DEMAND FOR ELECTRICITY FOR HYDRAULIC POWER SYSTEMS AT FISHING CUTTERS

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Abstract
The paper is focused on the presentation of operational research regarding the demand for electricity for hydraulic power systems based on an example of two typical solutions applied at fishing cutters belonging to the Polish fishing fleet. The selection of the particular cutters was determined by taking into consideration the economic and statistical aspects. This type of cutters is the most commonly used in the Polish fishing fleet. On the grounds of gathered operational data, two hydraulic power systems, installed on two real vessels, have been compared with each other. The obtained results prove that it is possible to reduce and limit the demand for electricity necessary to supply hydraulic power systems.

Key words: *hydraulic power systems, fuel consumption, operational state*

INTRODUCTION

The automation supporting crews of small fishing cutters and fishing boats used to be based on the solutions including the use of mechanical energy provided by the main diesel engine. Main reduction gear installed in the propulsion system not only transferred the power generated by the main diesel engine onto the propeller but also provided the power to auxiliary devices by additional power take-off shafts. Additional chain drive or belt drive drove rope winches, net winches and trawl winches. The complex structure of mechanical gears, low efficiency of energy transfer and low flexibility to select work parameters, problems with maintenance and poor safety of service were the main causes for changing the solution. Nowadays, on modern fishing cutters hydraulic power systems are used, rarely electric power systems (*Rajewski&Behrendt,2013*).

The older cutters, depending on the investment made on the modernization, were equipped with simple hydraulic power systems. They were used for driving the already existing net winches. The devices at cutters were also complemented with trawl winches and rope winches. The newer cutters, as well as the older ones, are subjected to thorough modernization and are equipped with hydraulic power systems of complex configurations. The hydraulic system at fishing cutters may be used to drive (*Behrendt,2014):*
- steering gear,
- trawl winches,
- net winches,
- rope winches,
- anchor winches,
- pumps for fish selection from the net,
- the remaining equipment with hydraulic power system e.g. deck cranes, power generators.

MATERIALS AND METHODS

Hydraulic pumps used at fishing cutters are driven directly by the main diesel engine or main reduction gear. It is presented in Figure 1 and Figure 2.

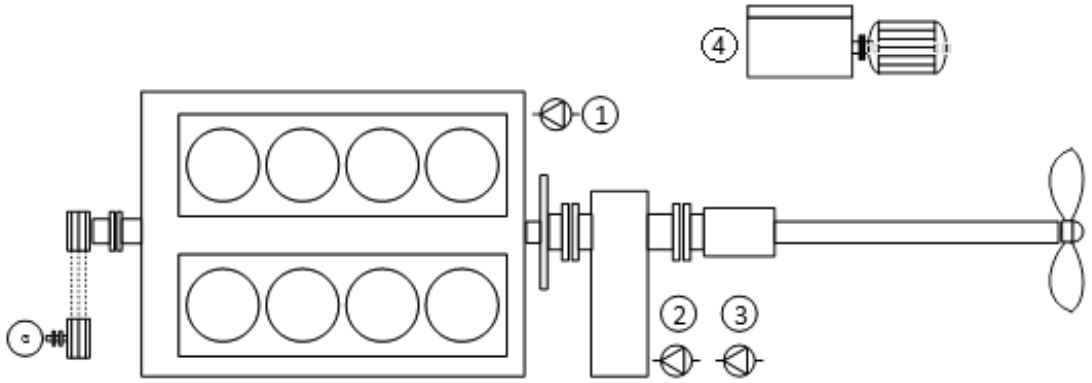

Fig 1. Propulsion system with hydraulic pumps driven by main reduction gear (*Borkowski&Myśków, 2015)*.
1.hydraulic pump for deck equipment and devices; 2. hydraulic pump for deck equipment and devices; 3. steering gear hydraulic pump, G – shaft power generator 4. power generator unit.

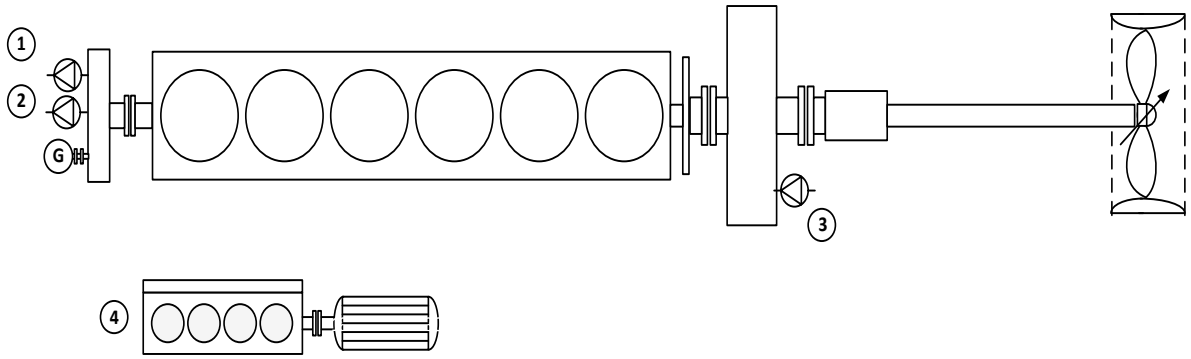

Fig 2. Propulsion system with hydraulic pumps driven by main diesel engine (*Borkowski&Myśków, 2015)*.
1. hydraulic pump for deck equipment and devices; 2. hydraulic pump for deck equipment and devices; 3. gear lubrication pump; G - shaft power generator; 4. power generator unit.

At fishing cutters, the hydraulic pumps are driven by the main diesel engine (Fig. 1) using mechanical or belt drive. In the case of the drive from the main reduction gear (Fig. 2) it is necessary to use a drive with an additional stage and power take-off shafts. An advantage of this solution is a high operational certainty. However, a disadvantage is that the pump is continuously working when the engine is activated. The only possible method to unload the hydraulic power system when it is not used to drive power devices (trawl winches, net winches, and auxiliary devices) is to change the working liquid circulation into the tank-tank flow, bypassing the remaining system part. However, even when the solution is applied, it is necessary to provide mechanical energy to drive the hydraulic pump. As the research showed, the demand for power is within 4% and even with unheated oil in the system, it equals up to 10% of the power consumed by the pumps at full working load *(Szczepanek&Kamiński, 2013)*.

RESULTS AND DISCUSSION

When using hydraulic driven devices and equipment, the energy is converted into mechanical work performed by a hydraulic engine. The research has been carried out at two fishing cutters of the same type, equipped with winches with various hydraulic drives, in three operational states of hydraulic power systems which are specific for catching fish process:

1. throwing trawl net – the work of net winch at throwing the trawl net, and then of two trawl winches (around 40 min.)
2. retrieving trawl– the work of two trawl winches (around 30 min.)
3. retrieving trawl net - the work of net winch (30 min., depending on the weight of fish caught).

The measurement and calculation results are presented in Table 1.

Table 1. Basic measured and calculated load values for winches with hydraulic drive during catching fish process at cutters subject to research

	Measured and calculated parameters	Unit	Catching fish process stages					
			Vessel 1			Vessel 2		
			Retrieving trawl	Retrieving trawl net	Throwing trawl net and a trawl	Retrieving trawl	Retrieving trawl net	Throw-ing trawl net and trawl
1	Input power of hydraulic pump PB	kW	26.0	21.0	16.0	29.0	28.0	18.0
2	Input power of hydraulic pump LB	kW	26.0	21.0	16.0	29.0	26,0	18.0
3	Trawl winch power PB	kW	11.6		7.2	13.0		8.1
4	Trawl winch power LB	kW	11.6		7.2	13.0		8.1
5	Net winch power PB	kW		9.4	7.2		12.5	8.1
6	Net winch power LB	kW		9.4	7.2			
7	Torque of trawl winch PB	kNm	6.2		3.8	6.9		4.3
8	Torque of trawl winch LB	kNm	6.2		3.8	6.9		4.3
9	Torque of net winch PB	kNm		9.8	7.5		13.0	8.4
10	Torque of net winch LB	kNm		9.8	7.5			
11	Pull force of trawl winch PB	kN	30.9		19.0	34.4		21.4
12	Pull force of trawl winch LB	kN	30.9		19.0	34.4		21.4
13	Pull force of net winch PB	kN		16.3	12.4		21.7	14.0
14	Fuel consumption	kg/h	6.5	5.3	4.0	7.3	3.5	4,5

The data included in Table 1 allowed for drawing charts presenting the demand for power and fuel consumption required to provide power by the main diesel engine to the hydraulic pumps' drive (Fig. 3-6)

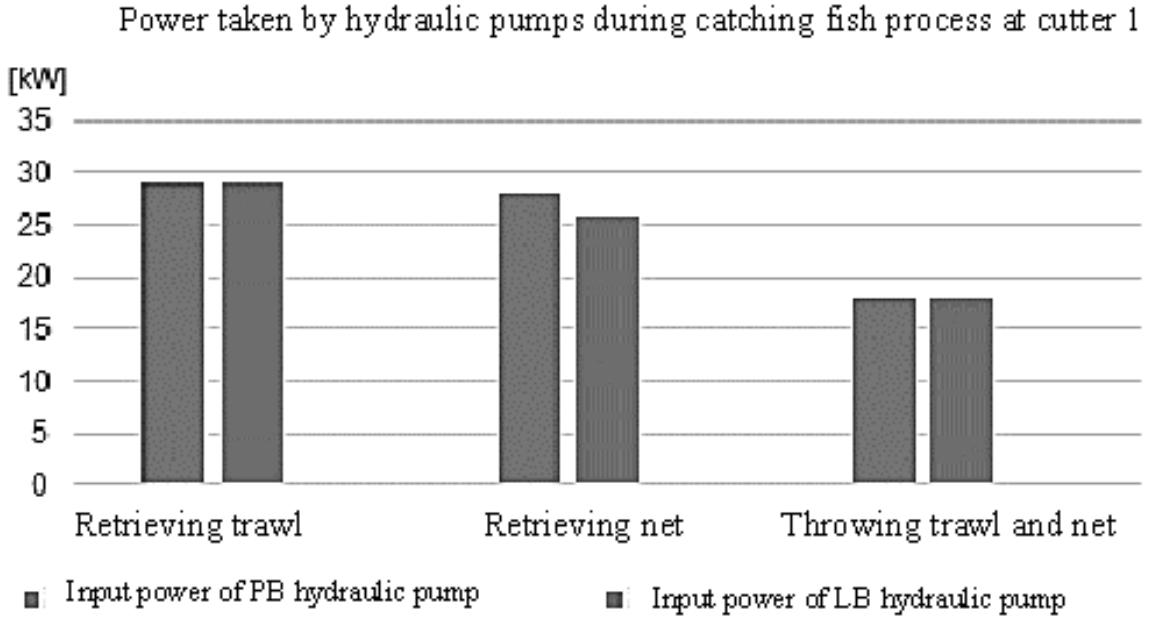

Fig 3. Power taken by PB hydraulic pumps at cutter 1

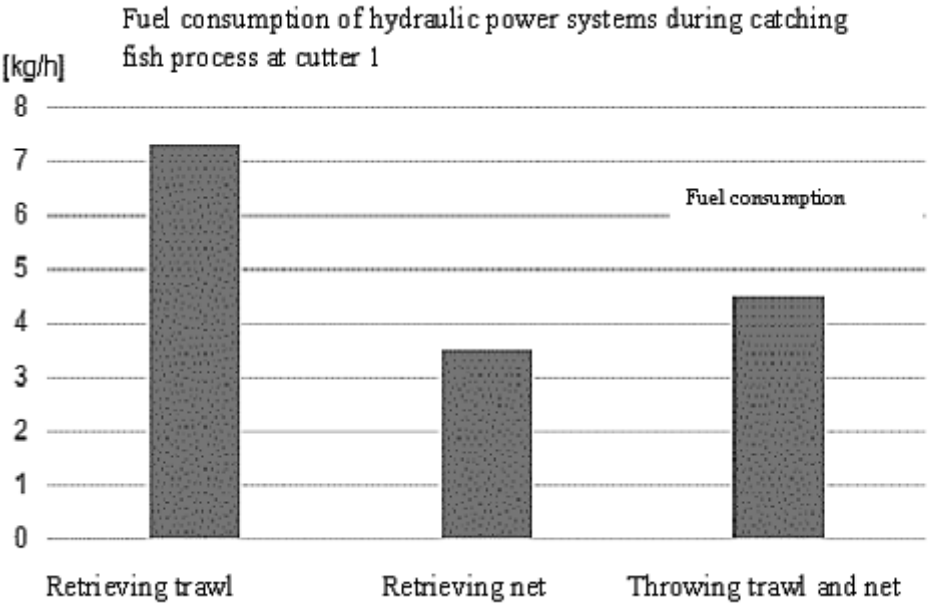

Fig 4. Fuel consumption of hydraulic power systems during catching fish process at cutter 1

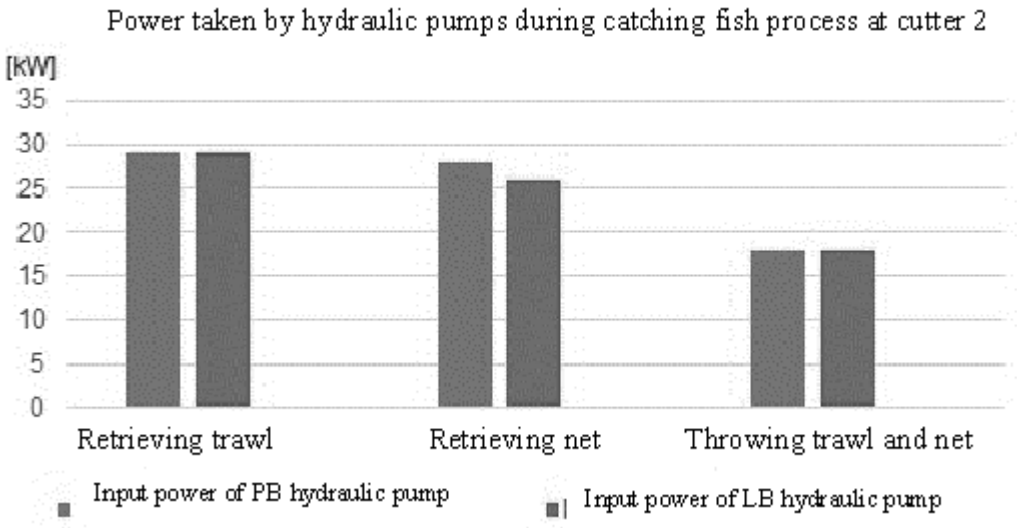

Fig 5. Power taken by hydraulic pumps at cutter 2

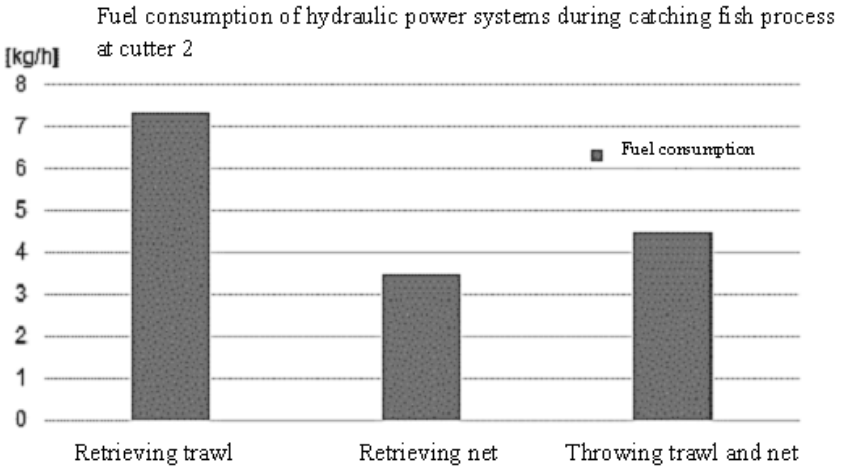

Fig 6. Fuel consumption of hydraulic power systems during catching fish process at cutter 2

The research results presented in the paper refer to the hydraulic systems. They are the outcome of the energy efficiency audits carried out at the vessels belonging to the Polish fishing fleet. The research has been performed for the very first time and therefore the results should be useful in order to reduce the energy consumption at the vessels. However, comparable methods aimed at the limitation of fuel consumption have been presented by Rajewski, P., Behrendt, C., and Szczepanek, M., Kamiński, W. and Szczepanek, M., Skarbek-Żabkin, A. in terms of the engine as a system, Erwin M. Schau.,Harald Ellingsen, Anders Endal, Sevin Aa. Aanondsen in reference to the Norway fleet, Mikkel Thrane in reference to the Dutch fleet and Muir James F in global overview the utilization of fuel energy by the global fisheries industry .
Based on the data included in the paper, it is justified to state the operational condition of a vessel may significantly affect the power consumption. Raising the crew members technical awareness may impact on the reduction of same.

CONCLUSIONS

Summing up, the hydraulic power systems used at fishing cutters are significant elements of the cutter equipment. The analysis of the obtained results proves that the demand for electricity at the selected

cutters vary insignificantly, regardless of the catching fish process. However, given that the main propulsion systems, auxiliary unit and the drives of hydraulic power systems at the cutters were comparable, the differences in fuel consumption should be noted. It should be assumed that this is a result of various technical conditions of the cutters, knowledge, financial situation of shipowners and the fact that these systems are in a different state of wear. Various demand for electricity depending on the operational state (maneuvers, trawling) may also be the effect of the above. Turning the systems on leads to extreme changes of the load of ship electrical power system, and in the case of power generators driven by the main diesel engine, it may result in changes of load. The observations made on real objects showed that the power of devices used in the hydraulic power systems at the cutters is larger than needed to perform the cutter tasks and they do not operate at minimum load at any operational condition, which affects in an economically unjustified increase of operational cost by the increased fuel consumption. Properly selected and adjusted devices and equipment for hydraulic power system might result in the reduced demand for electricity.

ACKNOWLEDGMENT

This research outcome has been achieved under the research project no. 2/S/IESO/2014 financed from a subsidy of the Polish Ministry of Science and Higher Educations for statutory activities of Maritime University of Szczecin.

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