Chapter 7

Energy saving in fishing vessels

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Introduction

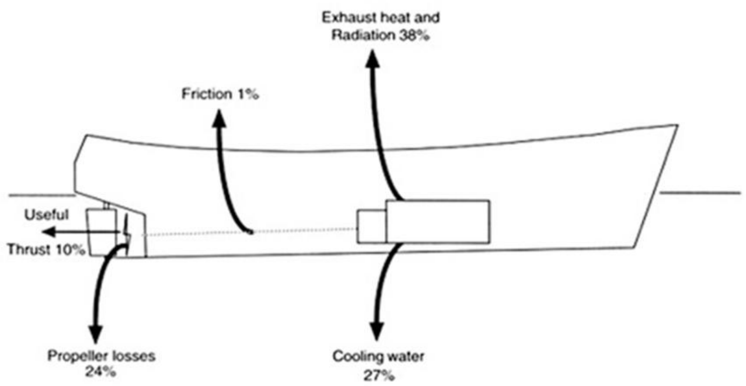
Fishing is the most energy-intensive food production method in the world today and depends almost completely on internal combustion engines based on oil fuels. Energy is spent during the design, construction and operation of vessels. Energy loss can take place during different stages such as design, construction, operation and maintenance of boats and at harbor.

The energy costs for a particular fishery is determined principally by the technology in use, the local economic conditions, including taxes, subsidies, labour cost and operational cost. (O.Gulbrandson, FAO, 2012)

Only about one-third of the energy generated by the engine reaches the propeller and, in the case of a small trawler, only one-third of this is actually spent on useful work such as pulling the net.

Materials and methods

The approximate distribution of energy created from the burning of fuel



A long liner or gill netter, the total energy gets distributed as follows:

35 % is used to turn the propeller;
27 % to overcome wave resistance;
18 % to overcome skin friction;

17 % to overcome resistance from the wake and propeller wash against the hull; and3 % to overcome air resistance.

Energy produced by the main engine

Most of the energy generated by the fuel burnt in the engine is lost as heat via the exhaust and cooling system and the operators are helpless to usefully recuperate this energy. Some of this can be regained through the use of a super charger and turbocharger but, in general, the thermal efficiency of small higher-speed diesel engines is low and little can be done to improve this. However, some engines are significantly more fuel-efficient than others, especially among different types of outboard motors.

The effect of wave resistance, determined principally by the dimensions and hull form of the vessel, increases dramatically with speed. Significant fuel savings can be made by maintaining a reasonable speed for the hull, irrespective of vessel type.

Fishing operations also influence energy consumption and efficiency through gear technology and operating patterns, particularly trip length.

Hull roughness

The amount of weed and marine growth that is allowed to accumulate on the hull. Both of these factors are under the direct influence of the operator's maintenance programme but, depending on the type of vessel and fishery, a significant expenditure on hull finish is not always worthwhile.

To improve fuel efficiency the operator of the vessel can contribute to reduce fuel loss by selecting a proper engine and gear box combination. The selection of a matching propeller and shaft also can lead to minimize the fuel loss.

Speed is the most important factor to influence fuel consumption.

As a vessel is pushed through the water by the propeller, a certain amount of energy is expended in making surface waves alongside and behind the boat. This generates wave-making resistance. As the vessel's speed increases, the wave resistance also increases very rapidly - disproportionately to the increase in speed. To double the speed of a vessel, it burns much more than double the amount of fuel. At higher vessel speeds, not only is more fuel lost to counteract wave resistance, but also the engine itself may not be operating at its most efficient, particularly at engine speeds approaching the maximum number of revolutions per minute (RPM). These two effects combine to give a relatively poor fuel consumption rate at higher speeds and, conversely, significant fuel savings through speed reduction.(O.Gulbrandson, FAO, 2012)

The choice of operating speed is usually under direct control of the skipper. Vessel speed during fishing may be constrained by other parameters such as optimum trawling or trolling speeds and may not be so freely altered.

Saving fuel through speed reduction is achieved by the awareness of the Skipper about what could be gained by slowing down and he must be prepared to go more slowly in spite of the fact that the vessel could go faster.

So by slowing down the vessel slows down and the journey takes longer the efficiency of the engine will change, but it will consume less fuel per hour. By this the resistance of the hull in the water drops very rapidly the efficiency of the propeller changes.

Engine performance

The amount of fuel that a diesel engine consumes to make each horsepower changes slightly according to the engine speed. A normally aspirated diesel engine (without a turbocharger) tends to use more fuel per horsepower of output at lower engine speed. At a lower RPM the engine may actually be working less efficiently.

A turbocharged diesel engine that is fitted with a small compressor to force more air into the engine has slightly different characteristics. This type of engine may work more efficiently at slightly lower speeds, but efficiency may drop rapidly as the speed is further decreased.(O.Gulbrandson, FAO, 2012)

Hull resistance: Rapid build-up of wave-making resistance takes place with increase in speed. The change in resistance of the hull is much more significant than the change in efficiency of the engine. A large increase in power is required to achieve a small increase in speed; and a small decrease in speed can result in a large decrease in the power requirement.

An outboard powered vessel will require approximately 50 percent more power, primarily on account of the low efficiency of outboard motor propellers. It is important to realize that the fuel consumption of both a diesel engine and a petrol outboard motor is approximately proportional to the rated power output, and high horsepower requirement equates directly to high fuel consumption.

For small changes in speed, an approximation of the change in fuel consumption per nautical mile can be made using the following equation:

- New fuel consumption = original fuel consumption x $\left(\frac{\text{new vessel speed}}{\text{original vessel speed}}\right)^2$

Saving fuel by reducing speed is cost to the vessel operator in terms of time, and a difficult decision has to be made as to whether it is worth slowing down. A reduced speed could imply less time for fishing, less free time between fishing trips or even lower market prices owing to late arrival.

Considering only the resistance of a vessel in the water, maximum operating speeds can be recommended as follows:

For long thin vessels such as canoes, the operating speed (in knots) should be less than 2.36 x $\sqrt{L}$

For shorter fatter vessels such as trawlers, the operating speed should be less than 1.98 x$\sqrt{L}$

Fouling: The loss of speed or the increase in fuel consumption owing to the growth of marine weed and small molluscs on the hull is a more significant problem for fishing vessel operators than hull roughness. The rate of weed and mollusc growth depends on the mode of operation of the vessel;the effectiveness of any antifouling paint that has been applied, and local environmental conditions, especially water temperature - the warmer the water, the faster weed grow. Estimates indicate that fouling can contribute to an increase in fuel consumption of up to 7 percent after only one month, and 44 percent after six months (Swedish International Development Authority/FAO, 1986b), but can be reduced significantly through the use of antifouling paints. A Ghanaian canoe, for example, was found to halve its fuel consumption and increase its service speed by 30 percent after the removal of accumulated marine growth (Beare in FAO, 1989a).

Roughness: Wooden vessels, and even to a certain extent glass fibre vessels, experience an increase in hull roughness with age (primarily owing to physical damage and the build-up of deteriorated paint), the effect is more significant with steel which is also subject to

The operational pattern of vessels will influence on the fuel efficiency. Larger fishing vessels, with endurance of several days or more at sea, tend to limit the length of fishing trips to the time necessary to fill the available hold space. In smaller-scale fisheries the tendency is to restrict the length of a fishing trip to a single day, often owing to the lack of storage facilities on board or long established routines. In many such cases, effective fuel savings could be made by staying longer at the fishing grounds, particularly if a considerable part of the day is spent travelling to and from the fishery. For example, if trips could be made in two days instead of one, the catch over those two days would be made at the cost of the fuel for one return journey rather than two. This would effectively cut the cost of the fuel expended on travelling to and from the fishing grounds, per kilogram of fish caught, by up to 50 percent.(O.Gulbrandson, FAO, 2012)

Use of technology to save fuel:

The technological steps such as optimization of hull form to reduce the resistance in water, use of light materials for the construction of vessels can save fuel. Also the use of solar power for the propulsion of fishing vessel will eliminate the use of fossil fuel. This will reduce the carbon foot print also.

Fig.1. Solar powered inland fishing boat designed and constructed by ICAR-CIFT in gill net operation

The solar panel on F.V.Sagar Harita of ICAR-CIFT

ICAR-CIFT has designed and constructed a 19.75 m Loa fuel efficient multipurpose fishing vessel. This vessel has been powered with a 400 h.p main engine whereas similar sized vessel in commercial operation is using a 500 h.p main engine. This saving is the out come of analysis and optimization of hull form through Computational Fluid Dynamics software. Another fuel saving feature onboard this vessel is the solar panel which gives 600 W power for emergency lights onboard.

Navigational aids auto pilot, chatrs and echo sounde helps reduce unnecessary cruising and can contribute to fuel savings of up to 10 percent (Hollin and Windh, 1984), depending on the type of fishery and the difficulty in locating small, focused hot spots. Not only can the equipment assist the vessel skipper in easily relocating fishing grounds (thereby reducing fuel wastage), but it can also identify new grounds and contribute to increased navigational safety. Both satellite navigators and echo sounders require a reasonable navigational ability and are most effectively used with maritime charts.

The propeller designer must strike a compromise based on the time the vessel spends operating in the two situations. For vessels working a great distance from their home port, the benefits to be gained from designing a propeller with increased towing power (and therefore catching capacity in the case of a trawler) may well be outweighed by the increased cost of fuel for the transit journey, and the design will err towards a higher-pitched propeller. A day boat operating relatively close to its home port would inevitably have a propeller optimized for towing.

Nozzle: A nozzle around the propeller significantly improve the efficiency of a propulsion system.

The duct is close fitting to the propeller, slightly tapered with an aerofoil cross-section. First, the duct helps to improve the efficiency of the propeller itself. The nozzle itself generates driving force in a similar way to the lift produced by the wing of an aeroplane.

Further reading

1. Fuel Savings for small fishing vessels, O.Gulbrandson, FAO, Rome Italy, 2012