The advent of the freezer-trawler bids well to end forever the seasonal variations in shrimp availability and should improve the yearly productivity of today's modern vessels by 30-35%.

Over the past few years, the shrimp industry has witnessed a dramatic improvement in trawler configuration, involving larger vessels, more powerful engines, better crew accommodations and the like. Modern vessels can trawl faster and range farther in quest of this incomparably valuable sea product, but strangely enough, the storage of shrimp aboard ship is still dependent upon the same 32°F ice which has been employed ever since the fleet first left the shoreline areas, many years ago. This curious situation has negated to a considerable extent the benefits to be derived from the improvements in the vessels themselves. The chief limitation to an ice-boat operation is the unfortunate 10 to 14-day shelf life of iced shrimp. This fact forces the modern vessel, with all of its durability and range, to periodically suspend fishing activities and pursue the time-consuming and expensive expedient of heading either for port or to a sometimes uncertain rendezvous with a shuttle boat. Needless to say, the bacteria growth and drip losses attendant to iced storage also leave something to be desired in the quality and value of the product delivered to port.

This brief lament on the status quo brings us to the important question of this moment. Is mechanical refrigeration the panacea which will finally eliminate all of the handling and quality problems normally inherent in the ice-boat operation? The answer is yes—and no. To understand this crystal clear answer let us first examine the functional requirements for effective freezing at sea. Obviously, the ultimate system should provide a process which will ensure what the trade calls "pearl" quality; that is, a condition in which the shrimp remain in essentially the same state of freshness and appearance as at the time of capture at sea. To accomplish this the refrigeration system must overcome: (1) dehydration—a process which shrivels, toughens and reduces the weight of the meat within the shell; (2) spoilage—bacteria growth which darkens the meat and often offends the nostrils; and (3) breakage—an appearance detractor which significantly reduces the value of the catch.

Let's discuss dehydration first. Freezing and then storing naked shrimp in a dry, refrigerated atmosphere was one of the first methods Westinghouse discovered for producing a tiny, tough and practically valueless seafood product. Further investigation revealed that in order to eliminate this problem, a vessel refrigeration process should totally encapsulate each shrimp with a safe glazing substance which would ensure against sublimation of moisture from the shrimp. One hundred percent encapsulation (or glazing) of each shrimp is so important

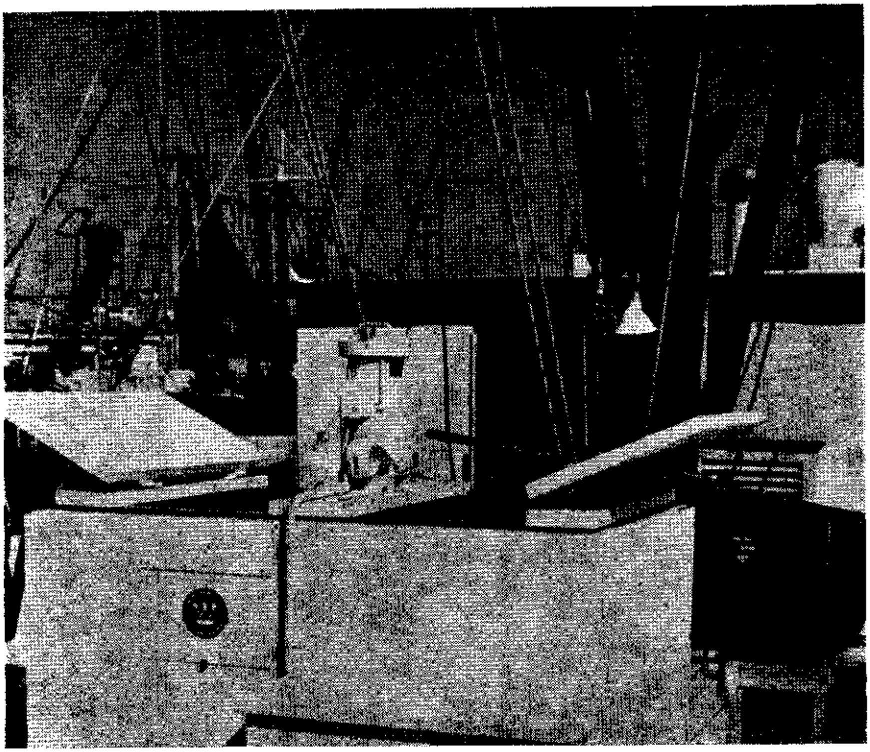

FIG. 1. One successful quick freezing device—the deck located immersion tank. Constructed of insulated stainless steel, it holds 400 gallons of saturated salt water-corn syrup solution at below zero temperatures. Note the agitator located on top of the tank between the loading covers.

that it must be provided as an inherent, functional part of the system, and never left to crew choice, crew judgment, or the vagaries of crew ambition. Glazing, when done rapidly and at low temperature, also prevents shrimp from sticking together during storage, thus simplifying the later thawing process and helping to keep each shrimp in its original whole configuration, legs and tails included.

And so we arrive at the second factor, spoilage. Once a shrimp is frozen stiff, of course, bacterial activity all but ceases, and the shrimp which is maintained below -10°F is generally considered safe from bacterial attack. The open secret here is speed, the dispatch with which the shrimp are frozen after arrival on the deck. The fastest way to freeze a shrimp is to carry away latent heat in a moving, fluid medium. The freezing process is extremely slow in a dormant surrounding, regardless of temperature. The hard rule is to have extracted all of the latent heat of fusion from the shrimp before it is stored in any dormant area or dead air space such as the hold. So, the buyer should beware, he will never be happy with a floating icebox. Some provision for quick freezing must be an integral part of the system. As an added feature, quick frozen shrimp have been stored heads-on with no apparent detriment to quality, and this can be a significant factor during peak catch periods.

The third problem, shrimp breakage, finds a solution in the fact that the container used for immersion freezing can also be employed as the storage container, and further handling, shovelling or other abuse to the product is avoided until after unloading at port.

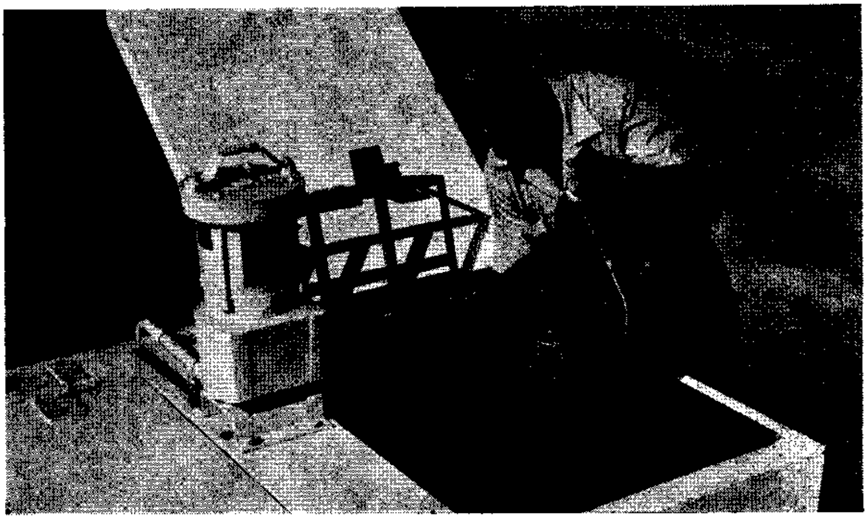

FIG. 2. A mesh bag, holding approximately 40 lbs. of headed shrimp, is shown being unloaded from the immersion tank. The mesh bags allow circulation of fluid during freezing and circulation of air during later storage in the hold. A bag depressor, shown in the upright position, is lowered over the naturally buoyant shrimp to assure complete immersion. After several minutes in the tank, the bags are simply loaded into the hold and stacked for refrigerated storage.

FIG. 3. Individually quick frozen and glazed shrimp ready for the processor. Properly frozen shrimp offer enhanced value to the processor. The processor, and ultimately the public, wants and deserves a "pearl" quality shrimp, which arrived at the dock in the same state of freshness and appearance as when caught and headed aboard ship.

A satisfactory vessel refrigeration system should, as a design criterion, lessen the processing work of the crew as opposed to an ice boat. In addition, a system design should preclude the necessity of extended duties in the hold. The human body was simply not designed for repeated periods of thermal shock ranging from perhaps 90°F on deck to -20° below.

Another factor we can't ignore when discussing refrigeration is reliability. No system, no matter how well it processes shrimp while it is working, is of real value if it cannot consistently go to sea and stay at sea for extended periods without malfunctioning. Any little thing that keeps the system from operating at sea is truly catastrophic. One way to ensure against this is to borrow a technique used in the design of sophisticated weaponry and space equipment; that is, start off with a reliable product, and then add to it by designing redundancy, or duplication, into all critical system components. Those of you who are students of statistics and probabilities will recognize that if you have two components to perform a job that normally requires only one, the probability that both will malfunction is only one-quarter as great as the probability that one will malfunction. Therefore, it just makes sense to provide as much duality as possible in equipment as critical as vessel refrigeration. Duality, or the double system approach, also gives another benefit. It allows for reserve freezing capacity to cope with occasional peak catches of 20 to 30 boxes a night when those great moments arise.

To this point we have covered only the manufacturer's obligations and design

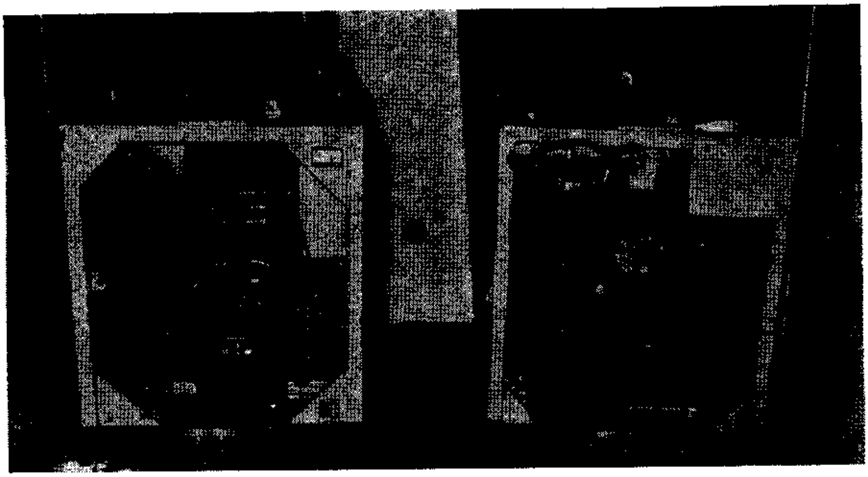

FIG. 4. An example of redundancy: two condensing units located in the engine room of a 73-foot wood Desco trawler. The units operate independently, and each has its own evaporator in the hold. The only commonality of units is the ship's fuel supply.

requirements for reliable vessel refrigeration, but reliability is a double-edged affair. The vessel owner or fleet manager must also understand that the addition of thousands of dollars worth of mechanical gear to a vessel, or a fleet of vessels, imposes an added requirement for technical support from competent crews and dockside mechanics. With proper preventive maintenance, a well designed system should not require excessive care at sea, but a thorough check-out between six-week trips is just as important as for an automobile before a 500-mile race, or an aircraft in preparation for a flight. In response to this customer need, Westinghouse, in cooperation with the Thermo King Corporation, offers a free 2-week course of instruction in mechanical refrigeration to customer designated mechanics, and encourages an additional familiarization period for mechanics and crews during system installation aboard a vessel. This type of program for effecting self-help in the fleet is doubly important in areas remote from the continental limits of the United States where the unfavorable logistics of factory supply and service could drastically reduce the expected advantages of the freezer vessel. Equipment manufacturers do have a strong interest in selling this equipment, you can be sure, but should do so only when satisfied that conditions are favorable for a successful operation.

Thus far we have covered the design requirements and maintenance responsibilities for successful freezer boat ownership, but the economics of the situation has yet to be heard. This subject, unfortunately, contains so many variables that it is difficult to generalize with statistics. For example, if a vessel is to operate from a port which is remote from productive shrimp grounds most of the year, such as Puerto Rico or Trinidad, a sizable increase in yearly productivity can be expected. In these areas, vessel refrigeration could almost be cited as a necessity item for a profitable operation. On the other hand, vessels operating from such ports as Freeport or Brownsville, Texas, have been blessed with highly productive grounds at their doorsteps for 4 or 5 months of the year. These vessels traditionally operate at a profit as ice-boats, and vessel refrigeration would tend largely to maximize profits during the off-Texas season.

Other variables to be considered in any economic analysis of vessel refrigeration would be the price and availability of ice, the age and durability of the vessel, the size of the hold, and as discussed before, the availability and cost of competent maintenance.

I am afraid that with all this hedging I have probably not settled the question of freezer economics to anyone's complete satisfaction, but I will conclude by saying that a freezer vessel should yield an increase of productivity of at least 25% annually, depending primarily on the geographic location of operations. Westinghouse has equipped a number of vessels operating from Tampa, Florida, during the past year, and the average productivity increase over ice vessels appears to be approximately 30%. One veteran Trinidad ice-boat captain, on the other hand, estimates that 4 of each 10 days at sea are consumed by the shrimp transfer operation. I would suggest that a vessel owner allow his accountant to compare his expected annual productivity increase, in dollars, to the annual amortization rate on a $20,000 to $21,000 vessel refrigeration system.

To conclude, when properly designed and placed in the right hands, mechanical refrigeration systems will allow today's advanced fish boats to reach their full potential for higher profits for the fisherman and the boat owner, as well as higher quality for both the processor and the most important person of all, John Q. Consumer.