Fishing vessel design & application of alternate energy in fishing

M.V.Baiju
Principal scientist
Fishing Technology Division, ICAR- CIFT, Cochin

Introduction

According to FAO, 2016 the total number of fishing vessels in the world in 2014 - 4.6 million. 64 % of reported fishing vessels were engine-powered. The fishing fleet in Asia was the largest, consisting of 3.5 million vessels and accounting for 75 % of the global fleet, followed by Africa (15 %) Latin America and the Caribbean (6 %) North America (2 %) and Europe (2 %).

Design and construction of fishing vessels

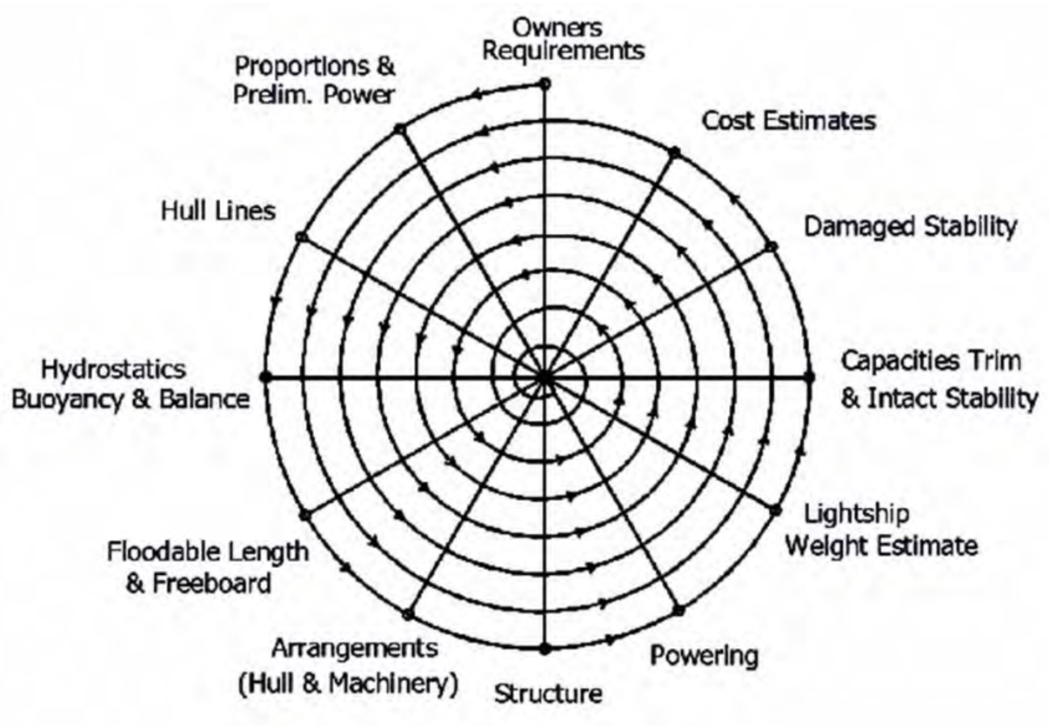
The sea going boats and ships are designed and constructed based on the rules of the classification societies and the registering authorities of the flag nation. This ensures the structural and operational safety of the vessel as well as the crew, cargo and other items onboard. Class or National Standard organisation approved raw materials only shall be used for the construction. Main engine, valves and other machinery ate to be approved type. Design of fishing vessel plays a vital role in fuel efficiency. Optimization of hull forms is the most effective and logical way to reduce the drag force for increasing fuel efficiency and the result is minimal carbon emission and considerable saving in expenditure of fishing operations.

Types of fishing vessels

The most common commercial fishing vessels are trawler, gillnetters, Liners, seiners and combination fishing vessels. Trawlers include stern trawlers, side trawlers, factory trawlers and pair trawlers. Liners consist of hand liners, long liners and pole and liners. Seiners are purse seiners and ring seiners. There are also dredgers, pot and trap vessels, trollers, mother vessels, carriers, factory vessels, fishery training vessels and fishery research vessels.

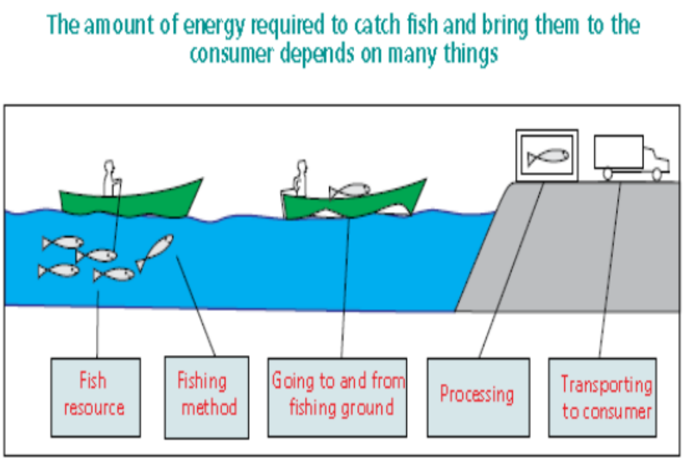
Design of fishing vessels

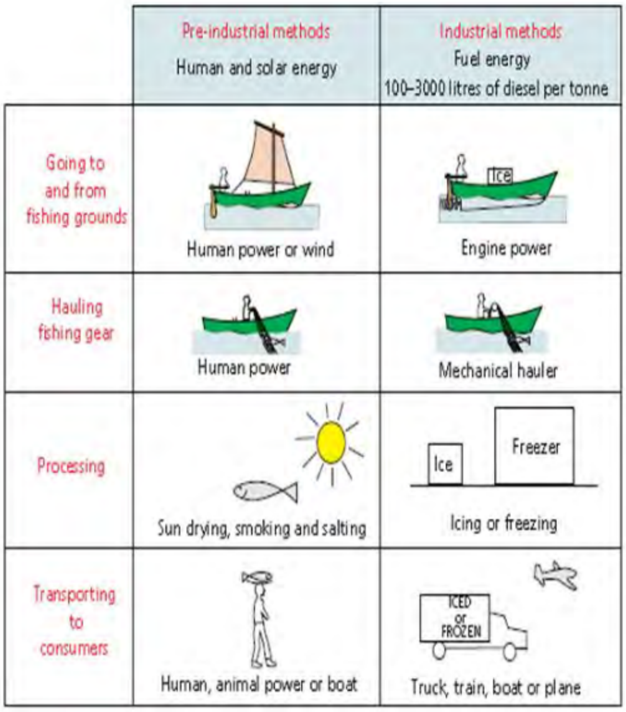
The commercial fishing vessels, are to be designed and constructed based on standard ship building procedure. Design starts from the ’ requirements. Then the preliminary lines plan, offset table, hydrostatic particulars, structural drawings and resistance calculation are done. The structural design is carried out based on class rules. The preliminary stability analysis is carried out during this design stage. Finally, the cost is estimated. The design stages will have to be refined at any of the above stages for excess of cost, resistance or any other reasons. So it becomes an iterative design. This method is called design spiral as given below.



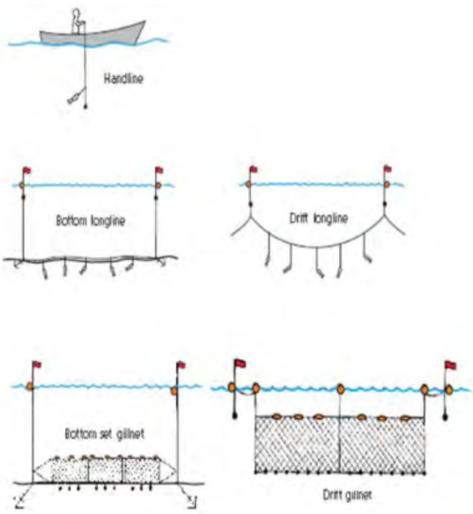
Energy use in fisheries

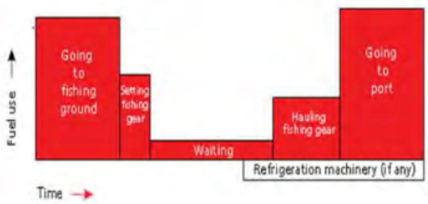
Energy is required to reach the fishing ground, carry out fishing and return to the harbor. This is shown as below.



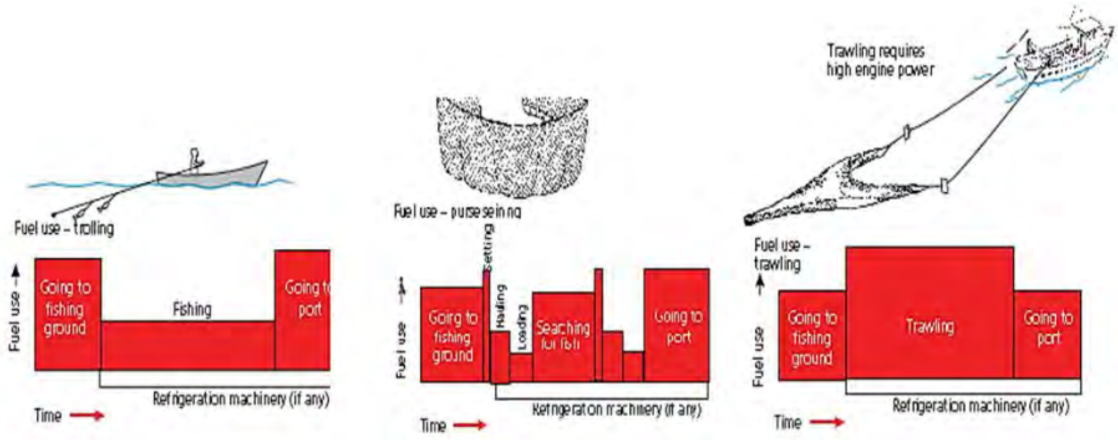


There are two fishing methods such as passive and active fishing methods.





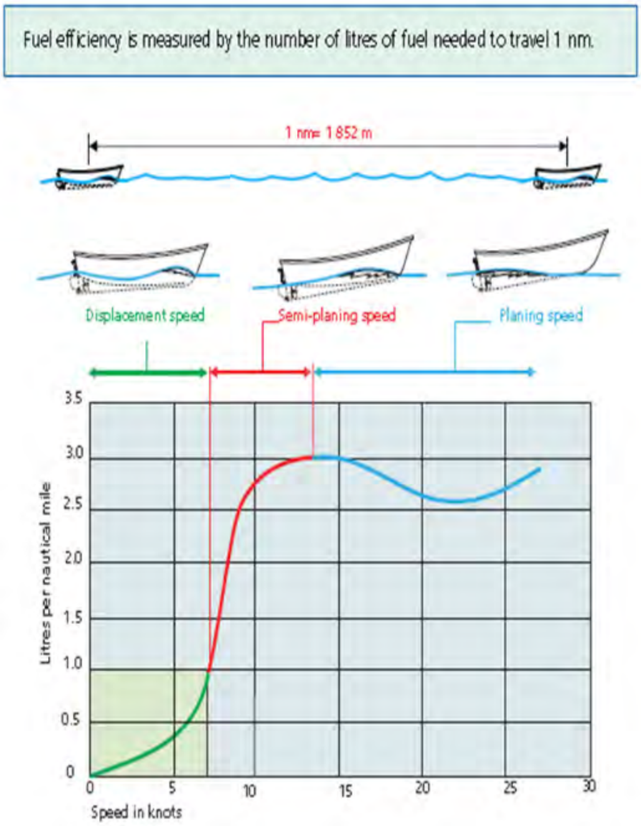
Passive fishing



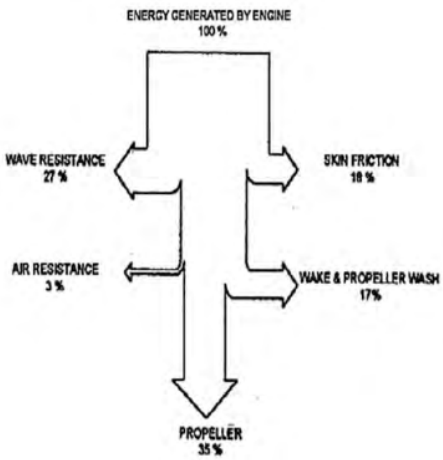
The above are active fishing methods.

Trolling	Purse seining	Trawling
Fuel is used both for travelling and for fishing	Most fuel is used going to and from fishing grounds and searching for fish	Most fuel is used to drag the trawl along the bottom (bottom trawling) or above the bottom (pelagic trawling). Reducing power going to and from fishing grounds saves fuel

The main energy consumption is in the burning of fuel. This depends on the type of fishing vessel hull, the speed of operation and endurance as explained below. Trawling consumes 0.8 kg of fuel while longlining and gillnetting consumes between 0.15 and 0.25 kg of fuel and purse seining requires 0.07 kg of fuel, to catch one kilogram of fish. (Gulbrandson ,1986). Trawling consumes nearly 5 times more fuel compared to passive fishing methods such as longlining and gillnetting and over 11 times more fuel compared to purse seining for every kilogram of fish produced. The gear resistance therefore has a large effect up on overall fuel economy

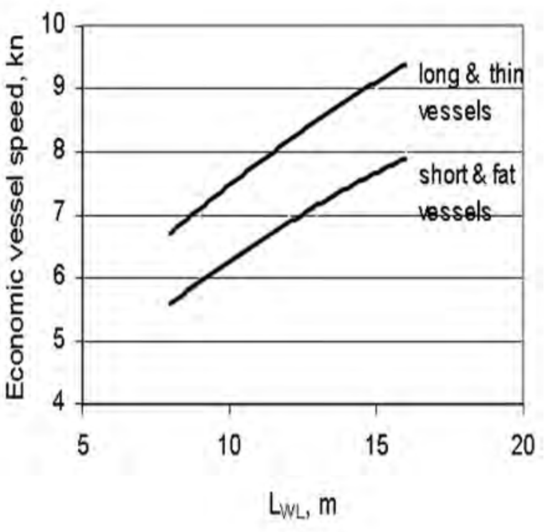


Energy losses in a small trawler when not dragging are indicated in Figure below.



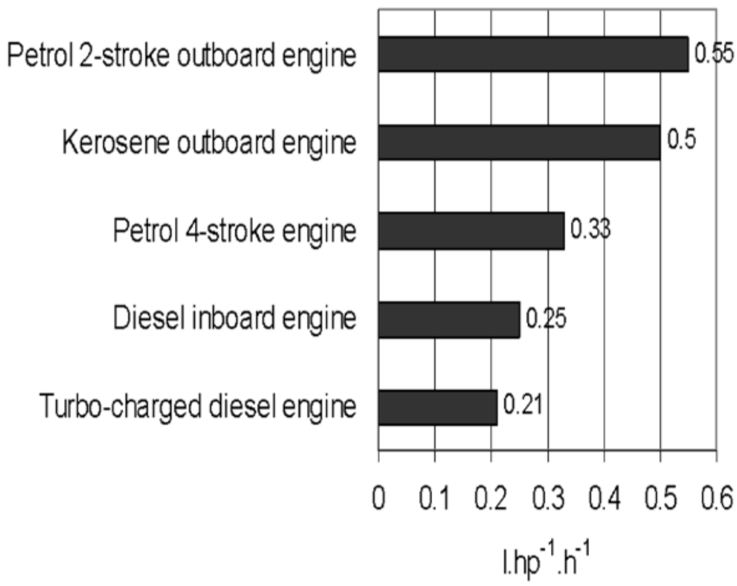
Energy efficiency can be achieved by designing fuel efficient hull form, making efficient propulsion system, optimum size of vessel, setting optimum speed of operation, following operational control for fuel efficiency, combination fishing in one vessel, energy efficient fuel, making bulbous bow for fuel economy, minimise the energy loss from the engine: reduction gear shaft, propeller and appendages and using ecofriendly materials for construction. An efficient propulsion system can be achieved by selecting a proper main engine power and rpm, reduction gear ratio, shaft diameter, length of shaft and making a Kort nozzle for trawling. Optimum size of vessel means the main dimensions are to be fixed for the maximum utilisation of space and minimising the waste. The Length Over All, Breadth, and Depth and Draft are to optimum. Optimumising fish hold volume, space for engine room, accommodation and wheel house helps in fuel conservation. Over speed will attract higher fuel consumption and operational expense. Also lead to more maintenance on engine, gear box and higher level of pollution. Minimising unnecessary idling at harbour and sea, unnecessary use of generator, fans, lights, etc will improve fuel efficiency. Keeping log book and making entry to know the daily fuel consumption will help in knowing the fuel use.

The power required to propel a vessel is mainly a function of (i) speed, (ii) length of water line and (iii) displacement. Vessel speed is the single most important factor affecting fuel consumption of the vessel. The fuel consumption drastically increases as the vessel approaches maximum speeds, due to great increase in wave breaking resistance. It has been shown 35 to 61% savings in fuel is possible for a reduction of 10-20% speed (The Oilfish project-Nordforsk, 1981-84; Gulbrandson, 1986; Aegisson & Endal, 1993). Economic vessel speed is the most important practical measure among fuel saving practices. The choice of operating speed, particularly while cruising to the fishing ground and back, is generally under direct control of the skipper of the vessel. Economic speed is shown below.



Reduction in power requirements can be achieved by (i) increasing length of water line (LWL) and (ii) reducing displacement wherever possible at the design stage, and (iii) by taking measures for control of hull fouling. For normal economic speed the ratio between the vessel speed ( ) ( ), /√

By increasing length of waterline while keeping the other dimensions same, it is possible to reduce the hull resistance and increase the speed. Increase in construction cost has to be balanced against fuel saving advantages. Trials in Norway, Denmark and India have indicated 15 to 20% reduction in hull resistance by modifications with bulbous bow.Reduction in displacement also contributes to lower fuel consumption. Hull built of aluminium, FRP and plywood will be lighter than that of steel, ferro cement and conventional wood construction. 23% reduction in fuel is reported for a 12.5% reduction in weight of small vessels. Fuel saving advantages in such cases has to be balanced against a possible reduction in stability, sea kindliness and cost of the vessel. Fuel consumption due to fouling could increase by 7 percent at the end of first month 44 percent at the six months and 88 percent at the end of 12 months (Gulbrandson, 1986). Hence periodic hull cleaning and application of antifouling paints can lead to considerable savings in fuel. The fuel consumed by different types of engines arte explained below.



Disadvantage of outboard is high propeller speed and consequent low propeller efficiency. Advantages are low cost and portability. Turbo-charged diesel engines are about 15% more fuel efficient than normally aspirated engines. Petrol 4-stroke outboard engines, which have a much better fuel economy and emission standards, are also being introduced in small-scale fisheries. Direct fuel injection (DFI) petrol outboard engines which is reported to have still better fuel efficiency, are expected to be introduced in small-scale fisheries. Modern marine diesel engines will run most economically at a service speed of 80 percent of the maximum continuous rating of the engine. The propeller design and size should be so selected as to allow the engine to operate in the area of lowest specific fuel consumption.

Right sizing the installed engine power

Smaller engines have multiple benefits of lower investment cost, lesser maintenance and huge reduction in the fuel consumption. Overpowering the vessel is wasteful in terms of energy as the maximum attainable speed of the vessel is dependent on length of the waterline. The installed engine power for a small fishing vessel engaged in passive fishing methods like gillnetting and lining, need not exceed 5-6 hp per tonne of displacement with a 10% increase in the tropical conditions (Gulbrandson, 1988). In the case of outboard engines, this should be 7.5 to 9 hp per tonne of displacement. A 3% reduction in engine RPM is reported to reduce fuel consumption by 10% and 11% reduction in RPM reduce fuel consumption by 30%.

Energy efficient fuel

Fuel form the major recurring input in fishing and is dependant on factors related to engine and size of vessel (Baiju & Boopendranath, 2014). The least polluting and cheap fuel for the vessel propulsion is wind power using sail. Before the 19th century almost every ship had been using only the wind power by classic sails, and supporting the worldwide trades and logistics in those I 1980’ , -assisted ships were developed. Now, they will be hoped to become one of the best solutions against the increasing CO2 discharge. Fishing vessels in many parts of the world are using sails in the small-scale fishery. Advantages are no fuel burnt and hence no pollution. The operational cost very low, no maintenance of engine gear box, etc and no battery/storage of power. The cost is minimum and successful in traditional sector.

Next is solar power. These two can be utilized well for propelling inland fishing boats. There is no atmospheric pollution from solar boats. The noise level is also very low. Fuel cell, Nuclear are also less polluting but very expensive. LNG has been successfully experimented in marine vessel propulsion. Diesel engines produce high thrust are the most widely used fuel in this sector. Foe small scale fishing petrol engines are utilised. A combination of kerosene and petrol in outboard engines are also popular in some countries. Diesel and petrol engines produce high pollution.

Materials of vessel construction

The popular materials used in the construction of boats and ships are woo, steel, Aluminium, Fiberglass reinforcement plastic and ferro cement. Among these woods utilizes least energy and is the most efficient material. But availability and maintenance of wood is a practical problem. Steel is the most popular material has been used worldwide for ships and deep-sea fishing vessels. This is corrosive in the marine environment and requires high care and maintenance. FRP is suitable for small vessels especially beach landing type fishing vessels due to its lightweight. Ferro cement has not become popular due to its weight and manufacturing difficulties.

References

1. Gulbrandson, O. (1986) Reducing the Fuel Costs of Small Fishing Boats, BOBP/WP/27, Bay of Bengal Programme, Madras, 15.
2. Endal, A. (1989) Energy fishing - challenge and opportunities. In: Proceedings of the World Symposium on Fishing Gear and Fishing Vessel Design 1988, Marine Institute, St. John's, Newfoundland, Canada, 74-78.
3. Aegisson, G. & Endal, A. (1993) Energy Conservation Programme in Indian Fisheries – Report from the Preparatory Phase, Report No. 402009.00.01.93, MARINTEK, Norwegian Marine Technology Research Institute, Trondheim, Norway: 45
4. Baiju, M.V and Boopendranath, (2014), Fishery Technology, Vol.51, Estimation of optimum engine power of fishing craft with reference to length.