ペルー旋網用油圧ウインチの力学特性

誌名	日本水産學會誌
ISSN	00215392
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巻/号	56巻3号
掲載ページ	p. 413-416
発行年月	1990年3月

Nippon Suisan Gakkaishi 56(3), 413–416 (1990)

Determination of Mechanical Properties of a Peruvian Purse Winch

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(Received May 16, 1989)

The study was undertaken utilizing only an engine tachometer and an oil pressure gauge of a prototype Peruvian small purse seiner. The empirical relationships between a velocity of a winch (V_w; m/s) and an enging revolution (N_e; rpm), and between an effective force of a winch (F_w; kgw) and an effective output pressure of an oil pump ($P-P_0$; kgw/cm^2) were determined based on the equations obtained by the previous study. Assuming the loaded pressure (P; kgw/cm^2) and the non-loaded pressure (P_0; kgw/cm^2) of the pump, since $P_0=19.7$ kg/cm^2, then

$$V_w=0.000415\,N_e \qquad \text{and} \qquad F_w=24.5\,(P-19.7)$$

Moreover, in standard fishing operations of Peruvian small purse seiners, $V_w=0.52$ m/s and $F_w=367$ kgw could be practically determined. These values could be used to examine the mechanical properties of a fishing gear during fishing operation.

Scientific researches or observations usually require precise instruments to measure or to get necessary data. To obtain and maintain such instruments means added cost.

Particularly in Third World Conutries, sufficient instruments can not be provided for research works mainly due to economic problems. The intention of the previous study[1] was to solve one of these problems without utilizing special instruments to measure the velocity and the force of a hydraulic purse winch.

It is to be noted that even small purse seiners using oil hydraulic system for winch and powered block are usually equipped with at least an engine tachometer and an oil pressure gauge. Utilizing only these simple and essential instruments of fishing boats, it was obtained from the study that there were strict relationships between the velocity of the winch and the revolution of the engine, and between the effective force of the winch and the oil pump's output pressure.

The purpose of this study is to determine the mechanical relationships and the values of the velocity and effective force during a standard fishing operation of a hydraulic purse winch on a Peruvian small purse seiner applying the equations obtained in the previous study.[1]

Materials and Methods

Materials

The hydraulic winch of the fishing research and training boat "UNA-I", belonging to the National Agricultural University (Universidad Nacional Agraria, La Molina) of Peru was used. The hydraulic system and the fishing gear are standard, as a Peruvian small purse seiners, in capacity and size which have been recently introduced in the Peruvian coastal fisheries.

Table 1 shows the specific characteristics of the hydraulic equimpments and the engine used in the study. Table 2 shows the particulars of the fishing gear and the fishing boat used. The fishing gear is 123 fathom in float line length and 13.3 fathom in net height. The fishing boat has an overall length of 36 ft and has 13 gross tons.

Methods

In the previous study,[1] the velocity of the winch (V_w; m/s) could be expressed in terms of the engine revolution (N_e; rpm) and the displacement of the pump (q_p; l/rev) and of the winch (q_w; l/rev) as

$$V_w=k_v(q_p/q_w)N_e\,, \qquad (1)$$

where

$$k_v=(\pi/60)\eta_t(D_e/D_p)D_w\eta_{vp}\eta_{vw}\,.$$

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Table 1. Specific characteristics of oil pump, hydraulic winch and engine

Item	Specification
a) Oil pump	
Tpe	Gear
Rating pressure	210 kgw/cm^2
Max. revolution	2,500 rpm
b) Hydraulic winch	
Type	Radial piston
Rating pressure	130 kgw/cm^2
Torque	233 kgw·m
Max. revolution	180 rpm
c) Engine	
Displacement	4,580 cc
Continuous horse power	56 ps
Continuous revolution	1,800 rpm

Table 2. Particulars of fishing gear and fishing boat

Item	Specification
a) Fishing gear	
Float line length	225 m
Stretched net height	35.7 m
Hanging at body net	27.5 %
Total weight in water	293 kgw
b) Fishing boat	
Displacement	15.8 m^3
Length overall	11.5 m
Breadth	3.61 m
Depth	1.59 m

Also, using the loaded pressure during pulling of the fishing gear (P; kgw/cm^2) and the non-loaded pressure without pulling of the fishing gear (P_0; kgw/cm^2), the effective force of the winch (F_w; kgw) could be expressed in terms of the effective pressure ($P-P_0$; kgw/cm^2) as

$$F_w = k_f q_w (P-P_0) , \qquad (2)$$

where

$$k_f = (10/\pi)(1/D_w)(\eta_w/\eta_{vw}) .$$

In the above Eqs., k_v and k_f are constants, D_w (m) is the warping drum's diameter of the winch, D_e (m) and D_p (m) are the driving system pulley's diameter connected to the engine and to the pump, respectively, η_t is the transmission's efficiency on the oil pump's driving system, η_w is the total efficiency of the winch, and η_{vp} and η_{vw} are the volumetric efficiency of the pump and the winch, respectively.

Results and Discussion

Mechanical Properties of a Peruvian Purse Winch

Experiments to determine the relationship between V_w and N_e were carried out under loaded condition when the fishing gear is being pulled. V_w is obtained for each definite N_e (1,300, 1350 and 1,400 rpm) by transforming the pulling times required for each definite 10 fathom length of purse line. In this case, one fathom corresponds to 1.8 m.

The value of V_w/N_e was calculated for each N_e and the results are shown in Table 3. Using the mean value in the bottom part of Table 3, the velocity of the winch (V_w) can be expressed in terms of N_e as

$$V_w = 0.000415\, N_e . \qquad (3)$$

Eq. (3) could be verified determining the unknown value of η_t by the experimental values V_w and N_e. The η_t can be presented by

$$\eta_t = (60/\pi)\{(D_p/D_e)/D_w\}(q_w/q_p) \times \{1/(\eta_{vp}\eta_{vw})\}(V_w/N_e) .$$

Substituting the known values (Table 4) and the value V_w/N_e obtained in Table 3 in the above equation, the η_t can be calculated as

$$\eta_t = 0.918 .$$

Since the oil pump is driven mechanically by three V belts (type C in JIS), the value of η_t obtained is reasonable because it is within the range $0.90 < \eta_t < 0.98$ referred to in the previous study.[1)]

On the other hand, an experiment to determine the other unknown value of P_0 could be realized for each N_e under the non-loaded condition when the net is not being pulled. Table 5 shows the results obtained. From the bottom part of Table 5, the mean value of P_0 is given by

$$P_0 = 19.7 \text{ kgw/cm}^2 .$$

Since $k_f = 17.8$ using the known values (Table

Table 3. Mean value of velocity of hydraulic winch (V_w) against engine revolution (N_e)

N_e rpm	V_w m/s	V_w/N_e
1,300	0.540	0.000415
1,350	0.563	0.000417
1,400	0.578	0.000413
Mean		0.000415

Table 4. Known values of driving system of oil pump, and hydraulic equipments

Item	Simbol	Specification
a) Driving system of oil pump		
Dia. of driving pulley of engine	D_e	0.195 m
Dia. of driving pulley of oil pump	D_p	0.152 m
Warping drum's dia. of winch	D_w	0.152 m
b) Oil pump		
Volumetric efficiency	η_{vp}	0.970*
Total efficiency	η_p	0.811*
Displacement	q_p	0.0662 l/rev
c) Hydraulic winch		
Volumetric efficiency	η_{vw}	0.952*
Total efficiency	n_w	0.807*
Displacement	q_w	1.38 l/rev

* From the characteristic curves in the previous study.[1]

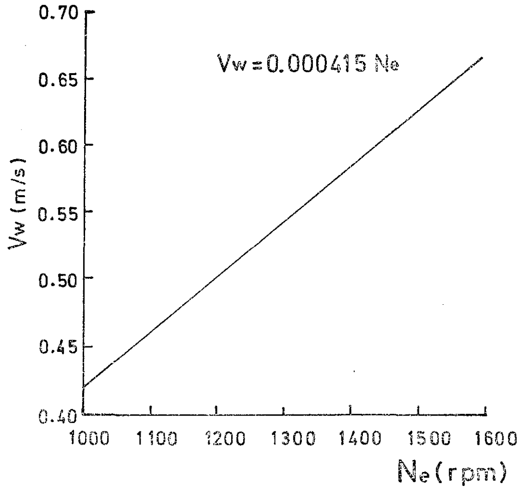

Fig. 1. Relationship between engine revolution and velocity of hydraulic winch.
N_e; engine revolution and V_w; velocity of hydraulic winch.

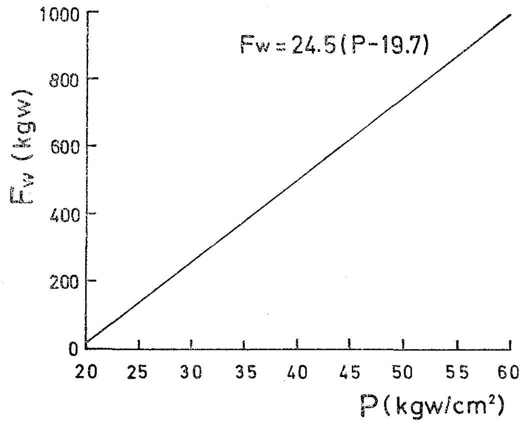

Fig. 2. Relationship between output pressure of oil pump and effective force of hydraulic winch.
P; output pressure of oil pump and F_w; effective force of hydraulic winch.

Table 5. Mean value of non-loaded pressure of oil pump (P_0) against engine revolution (N_e)

N_e rpm	P_0 kgw/cm²
1,050	18
1,150	18
1,250	21
1,350	21
1,450	20
1,550	20
Mean	19.7

4), the effective force of the winch (F_w) can be expressed in terms of P as

$$F_w = 24.5\,(P - 19.7)\,. \qquad (4)$$

Figs. 1 and 2 show the relationships between V_w and N_e, and between F_w and P, respectively.

Values of V_w and F_w at a Standard Fishing Operation

The fishing operation of Peruvian small purse seine can be divided distinctly into two stages,[2] *i.e.*, the pursing stage and the hauling stage. Under the loaded condition, four experiments to determine relationships between V_w and N_e, and between F_w and P were undertaken at the hauling stage. The values of V_w and F_w were calculated by Eqs. (3) and (4), respectively, using the measured values of N_e and P. Table 6 shows the result obtained.

Since measured values of N_e and P during fishing

Table 6. Mean values of velocity (V_w) and effective force (F_w) of hydraulic winch based from the measurement of engine revolution (N_e) and output pressure of oil pump (P)

Experiment number	N_e rpm	P kgw/cm^2	V_w m/s	F_w kgw
1	900	30	0.374	252
	1,100	30	0.457	252
	1,090	25	0.452	130
	1,090	25	0.452	130
2	1,280	30	0.531	252
	1,300	35	0.540	375
	1,280	35	0.531	375
	1,260	40	0.523	497
3	1,380	45	0.573	620
	1,400	45	0.581	620
	1,400	30	0.581	252
	1,400	40	0.581	497
4	1,300	40	0.540	497
	1,290	35	0.535	375
	1,300	30	0.540	252
	Mean		0.521	367

operation are affected by the influence of the boat's rolling due to swells, waves, winds and other unexpected irregularities on board, the calculated values V_w and F_w are represented with the mean values of the experiments as shown in the bottom part of Table 6.

From Table 6, the values of V_w and F_w at the hauling stage are given as,

$$V_w = 0.52 \text{ m/s}$$

and

$$F_w = 367 \text{ kgw}.$$

Peruvian small purse seiners operate usually at about 2/3 of the continuous revolution of the engine. This is the same as in the case of "UNA-I". As the continuous revolution of the engine of "UNA-I" is 1,800 rpm (Table 1), the value $V_w = 0.52$ m/s corresponds to $N_e = 1{,}250$ rpm. Therefore, the values obtained above V_w and F_w can be considered as the values under the condition at "standard fishing operation" of a Peruvian small purse seiner.

Aside from this, the condition at which the effective force of the winch F_w (367 kgw) at a standard fishing operation must be naturally larger than the fishing gear's weight in water (293 kgw in Table 2), was also met.

In this paper, the results obtained in the previous study were applied to a small Peruvian pures seiner. The values of the velocity and the force of a hydraulic purse winch were given as $V_w = 0.52$ m/s and $F_w = 367$ kgw, respectively, at standard fishing operation. The simplified method and its application are useful particularly in the Third World Countries, because the V_w and F_w of a hydraulic purse winch could be measured without utilizing special instruments. At the same time, the values V_w and F_w obtained can be used in the future study to examine the mechanical properties of a fishing gear during fishing operation.

Acknowledgment

The authors wish to thank Professor Víctor Paredes G., and Associate Professor and Captain of the "UNA-I" Lius Garayar M., the National Agricultural University (Universidad Nacional Agraria, La Molina) of Peru, for their sincere collaborations, and all the members of Department of Fishing Science and Technology (Departamento de Extracción Pesquera) of the same University for their help to realize experiments at sea.

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Nippon Suisan Gakkaishi : Formerly *Bull. Japan. Soc. Sci. Fish.*