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DESIGN OF FISHERMAN BOAT PULLING MACHINE FOR IMPROVING WORK EFFICIENCY AND WELFARE OF TRADITIONAL FISHERMEN AT PASIE KATAPIANG BEACH, PADANG PARIAMAN

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Abstract

This study aims to design an efficient boat-pulling machine to support traditional fishermen at Pasie Katapiang Beach, Padang Pariaman. The research method employed is the design of the tool based on the principles of design engineering, involving a systematic process in creating a machine that can assist fishermen in the boat docking process more efficiently. Through calculations and planning, it was found that the force required to pull the fishermen's boat is 6,522.88 N, using a shaft made of ST 37 material with a diameter of 22.413 mm. The rotations generated on the transmission shaft are 2000 rpm, while on the wheel and drum shafts are 750 rpm and 500 rpm, respectively. The selection of a slip clutch with 2 bolts on the transmission shaft and the use of pillow block bearing ucp 206 ass 30 with specified bearing life estimates have been considered in the machine design. Practical test results indicate that the time required to reel or pull the boat is 0.98 minutes. In this research, the design of the boat-pulling machine meets operational needs. It has the potential to positively contribute to improving the work efficiency and welfare of traditional fishermen in the field.

Keywords: Design, boat pulling machine, fishermen

INTRODUCTION

The coastal areas of Indonesia offer tremendous economic potential through their rich natural resources, particularly in the fisheries sector. With the world's second-longest coastline and thousands of islands scattered across its territory, Indonesia is home to many traditional fishing communities whose livelihoods depend on marine catches (Aminuddin and Agussalim Burhanuddin, 2023). However, amidst this natural wealth, challenges faced by traditional fishermen, especially in the process of beaching their boats, remain an unavoidable reality. Traditional fishermen, who typically use simple equipment and rely on human physical strength, often encounter difficulty beaching their boats (Prihatin, 2019). At Pasie Katapiang Beach, Padang Pariaman Regency, West Sumatra, a similar story unfolds where fishermen still rely on time-consuming and energy-intensive manual techniques. As a community living on the poverty line, efficiency in the boat beaching process is critical to improving the welfare of fishermen.

In this study, designing a fisherman boat pulling machine becomes increasingly urgent. This machine is expected to provide practical and efficient solutions for traditional fishermen, enabling them

to quickly and easily beach their boats. Furthermore, with simple and easy-to-operate equipment, this machine is also expected to be well-received by lower-middle-class fishermen, who constitute the majority of the fishing communities in Indonesia (Ginting, 2022; Goso and Anwar, 2017). This research provides innovative ideas and solutions to address the technical challenges in designing an efficient boat-pulling machine and advocates for efforts to improve traditional fishermen's social and economic welfare (Abidin As, 2019). By providing sustainable and affordable solutions, this research will significantly impact the daily lives of fishermen at Pasie Katapiang Beach. Its potential could be extended to other coastal areas in Indonesia.

The manual boat beaching process, which is still dominant at Pasie Katapiang Beach, Padang Pariaman Regency, West Sumatra, demands significant human effort and consumes considerable time. Innovation is needed to assist fishermen in overcoming this challenge and improve efficiency in the boat-beaching process (Hanik, 2021). Therefore, the plan to create a boat-pulling machine that is easy to use for lower-middle-class fishermen is a suitable step in providing practical and efficient solutions to improve the welfare of local fishermen (Dewi & Fakhrurrozi, 2021; Indriyani, Satriyo, and Sari 2017).

The construction of this machine is expected to address the challenges faced by the community at Pasie Katapiang Beach in beaching fishermen's boats. Additionally, the construction of this machine can also serve as a project for students involved in its making as part of their undergraduate thesis report. With the availability of this boat-pulling machine, it is hoped that the process of beaching fishermen's boats will become more accessible and more efficient, adding value to the daily lives of fishermen and serving as a tangible example of technological advancement that can be utilized to improve the welfare of coastal communities.

METHOD

The research methodology for designing the fisherman boat pulling machine aims to understand the needs and challenges faced by traditional fishermen at Pasie Katapiang Beach, Padang Pariaman.

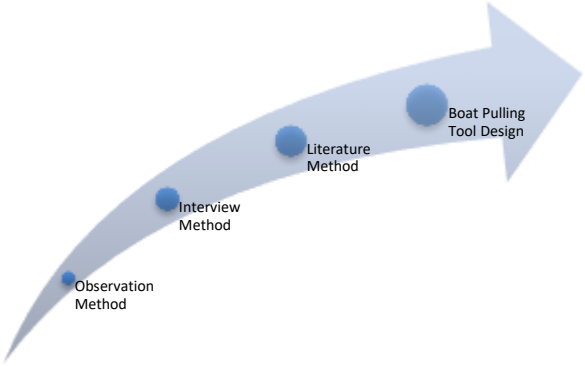


Figure 1. Scheme of the research methods implemented

1. Observation Method

This method involves direct field observations to record the problems encountered in the traditional fishermen's boat beaching process at Pasie Katapiang Beach. Observations are conducted meticulously to identify the obstacles fishermen face when beaching their boats. The data collected from observations will be used to analyze and improve the boat beaching process.

2. Interview Method

   This method involves interviews with supervisors and relevant parties, such as traditional fishermen, community leaders, or fisheries technology experts. Interviews are conducted to gain a deeper understanding of fishermen's problems and obtain input and perspectives from various stakeholders. The results of these interviews will be used as discussion material and references in the thesis writing.

3. Literature Method

   This method involves gathering information from literature and references relevant to the discussion topic, such as books, scientific journals, online articles, and other sources. The collected literature will be used as a theoretical foundation and as support for the arguments presented in this thesis. The literature search process is conducted systematically to ensure the obtained information is high quality and relevant to the research.

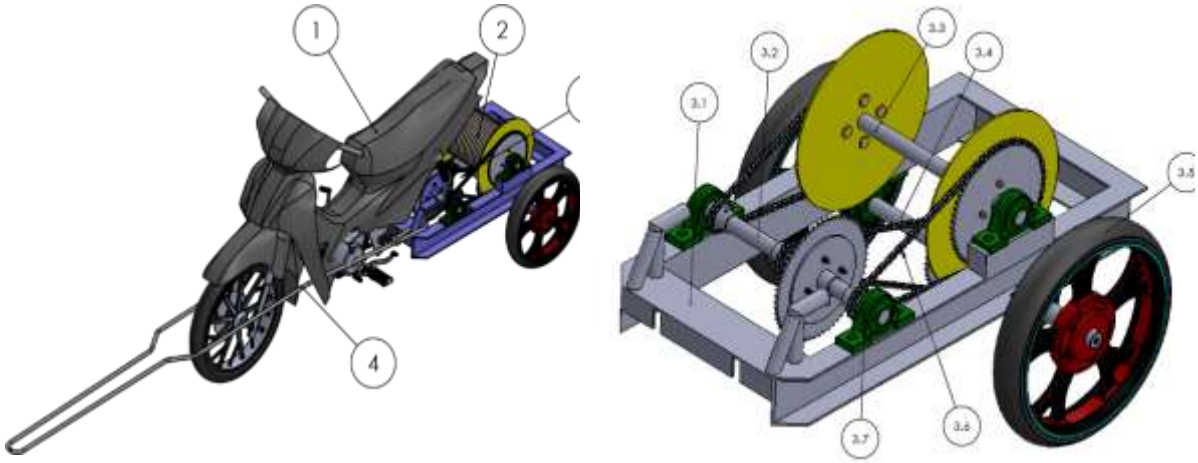
4. Boat Pulling Tool Design

   The design of the boat-pulling tool refers to designing a device or machine specifically designed to assist fishermen in pulling or beaching their boats. The main objective is to improve traditional fishermen's work efficiency and welfare by reducing the heavy physical workload and time required (Ardian & Purba, 2021).

Boat-pulling devices are typically designed considering various factors, such as the size and weight of the boat to be pulled, the natural conditions of the fishing location, and the abilities and needs of the fishermen who will use them (Asmara and Hasanudin 2021). This process involves technical aspects such as selecting solid and durable materials, ergonomic design to facilitate operation, and using appropriate technology to enhance tool efficiency and durability.

RESULTS AND DISCUSSION

The design of a boat-pulling tool in design engineering involves a systematic and structured process of creating a device or machine capable of assisting fishermen in beaching their boats more efficiently and effectively. The following are the design and components of the fisherman boat pulling machine, which can be seen in Figure 3:



(a) (b)

Figure 3. Design of the fisherman boat puller (b) Machine construction design

Figure description:

1. Pulling motor
2. Pulling rope
3. Machine construction

3.1 Frame

3.2 Transmission shaft

3.3 Drum roller

3.4 Wheel shaft

3.5 Rear wheel

3.6 Chain

3.7 Bearing

4. Mooring rope

The fisherman boat pulling machine's operation principle is based on using mechanical energy to move the boat from point A to point B more efficiently than manually using human power. The following are the general steps in the operation principle of the fisherman boat pulling machine:

1. Power Source: Fisherman boat-pulling machines typically utilize energy sources such as gasoline engines, diesel engines, or electric motors as the primary driving force. The power from these engines will be converted into the necessary mechanical movement required to pull the boat.
2. Transmission: The power from the engine is connected to a transmission system that can convert the engine rotation into the linear movement needed to pull the boat. Depending on the machine's design, this transmission can utilize various mechanisms, such as gearboxes or drive belts.

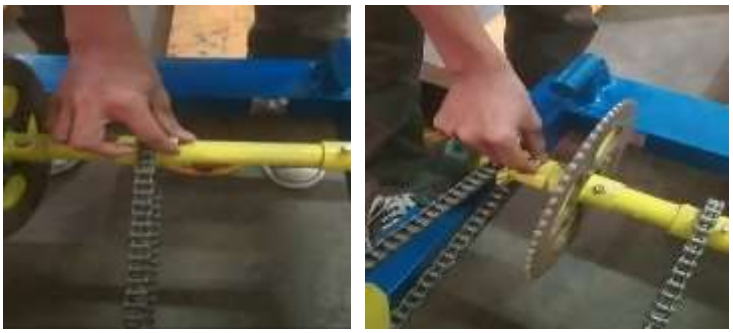


Figure 4. Installation of the drive sprocket pin on the drum

Drive Wheel: The linear movement from the transmission is then transmitted to the drive wheel directly connected to the boat. This drive wheel is placed at the bottom of the boat and propels the ground or sand surface at the beach.

Control: The boat-pulling machine has a control system that allows fishermen to adjust the speed and direction of the machine's movement as needed. This control can be a throttle to adjust engine rotation or a steering mechanism to change direction.

Additional Drive: In some designs, the boat-pulling machine can also be equipped with additional drives, such as tires or tracks that provide additional traction on uneven or muddy beach surfaces.

Several analyses used in the design of the boat-pulling machine involve calculation steps as follows:

1. Calculation of Force Required to Pull the Boat

   To calculate the force required for the boat [(Leni, D, Bahar, Z, and Bahar, Z 2018), it is known

   Mass (m) = 1 ton = 1000 kg

   The coefficient of sand friction (μ) = 0.5

   Beach slope (α) = 10°

   Acceleration (a) > 0 (moving forward)

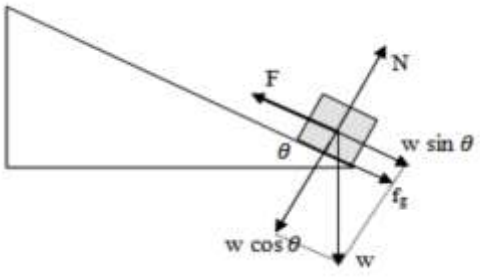


Figure 5. Force on an object on an inclined plane

Thus, the force required to pull the boat can be calculated as follows:

$F - w \sin \alpha - fg = m.a$

$F - m.g \sin \alpha - \mu . N = 1000. 0$

$F - m.g \sin 10° - \mu .w \cos \alpha = 0$

F – m.g sin 10° - μ. m. g cos 10° = 0

F = m.g sin 10° + μ. m. g cos 10°

F = 1.000. 9,8. sin 10° + 0,5. 1.000. 9,8. cos 10°

F = 1.701,28 + 4.821,6

F = 6.522,88 N

So, the force required to pull a fisherman's boat weighing 1000 kg is 6,522.88 N.

2. Sprocket and Chain Calculation

The calculation of Sprocket Diameter (Putra, F. K, Safril, S, and Leni, D 2019; Leni, D, Bahar, Z, and Bahar, Z 2018) utilizes the following analysis:

a) Large Diameter (Db)

$$Db = \frac{p}{\sin\frac{180}{zb}}$$

$$Db = \frac{12,7}{\sin\frac{180}{60}}$$

Db = 242,663 mm

b) Medium Diameter (Dm)

$$Dm = \frac{p}{\sin\frac{180}{zm}}$$

$$Dm = \frac{12,7}{\sin\frac{180}{40}}$$

Dm = 161,868 mm

c) Small Diameter (Dk)

$$Dk = \frac{p}{\sin\frac{180}{zk}}$$

$$Dk = \frac{12,7}{\sin\frac{180}{15}}$$

Dk = 61,084 mm

d) Large Outer Diameter (Dlb)

$Dlb = Dpb + (1,25 \,.\, p) - Dr$

Dlb = 242,663 + (1,25 . 12,7) − 7,95

Dlb = 250,588 mm

e) Large Outer Diameter (Dlb)

Dlm = Dpb + (1,25 . p) − Dr

Dlm = 161,868 + (1,25 . 12,7) − 7,95

Dlm = 169,793 mm

f) Small Outer Diameter (Dlk)

Dlk = Dpk + (1,25 . p) − Dr

Dlk = 61,084 + (1,25 . 12,7) − 7,95 Dlk = 69,009

mm

Calculation of Sprocket and Chain from Engine to Middle Transmission Shaft

a) Rotation of the large sprocket

$$n_b = \frac{n_k . z_k}{z_b}$$

$$n_b = \frac{7500.15}{60}$$

$n_b = 2000$ rpm

b) Chain speed (v) [11],

$V = \frac{p.n.Z}{60\times1000}$ (m/s)

$$V = \frac{12,7 . 2000. 60}{60 \times 1000}$$

$V = 25,4\ m/s$

c) The load exerted by the sprocket on the chain,

$F = \frac{200xDb}{v}$ kg

$F = \frac{200x60}{25,4}$

$F = 472,44$ kg

d) Tensile strength of the chain,

$f_t = s_f x f$

The value of s_f used for tensile strength is 10.

$f_t = 10x\ 472,44$

$f_t = 4724,4$

e) Length of chain pitch

$$L_p = \frac{z_1 + z_2}{2} + \frac{2c}{p} + \frac{\{(z_2 - \frac{z_1}{2\pi})^2}{c/p}$$

$$L_p = \frac{60 + 15}{2} + \frac{2.436,22}{12,7} + \frac{(15 - \frac{60}{2.3,14})^2}{436,22/12,7}$$

$$L_p = \frac{75}{2} + \frac{872{,}44}{12{,}7} + \frac{29{,}659}{34{,}348}$$

$$L_p = 37{,}5 + 68{,}696 + 0{,}863$$

$$L_p = 107{,}059\ mm$$

Here is the table of results from the analysis of the components as obtained, which can be seen in Table 1.

Table 1: Overall Results in Calculations

No	**Parameter**	**Calculation Result**
1.	Force required	6.522,88 N
2.	Large sprocket diameter	242,663 mm
3.	Medium sprocket diameter	161,868 mm
4.	Small sprocket diameter	61,084 mm
5.	Rotation of sprocket Shaft 1	2000 rpm
6.	Chain speed Shaft 1	25,4 m/s
7.	Rotation of sprocket Shaft 2	500 rpm
8.	Chain speed Shaft 2	6,35 m/s
9.	Rotation of sprocket Shaft 3	750 rpm
10.	Tensile strength of Shaft 3	6,35 m/s
11.	Twisting moment	2615,19 kg. mm
12.	Shear stress	3,08 Kg/mm^2
13.	Shaft diameter	22,413 mm
14.	Maximum torque	25,653 N/m
15.	Force in bolt	22,694 kN
16.	M_a	18,1552 Nm
17.	Bearing unit number	UCP 206
18.	Bearing lifespan 1	8 tahun 9 bulan
19.	Bearing lifespan 2	5 tahun 7 bulan
20.	Bearing lifespan 3	1 tahun 2 bulan
21.	Drum roller rotation	32,757 $putaran$
22.	Rolling time	0,98 $menit$

f) Specifications of the Fisherman Boat Pulling Machine

The specifications of the designed fisherman boat pulling machine can be seen in Table 2.

Table 2. Specifications of the fisherman boat pulling machine

No.	**Type**	**Specifications**
1.	Mesin	Supra motorcycle x 100
2.	Daya maksimum	7,3 Ps / 8000 rpm = 5,37 kW
3.	Sproket	15 T , 40 T , 60 T
4.	Rantai	428 -110
5.	Sistem transmission	Clutch flange
6.	Poros transmisi	500 x Ø 30
7.	Slonsong kopling	Steel pipe
8.	Ukuran slongsong	60 x Ø 30
9.	Breacket sproket 60 T	Steel plate
10.	Ukuran breacket sproket 60 T	5 x Ø 170
11.	Bracket sprocket 40 T	Steel plate
12.	Ukuran breacket sproket 40 T	5 x Ø 100
13.	Bantalan	UCP 206 Ass 30 mm

No.	Type	Specifications
14.	Rangka	U-profile steel
15.	Ukuran rangka	950 x 500 x 100
16.	Poros drum	500 x Ø 30
17.	Dinding drum	Steel plate
18.	Ukuran dinding drum	5 x Ø 350
19.	Velg belakang	14 inch
20.	Ban belakang	80 /90 14 inch
21.	Poros roda	765 x Ø 30
22.	Spacer external velg	Steel pipe
23.	Ukuran spacer external velg	30 x Ø 30
24.	Spacer inner velg	Steel pipe
25.	Ukuran spacer inner velg	90 x Ø 30
26.	Baut kopling	M8
27.	Baut breacket	M10
28.	Baut poros roda	M 12
29.	Baut bearing	M22
30.	Tali panarik	Mooring rope Ø 16
31.	Tali penambat	Mooring rope Ø 16

The machine design and implementation results can be seen in Figures 6 and 7. The operation of the fisherman boat pulling machine can be briefly described as follows:

a. Step 1: The restraining rope of the fisherman boat pulling machine is connected to the land pylon. It is done to provide stability to the machine during the boat-pulling process.
b. Step 2: The pulling rope of the fisherman boat pulling machine is attached to the boat on the beach. This process allows the machine to transfer its pulling force to the boat efficiently.
c. Step 3: The sprocket pin on the transmission shaft is released to initiate the pulling operation. This step is the driving action, activating the sprocket on the rear wheel shaft to initiate movement and pull the fisherman's boat.

The operation of this machine is designed to create a simple yet effective system, ensuring that the fisherman boat pulling machine can operate well in supporting fishing activities on the beach (Wahyudi & Sutisna 2021).

Figure 6. Connection of the pylon rope

Figure 7. Connection of the boat pulling rope

Efforts to improve the efficiency of work and the welfare of traditional fishermen working at Pasie Katapiang Beach, Padang Pariaman, are one form of in-depth research that has been conducted. The main focus of this research is to design a boat-pulling machine that not only meets the operational

needs of fishermen but also significantly improves their fishermen's working conditions and welfare. By considering various technical and practical factors and integrating careful calculations, this research aims to provide reliable and effective solutions for traditional fishermen in pulling traditional fishing boats at Pasie Katapiang Beach, Padang Pariaman.

CONCLUSION

Several key findings have been identified in formulating conclusions from the calculations and planning in the design of the fisherman boat pulling machine. First, based on the calculations, it was found that the force required to pull the fisherman's boat is 6,522.88 N. Additionally, the shaft used in this machine is made of ST 37 material with a carbon content of 0.2% and a diameter of 22.413 mm, according to the calculations. Furthermore, the rotation generated on the transmission shaft is 2000 rpm, while the rotation on the wheel shaft and drum shaft are 750 rpm and 500 rpm, respectively. The machine design has also considered a slip clutch with bolts using 2 bolts on the transmission shaft. The bearings used are bearing pillow block UCP 206 ASS 30, with estimated bearing lifespans for each shaft determined as 8 years 9 months, 5 years 7 months, and 1 year 2 months for the transmission shaft, wheel shaft, and drum shaft, respectively. Finally, the time required to wind or pull the boat in practical testing is 0.98 minutes. Therefore, based on the results of this research, it can be concluded that the design of the fisherman boat pulling machine has produced parameters that meet operational needs and can significantly contribute to improving the efficiency and welfare of traditional fishermen in the field.

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