
DEVELOPMENT OF A PRESSURE-BASED AUTOMATIC EMERGENCY RELEASE SENSOR SYSTEM TO IMPROVE SAFETY IN RECOVERY BUOY OPERATIONS ON AHTS VESSELS

Beautiful Princess Safiira*, Samsul Huda, Fitri Kensiwi

Polytechnic of Maritime Science Semarang, Indonesia

*Corresponding author: wspotri0@gmail.com

Abstract

The buoy recovery process on the Anchor Handling Tug and Supply (AHTS) vessel is one of the important operations in supporting offshore oil drilling activities. This activity involves using devices such as a buoy catcher and a work wire connected to a shackle to lift the buoy to be recovered. However, operational problems often occur because the operator's manual response to the wire tension monitor is less than optimal, increasing the risk of equipment failure, including breaking off the buoy catcher or other towing equipment. This condition endangers crew safety and reduces operational efficiency. This research aims to develop an automatic sensor capable of detecting excessive pressure which can also be set to a maximum of 3x the SWL of the towing device used during the recovery process and provide a response in the form of automatic release of the hook when it is safe pressure limit is exceeded. This system is designed to improve work safety and prevent potential equipment damage. The research approach used is the Research and Development (R&D) method, which includes data collection through observation, questionnaires, and animation-based simulations to visualize system performance. The research results show that the developed automatic sensor system can significantly improve buoy recovery operational safety by eliminating dependence on manual operator responses. By integrating this technology, shipping companies can create new safety and operational efficiency standards, especially for AHTS vessels operating in high-risk environments.

Keywords: Animation simulation, Automatic sensors, Maritime technology, Recovery buoy, Work safety.

INTRODUCTION

Indonesia is a maritime country. The Great Dictionary of the Indonesian Language defines maritime as relating to the sea; relating to shipping and trade at sea (Kemdikbud, 2021). As a maritime country, it has great potential in the marine sector, such as deep waters, shipping, ocean wave energy, marine tourism, and fisheries. In addition, around 70% of Indonesia's oil potential is found in 40 oil basins on the seabed. To manage and utilize these natural resources optimally, Indonesia requires efficient sea shipping facilities, including the operation of AHTS type supply ships which plays an important role in supporting oil and gas exploration in offshore oil fields.

Anchor Handling Tug and Supply (AHTS) is a multifunctional vessel in carrying out anchor handling/Anchor job, towing and supply cargo for offshore oil drilling activities. Anchor Job is the process of carrying out and managing anchor and bouy work starting from retrieving, lifting, and carrying anchors and buoys to placing them in predetermined positions. The stages of the process of retrieving and lifting anchors and buoys are known by offshore workers as buoy recovery.

Anchor Job has a high level of difficulty and risk, so it requires qualified human resources in their work, supported by the facilities and infrastructure (equipment) needed to ensure that the

anchor job is carried out according to work safety standards. In the implementation of Anchor job where researchers carry out sea practice on the AHTS. Pelangi Escort 2 ship which is one of the Indonesian-flagged offshore supply ships owned by PT. Pelangi Niaga Mitra Internasional and chartered by PT. Indoliziz Marine where the company where the researcher carries out sea practice operates in Pertamina Hulu Mahakam which the researcher will hereinafter refer to as PHM. The AHTS. Pelangi Escort 2 ship was requested by PHM Company Man to carry out recovery breakdown buoy no.1 at the offshore oil drilling location owned by PHM on the WPN platform in the Nubi Offshore Field area, because the platform will be used by one of the Accommodation Work Barges (AWB) chartered by PHM to carry out electrical installation maintenance on the platform.

According to the researcher's experience during practice as a Deck Cadet on the AHTS. Pelangi Escort 2 ship has just experienced a delay in anchor job for the first time. As the ship started work at 06.48 WITA on October 18, 2023 until it finished at 10.18 WITA on October 19, 2023. Which previously in the implementation of the work never took more than a quarter of a day. Thus, the result of the delay in the work caused the operational activities of PHM to be hampered. The table of the time period for the buoy recovery process by the AHTS. Pelangi Escort 2 ship that the researcher experienced during the Sea Practice (prala):

Table 1 Recovery buoy process time period on AHTS. Rainbow Escort 2 During 2023

Date	Time (WITA)		Period		
	Start	Finished	Day	Hour	Minute
02/08/2023	10:51	16.00	0	5	9
03/08/2023	07:30	11:32	0	4	2
10/18/2023	06:48		1	3	30
10/19/2023		10:18			

Source: Researcher (2024)

AHTS. Pelangi Escort 2 ship experienced obstacles and constraints caused by several factors in the implementation of recovery breakdown buoy no. 1. Starting from the condition of breakdown buoy no. 1 which was tilted due to water entering from the manhole which was not tight, making the buoy heavier several times so that it was difficult to lift onto the ship. As well as the condition of the AHTS. Pelangi Escort 2 ship which was trim by head could affect the buoy recovery process. The buoy recovery procedure is one of the most critical parts in supporting offshore oil drilling activities by AHTS ships. This process requires reliable equipment to lift damaged buoys, but manual methods are often an obstacle due to the lack of efficiency and accuracy in responding to excessive pressure on the towing tool.

Wire tension monitors have become standard tools used to detect loads during operations, but they rely on the operator's reflexes, which are sometimes slow to respond. As a result, equipment failures such as broken buoy catchers and penant wires are major threats that can cause work accidents and operational losses. Dynamic marine environmental conditions further increase this risk. As shown in previous research on the Pelangi Escort 2 AHTS, buoy recovery efficiency is greatly influenced by buoy conditions, ship conditions, and external factors such as weather and sea waves. The limitations of the manual system that still relies on crew observation often cause a delay in response to press the emergency release button when realizing that the work wire pulling pressure has exceeded the maximum SWL limit of the pulling device and there is a safety risk.

This research is designed to overcome these challenges by creating an autonomous pressure-based sensor that can work independently. This sensor can detect excess pressure in real-time and provide an automatic response in the form of work wire relaxation if the pressure limit is exceeded. This technology is expected to improve safety and efficiency, while introducing a new standard in AHTS vessel operations.

LITERATURE REVIEW

The researcher discusses in depth the related theories to be able to more easily understand the contents of the thesis in its creation. The researcher takes several references from reliable sources that serve as guidelines and provide a deeper understanding of the theories and terms related to the problems and analysis of problem solving in this thesis, as follows:

1. Boat AHTS

Anchor Handling Tug and Supply (AHTS) is a ship specifically designed to support offshore oil drilling activities that act as work vessels, transportation and accommodation for a number of other workers who participate in offshore oil drilling activities. Anchor Handling is one of the special jobs of the AHTS ship, where the work is carried out in the oil field area, anchor handling is specifically for work barges and rigs in the process of moving from the old location to the new location (Afdhani, 2024). Michael Hancox (2015) revealed that the operation of Anchor handling is the implementation and stages of handling anchors, starting from how to take, lift and carry it and then place it in the desired position based on the request of the rig / barge master, where the anchor functions to hold the rig / barge so that it does not drift and remains in its position.

2. Buoy

A buoy is a floating tool that acts as a marker to show differences in the use of an area, or a marker for dropping water. and as a guide for the ship to anchor (Boo & Shelley, 2021). In the context of offshore drilling, a "breakdown buoy" (or "breakdown buoyancy tank") usually refers to a buoy or buoyancy tank used as part of an anchoring or mooring system for vessels operating in the vicinity of a rig.

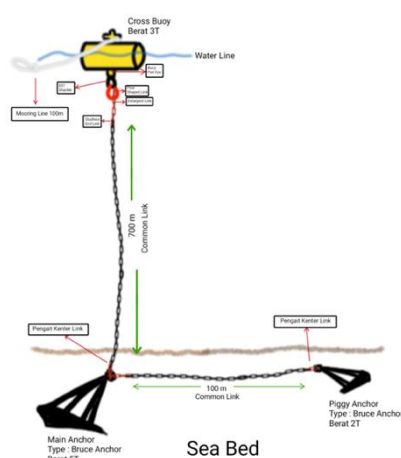


Figure 1 Breakdown buoy system circuit
Source: Researcher (2024)

3. Recovery Buoy Process

Buoy Recovery is the process of lifting buoys, pennant wires, anchor chains, main anchors, and piggy anchors from the seabed, placed on the ship's deck or on the stern (stern roller), then sent to the port, rig or transported to the barge. The buoy recovery process involves complex operations that utilize tools such as buoy catchers to lift the buoy onto the ship's deck. According to Barstow (1997), failure in this process is often caused by uncontrolled pressure on cables and equipment.

4. Wire Tension Monitor Technology

Wire tension monitor is a tool that detects tension on the cable manually. However, as stated by Gittell (2003), this tool has limitations in dynamic work environments because it requires direct operator interaction to prevent failure.

5. Pressure Sensor

Pressure-based sensors have been widely used in various industrial sectors to automatically detect pressure changes and reduce the risk of failure. Tufano (2017) explains that this technology is very effective in improving system reliability in high-risk environments. Animated simulations show that pressure sensors can detect excess pressure with high accuracy. When the pressure exceeds the safe limit, the system automatically releases the working hook, preventing failures such as the breaking of the buoy catcher which often occurs in manual processes. Data from AHTS research shows that the contribution of buoy conditions is 34% to buoy recovery efficiency, so this automation solution is relevant to reducing operational time and risk.

6. Weather and Ocean Wave Factors

Weather and climate are two terms related to air conditions in the atmosphere. The definition of weather is the daily atmospheric conditions that can occur and change in a short time in a narrow area. Meanwhile, climate is interpreted as the average annual weather conditions and covers a wide area (Gibbs in Handoko, 2019). Ocean waves (Waves) are the movement of water rising and falling in a direction perpendicular to the sea surface that forms a sinusoidal graph/curve (Djabbar in Faharuddin *et al.*, 2019).

The animation shows the direct impact of waves up to 2-3 meters high on the stability of the ship and buoy. In this condition, the manual system requires close supervision which increases the work pressure of the crew. With an automated system, the influence of weather factors on efficiency can be minimized, as suggested by the results of multivariate regression testing in the article "The Impact of Buoy Conditions and AHTS. Pelangi Escort 2 Ship on the Efficiency of the Breakdown Buoy Recovery Implementation Process".

7. Research Framework

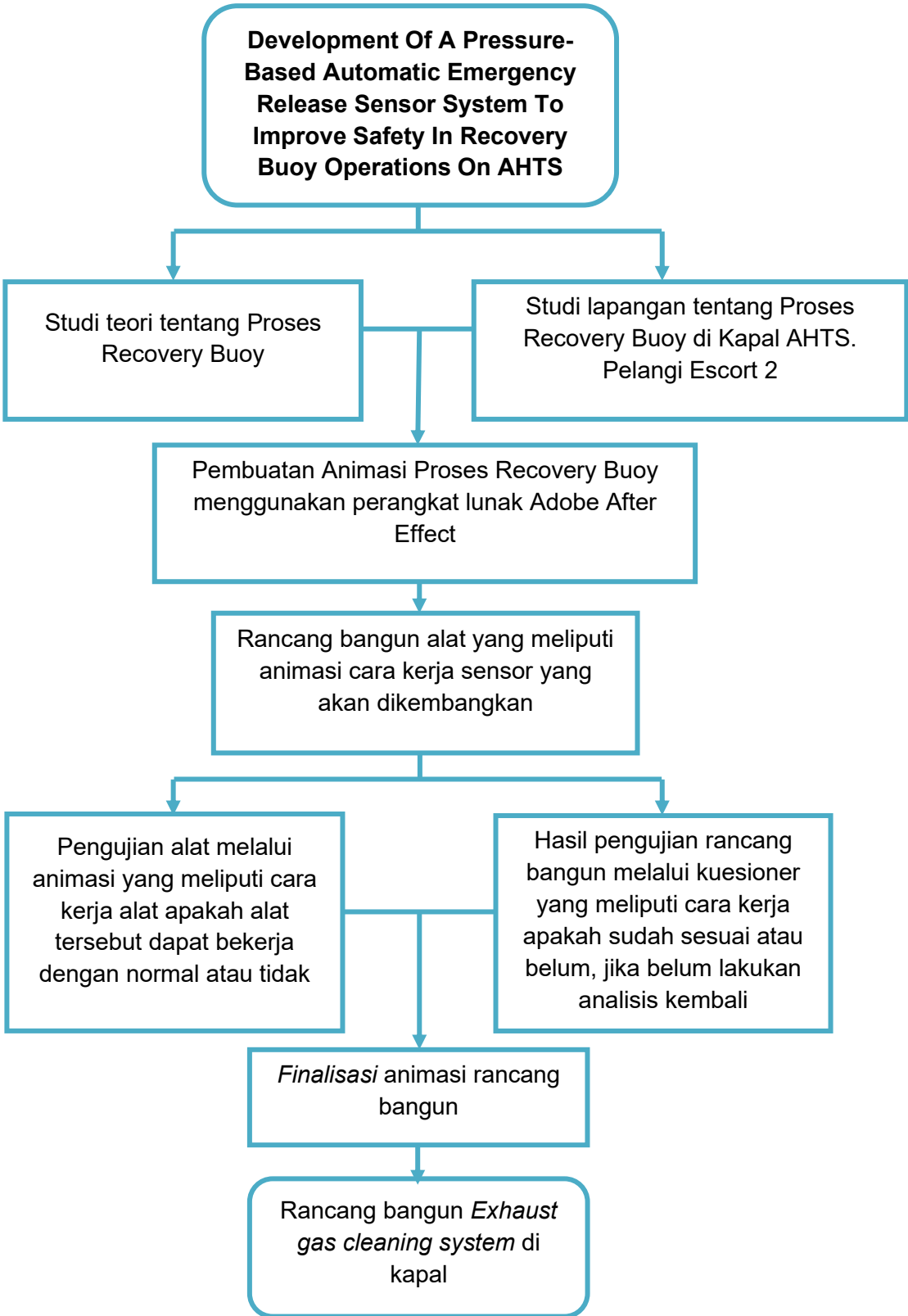


Figure 2 Research framework

RESEARCH METHOD

1 Research Design

This study uses the Research and Development (R&D) method, which is designed to produce a product in the form of a prototype of an automatic pressure-based sensor. The R&D process in this study refers to the model developed by Borg & Gall (2003), which consists of several stages, namely: identification of needs, product design, validation, implementation, and evaluation.

This model is suitable for technology-based research because it allows integration between technical development and practical evaluation. The R&D stages in this study include the observation process, data collection through questionnaires, prototype design, and animation-based simulation to validate the effectiveness of the sensor system.

2 Location and Time of Research

This research was conducted on board the AHTS Pelangi Escort 2 vessel operating in the offshore drilling area of Pertamina Hulu Mahakam (PHM). The research period includes 2 months of observation, starting from primary data collection to system testing.



Figure 3 AHTS Ship. Rainbow Escort 2

Source: Ship Documents (2023)

3 Data collection technique

This study uses three main techniques to collect data, namely:

a. Observation

Observations were made directly during the buoy recovery process to understand the technical and social constraints in manual operations. The focus of observations was on crew interactions, operator responses to wire tension monitors, and equipment failures such as buoy catchers.

b. Questionnaire

The questionnaire was designed to obtain the crew's perception of the current manual system and evaluate the potential for implementing automated sensors. The population of this study was the AHTS crew, including captains, deck officers, engine officers, and ship's crew. With a census sampling technique, a total of 31 people. The questionnaire used a Likert scale (1–5) with dimensions of communication, work efficiency, and safety.

Table 2 Likert scale weighting

Alternative Answers	Code	Weight
Strongly Disagree	STS	1
Don't agree	TS	2
Doubtful	R	3
Agree	S	4
Strongly agree	SS	5

Source: Researcher (2024)

The list of statements includes 2 variables which include 1 independent variable, as well as 1 dependent variable along with the respective indicator criteria which are displayed in the following table. :

Table 3 Research questionnaire table

No	Variables	Dimensions	Indicator	Statement
1.	Automatic Sensor System (X)	Detection Reliability	Accuracy in detecting overpressure in real-time	1. Automatic sensors can detect overpressure accurately in real time.
			Ability to minimize errors	2. The sensor system reduces errors that often occur in manual systems.
		Response to Pressure	Automatic system response time to overpressure	3. The automatic sensor system provides a quick response to pressure exceeding safe limits.
			Accuracy in loosening work wire	4. The automatic system precisely loosens the work wire in case of excessive pressure.
2.	Efficiency and Safety of the Recovery Buoy Process (Y)	Operational Efficiency	Reduced reliance on manual operators	5. The implementation of automated sensors reduces

No	Variables	Dimensions	Indicator	Statement
				reliance on operators for decision making.
			The implementation of automated sensors reduces dependence on operators for decision making.	6. Automated systems help speed up the buoy recovery process.
			Accident risk reduction	7. The automatic sensor system helps reduce the risk of accidents during the buoy recovery process.
	Work safety		Equipment protection	8. The use of automatic sensors prevents damage to equipment such as buoy catchers and penant wires.
		Time Efficiency	Reduction of operational time	9. The use of automatic sensors speeds up the buoy recovery process compared to manual methods.

Source: Researcher (2024)

c. Animation Simulation

Simulations were performed using Adobe After Effect software to visualize the automatic sensor response to overpressure. These simulations helped evaluate the effectiveness and reliability of the system under various pressure scenarios.

4 Data Analysis Techniques

quantitative and qualitative approaches. Bryman (2021), in the book "Social Research Methods", states that quantitative research attempts to measure and analyze the relationship between variables using statistically processed data to explain or predict the phenomena being measured. Meanwhile, qualitative research is research that needs to be carried out after a problem

has been studied quantitatively, but the solution has not been revealed (Rusandi & Muhammad Rusli, 2021).

a. Quantitative Analysis

Data from the questionnaire were analyzed using descriptive statistics to see the crew's perceptions of the manual system and automatic sensors. This analysis includes frequencies, means, and standard deviations to identify response patterns. In addition, validity tests and reliability tests will also be carried out to ensure that the research instrument produces valid and consistent data.

b. Qualitative Analysis

Observation data and simulation results are analyzed descriptively to understand the operational dynamics and effectiveness of automatic sensors under real conditions.

5 Sensor Prototype Design

The automatic sensor prototype was developed with the following main components:

- a. Pressure Sensor: Designed to detect pressure up to 3 times the SWL (Safe Weight Load) of the towing tool.
- b. Control Module: Uses a microprocessor to manage signals from sensors.
- c. Automatic Release Mechanism: Automatically disconnects the working link if the pressure exceeds the safe limit.

6 Research Stages

- a. Problem Identification: Conducted through field observation and primary data collection.
- b. Prototype Design: Using a design based on the operational needs of the recovery buoy.
- c. Simulation Validation: Prototypes are tested under various stress scenarios through animation using keyframe animation and visual-based effects to create movement.
- d. System Evaluation: Data from the questionnaire and simulations were used to evaluate the effectiveness of the system.

RESULTS AND DISCUSSION

1. Questionnaire Data Analysis Results

Questionnaire data collected from 31 AHTS ship crew respondents showed a positive perception of the potential for implementing automatic pressure-based sensors. The following shows the identities of respondents described using absolute frequency distribution and percentages, further analysis is grouped by age, gender, education level and length of service as follows :

Table 4 Respondent frequency distribution table

Information	Frequency (People)	Percentage (%)
Gender :		
Woman	2	6.5
Man	29	93.5
Age :		
21 – 30 years	6	19.4

Information	Frequency (People)	Percentage (%)
31 – 40 years	5	16.1
41 – 50 years	16	51.6
>5 1 year	4	12.9
Last education :		
ANT/ATT 1	13	41.9
ANT/ATT 2	11	35.5
ANT/ATT 3	7	22.6
ANT/ATT 4	0	0
ANT/ATT 5	0	0
Other	0	0
Sailing Experience		
0– 5 years	4	12.9
6 – 10 years	5	16.1
11 – 15 years	3	9.7
16 – 20 years	7	22.6
>20 years	12	38.7

Source: Researcher (2024)

The majority are aged 41-50 years (51.6 %), the productive age for working at sea with high risks. Mostly male (93.5 %), this dominance is in accordance with the characteristics of sailor work which requires physical strength and long working hours. The majority had ANT/ATT 1 (41.9 %) and ANT/ATT 2 (35.5 %) degrees, meeting the minimum standards for nautical or engineering professionals. Most have >20 years of experience (38.7 %), showing high work experience with certification and adequate problem-solving skills.

The results of the respondents' answers, description of the Automatic Sensor System variable (X) are shown from the following data processing results:

Table 5 Automatic sensor system variable description table (X)

Variable	Mean	Median	Mode	Minimum	Maximum
X1	4,39	5	5	3	5
X2	4,42	4	5	3	5
X3	4,35	4	5	3	5
X4	4,48	5	5	3	5

Source: Researcher (2024)

The results of respondents' answers, descriptions of the variables of Efficiency and Work Safety of the Recovery Buoy Process (Y) are shown from the following data processing results:

Table 6 Description table of variables for efficiency and work safety of the recovery buoy process (Y)

Variable	Mean	Median	Mode	Minimum	Maximum
Y1	4,35	5	5	3	5
Y 2	4,03	4	5	1	5
Y 3	4,65	5	5	3	5
Y 4	4,52	5	5	3	5
Y5	3,84	4	4	1	5

Source: Researcher (2024)

From the two tables of the results of the description of the variables, it is illustrated that the average value of the respondents' answer choices is visible and represented by the mean number ranging from 3 to 4 and above, meaning that on average the respondents chose the answer agree to strongly agree. Descriptive statistical analysis produces several important findings. :

- Detection Reliability: Most respondents stated that the automatic sensor has high accuracy in detecting overpressure in real-time.
- Response to Pressure: Respondents indicated that the system provides a fast response, thereby reducing the risk of failures such as breakage of the pennant wire or buoy catcher.
- Operational Efficiency: The automated sensor system is considered capable of reducing dependence on manual operators and speeding up the buoy recovery process.

In addition to the above description test, for the first analysis carried out with a validity test of a sample, data processing can be carried out with the first test, namely the adequacy of the sample used in the study. The adequacy of the sample can be seen if the R count value > R Table, then the statement is said to be Valid, if the R count value < R Table, then the statement is said to be Invalid. For R Table from 31 respondents with a significance of 5% is 3.55.

n	Taraf Signifikan		n	Taraf Signifikan		n	Taraf Signifikan	
	5%	1%		5%	1%		5%	1%
3	0,997	0,999	27	0,381	0,487	55	0,266	0,345
4	0,950	0,990	28	0,374	0,478	60	0,254	0,330
5	0,878	0,959	29	0,367	0,470	65	0,244	0,317
6	0,811	0,917	30	0,361	0,463	70	0,235	0,306
7	0,754	0,874	31	0,355	0,456	75	0,227	0,296
8	0,707	0,834	32	0,349	0,449	80	0,220	0,286
9	0,666	0,798	33	0,344	0,442	85	0,213	0,278
10	0,632	0,765	34	0,339	0,436	90	0,207	0,270

Figure 4. R Table

Source: <https://images.app.goo.gl/A1HkFSieDPLdNFT46> (2024)

The results of the validity test of this research, where each statement was proven valid, are as follows:

Table 7 Validity test results

No	Variables	Indicator	R Count	R Table	Information
1.	Automatic Sensor System (X)	X1	0.76	0,355	Valid
		X2	0.80	0,355	Valid
		X3	0.63	0,355	Valid
		X4	0.58	0,355	Valid
2.	Efficiency and Safety of the Recovery Buoy Process (Y)	Y1	0.51	0,355	Valid
		Y2	0.86	0,355	Valid
		Y3	0.53	0,355	Valid
		Y4	0.59	0,355	Valid
		Y5	0.83	0,355	Valid

Source: Researcher (2024)

The level of reliability of a variable or research construct can be observed based on the results of the Cronbach Alpha (α) statistical test. The variable is said to be reliable if it meets the requirements of the Cronbach Alpha value > 0.60 (Sugiyono, 2022). The closer the alpha value is to one, the more reliable or "reliable" the data reliability value will be. The results of the reliability test of this study which are said to be reliable can be observed in the following table :

Table 8 Reliability test results

No	Variables	Cronbach's Alpha	Rule of Thumb	Information
1.	Automatic Sensor System (X)	0.64	0,60	Reliable
2.	Efficiency and Safety of the Recovery Buoy Process (Y)	0.70	0,60	Reliable

Source: Researcher (2024)

2. Animation Simulation

Animated simulations based on Adobe After Effects show that automatic sensors can detect pressures exceeding safe limits (up to 3x the SWL of the pulling tool) and provide a response by automatically releasing the work hook. Simulation results include:

a. Effectiveness of Automatic Sensor System

The animation shows that the automatic sensor system is able to detect excessive pressure in real time with a high degree of accuracy. When the pulling pressure on the work wire reaches the maximum limit of 3x the SWL (Safe Working Load) of the pulling tool, the sensor immediately triggers the automatic work wire slackening mechanism, reducing the risk of tool failure such as cable breakage or damage to the buoy catcher.

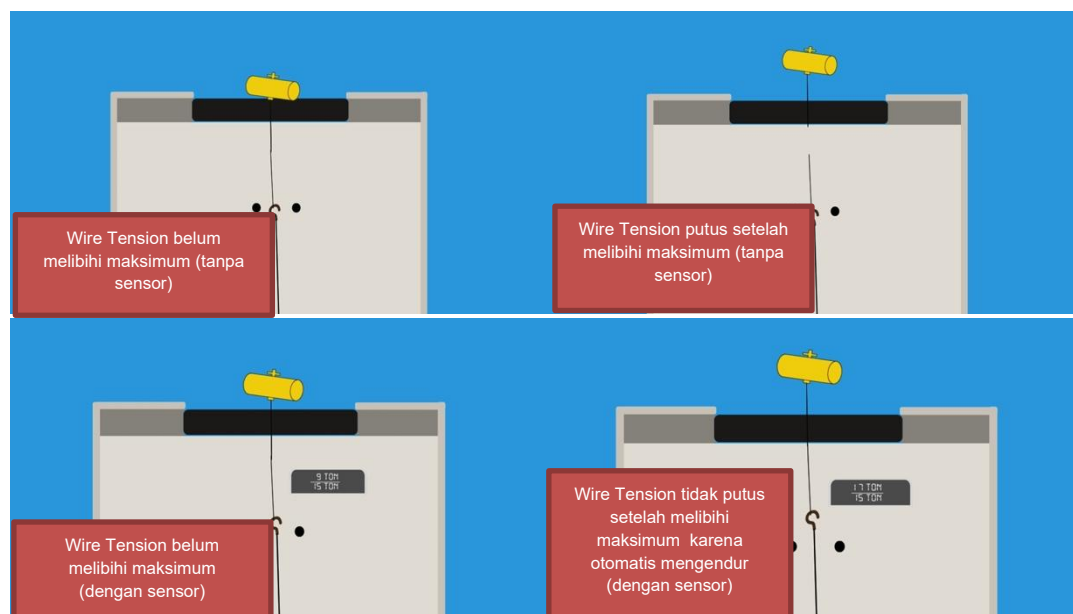


Figure 5. Wire tension sensor working principle animation

Source: Personal Document (2024)

b. Operational Efficiency

Based on simulations, this automatic system has succeeded in accelerating the buoy recovery duration by 30-40% compared to the manual method. This is in line with data showing that the manual method often requires additional time due to the operator's delayed response to excessive pressure. If the operator is late in responding to the emergency release, it will result in the towing aid breaking, because it takes more time to find a replacement tool to pull the target buoy.



Figure 6 Manual Emergency Release Button

Source: Personal Documentation (2023)

c. Improving Occupational Safety

The automatic sensor system significantly reduces the reliance on operator reflexes, which is often the main cause of work accidents. The simulation shows how the sensor works consistently despite dynamic sea conditions (2-3 meter waves), providing better protection for the crew. With the automatic release sensor, things like the one in the picture will not happen again.



Figure 7 Buoy catcher breaks due to buoy getting caught so that the tension increases
Source: Personal Documentation (2023)

d. Social Impact: Team Communication and Coordination

The implementation of this automated technology also has an impact on reducing the crew's workload, so they can focus more on communication and coordination aspects. This improves the effectiveness of teamwork during buoy recovery operations.

e. Validation Through Animation Simulation

Animation using visualization software shows the system performance in various stress scenarios. As a result, the system prototype successfully executes automatic responses in each scenario without any delay. Simulation image shows the automatic release mechanism when the pressure reaches the maximum allowable limit. This provides a real visualization of the effectiveness of the designed system.

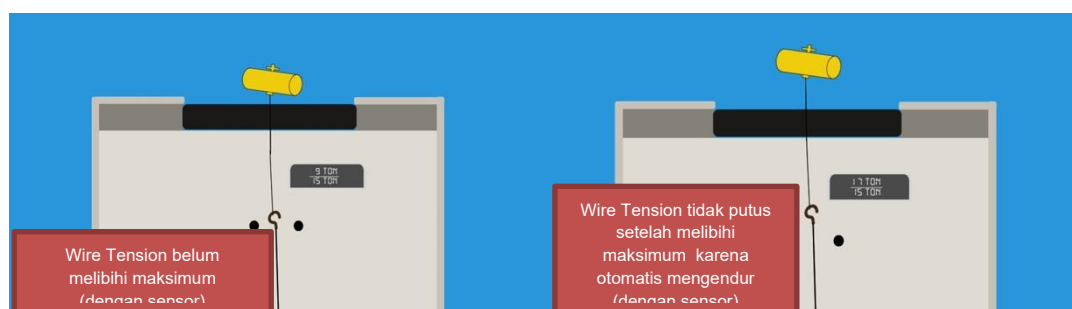


Figure 8 Wire tension sensor system performance simulation
Source: Personal Document (2024)

3. Discussion

a. Reliability of Automated Systems

The results of this study indicate that automatic pressure-based sensors have great potential in improving operational safety. In line with Tufano's research (2017), the automatic system has proven effective in detecting and responding to excessive pressure in high-risk work environments.

b. Improving Occupational Safety

Manual failure in using wire tension monitor is often caused by lack of operator response time. With the presence of an automated system, this risk can be minimized. These results support Gittell's (2003) theory about the importance of automation in improving system reliability.

c. Operational Time Efficiency

The reduction in the buoy recovery process time from more than 5 hours to less than 4 hours is one of the significant results of the implementation of this system. This finding is also supported by Barstow's research (1997), which emphasizes the importance of time efficiency in maritime operations.

d. Obstacles and Solutions

Although the system has great potential, the main challenges faced are the cost of implementation and training the crew to operate the new device. To overcome this, shipping companies need to provide intensive training to the crew and carry out system integration gradually.

CONCLUSION

The pressure-based automatic sensor system has proven to be reliable in detecting overpressure in real time with high accuracy, thus increasing work efficiency and safety by reducing the risk of equipment failure such as broken buoy catchers and penant wires, and accelerating the buoy recovery process. This technology is relevant for the maritime industry that requires higher standards of safety and operational efficiency, especially on AHTS vessels operating in high-risk environments. Gradual implementation, intensive training for ship crews, and further development, such as the integration of IoT technology for remote monitoring, are recommended to optimize the application of this system. The results of this study are expected to provide a real contribution to the development of occupational safety technology in recovery buoy operations on AHTS ships.

ACKNOWLEDGEMENT

All praise and gratitude the researcher prays to the presence of God Almighty for His grace and guidance so that the research entitled "Development Of A Pressure-Based Automatic Emergency Release Sensor System To Improve Safety In Recovery Buoy Operations On AHTS Vessel" can be completed properly. The researcher would like to thank Dr. Capt. Samsul Huda, MM, M.Mar., and Ir. Fitri Kensiwi, M.Pd., as the supervisors, all lecturers and employees of the Semarang Maritime Polytechnic, Mr. Widodo and Mrs. Muji Astuti Sulistia Ningsih and their families, operational staff of PT. Indoliziz Marine, Capt. Kurniansyah, M.Mar., as well as the crew of the AHTS Pelangi Escort 2 ship, and fellow Cadets Class LVII for the support, prayers, and guidance that have been given. With all humility, the researcher realizes that there are still many shortcomings in this research and hopes for constructive suggestions for the perfection of this research and so that the results are useful for the readers.

REFERENCES

- Afdhani, A. Al. (2024). *Analisis Pelaksanaan Kerja Dalam Pelayanan Anchor Handling Di Deck AHTS. Etzomer 505*.
- Ahmaddien, I., & Syarkani, Y. (2019). *Statistika Terapan dengan Sistem SPSS*. In *ITB Press*.

- Amir, S., & Suhartini, E. (2018). Mekanisme Pembagian Kerja Berbasis Gender. *Artikel Ilmiah Hasil Penelitian Mahasiswa*.
- Basuki, A. T., & Prawoto, N. (2019). Analisis Regresi Dalam Penelitian Ekonomi dan Bisnis (Dilengkapi Aplikasi SPSS dan Eviews). *PT Rajagrafindo Persada, Depok, 18*.
- Boo, S. Y., & Shelley, S. A. (2021). Design and analysis of a mooring buoy for a floating arrayed wec platform. *Processes, 9*(8). <https://doi.org/10.3390/pr9081390>
- Borg, W. R., & Gall, M. D. (2003). *Educational Research: An Introduction*. Pearson.
- Dorf, R. C., & Bishop, R. H. (2016). *Modern Control Systems*. Pearson Education.
- Hancox, Michael. (2015). *Anchor Handling Book*. 3.
- Handayani, Rinin. (2020). *Metodologi Penelitian Sosial*.
<https://www.researchgate.net/publication/340663611>
- Handoko, Toni. (2019). *Kapal Ahts Logindo Stamina Pada Saat Sandar Di Jack Up Rig Menggunakan Mooring Buoy*, Skripsi. Jakarta: Sekolah Tinggi Ilmu Pelayaran.
<https://indonesian.pneumaticrubberfenders.com/sale-14332632-high-buoyancy-large-steel-mooring-buoy-floating-marine-buoys-for-yacht.html> diakses pada 25 April 2024.
- Kemdikbud. (2021). Kamus Besar Bahasa Indonesia,” in Kamus Besar Bahasa Indonesia. *Kamus Besar Bahasa Indonesia*.
- Letcher, T. M. (2023). Wind Energy Engineering: A Handbook for Onshore and Offshore Wind Turbines. In *Wind Energy Engineering: A Handbook for Onshore and Offshore Wind Turbines*. <https://doi.org/10.1016/C2021-0-00258-3>
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. Sage Publications.
- Rusandi, & Muhammad Rusli. (2021). Merancang Penelitian Kualitatif Dasar/Deskriptif dan Studi Kasus. *Al-Ubudiyah: Jurnal Pendidikan Dan Studi Islam, 2*(1), 48–60.
<https://doi.org/10.55623/au.v2i1.18>
- Sargent, R. G. (2013). Verification and Validation of Simulation Models. *Journal of Simulation*.
- Schwaber, K., & Sutherland, J. (2020). *The Scrum Guide*. *Scrum Alliance*.
- Shu, Hongbo, Yao, Aifeng, Ma, Kai-Tung, Ma, Wei, & Miller, Jonathan. 2018. *API Recommended Practice 2SK 4th Edition - An Updated Stationkeeping Standard for the Global Offshore Environment*, Makalah. <https://doi.org/10.4043/29024-MS>
- Sugiyono. (2022). Metode penelitian pendidikan pendekatan kuantitatif, kualitatif dan R&D. *Jurnal Ilmu Dan Riset*.
- Trochim, W. M. K. (2021). *Research Methods: The Essential Knowledge Base*. Cengage Learning.