Hazard Risk Management for Occupational Safety and Health on Phinisi Shipbuilding

Manajemen Risiko untuk Keselamatan dan Kesehatan Kerja Pada Pembuatan Kapal Phinisi

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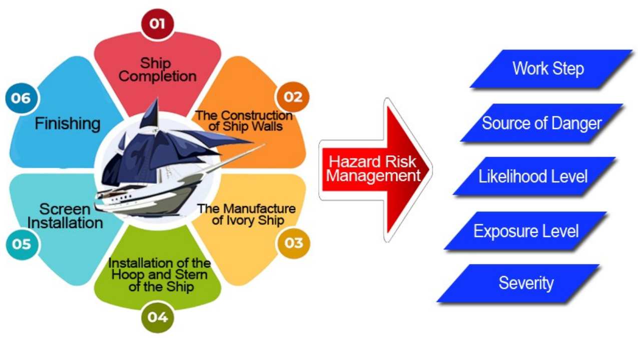
ABSTRACT

The implementation of the making process of a Phinisi ship has a potential hazard impact on occupational safety and health, including the tools, materials, and work processes respectively. One of the accident risk management methods used is called the Hazard and Operability method, which reviews the process of making a Phinisi ship in order to identify some hazards and analyze the risk of work accidents. The purpose of this study was to use hazard and operability (HAZOP) to assess the level of occupational health and safety risk for Phinisi ship workers. This research was quantitative with a descriptive approach because it described the risk of work accidents in making Phinisi Ships. The population in this study were all Phinsi ship workers, whilst the sampling technique was total sampling. The results showed that the hazards identified in the Phinisi shipbuilding process were physical, chemical, physiological, and mechanical hazards. The most dominant hazard identified in each work step process was a physical hazard. At the stage of making ivory or ship hulls, there was a very high level of possible risk. In addition, at the work step of installing ship sails, the severity of the risk was very serious. This study led to a systematic evaluation of the possible risks and a suggestion for how industrial managers can reduce the risks that come up when building ships.

ABSTRAK

Pelaksanaan proses pembuatan kapal Phinisi memiliki dampak potensial bahaya terhadap keselamatan dan kesehatan kerja baik itu bersumber dari alat, bahan, maupun proses kerjanya. Salah satu metode manajemen risiko kecelakaan dengan digunakan adalah metode *hazard and operability* yang meninjau proses pembuatan kapal Phinisi untuk mengidentifikasi bahaya dan menganalisis risiko kejadian kecelakaan kerja. Penelitian ini bertujuan untuk menganalisis tingkat risiko kesehatan dan keselamatan kerja pada pekerja kapal Phinisi dengan menggunakan *hazard and operability* (HAZOP). Penelitian ini adalah jenis kuantitatif dengan pendekatan deskriptif karena menggambarkan risiko kecelakaan kerja pada proses kerja pada pembuatan Kapal Phinisi. Populasi dalam penelitian ini adalah seluruh pekerja kapal Phinsi sedangkan teknik pengambilan sampel menggunakan *total sampling*. Hasil penelitian menunjukkan bahwa bahaya yang teridentifikasi pada proses pembuatan kapal Phinisi adalah bahaya fisik, kimia, fisiologi dan mekanis. Bahaya yang paling dominan yang teridentifikasi pada setiap proses langkah kerja adalah bahaya fisik. Pada langkah pembuatan gading atau rangka kapal memiliki tingkat kemungkinan risiko yang sangat tinggi. Selain itu pada langkah kerja pemasangan layar kapal memiliki tingkat keparahan risiko yang sangat serius. Studi ini menghasilkan evaluasi secara sistematis dalam menentukan potensi bahaya yang ditimbulkan serta menjadi rekomendasi bagi pengelola industri dalam meminimalkan bahaya yang timbul dalam pembuatan kapal

GRAPHICAL ABSTRACT



Keyword
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PENDAHULUAN

Industrial activity is strongly associated with the possibility of an accident. Every mishap, no matter how minor, will have a significant impact on a company or social society (Sengupta et al., 2016; Takala et al., 2014). Similarly, the manufacturing business relies on humans to complete the production process, leading to workplace accidents (Reniers, 2017). Workplace accidents can create a great deal of pain for both the workers and their families. As a result, it is vital to coordinate accident risk management activities with the intention of reducing the more serious health consequences (Badri et al., 2012).

The Hazop approach, or also the so-called *Hazard and Operability Study*, is one of the accident risk management methods employed. This is hazard identification and analysis methodology that is used to analyze a process or operation in a system that includes *hazard identification*, *risk assessment*, and *risk control* (Lee & Lee, 2018). Hazop analysis is a method of carefully evaluating a process or operation to identify deviations from potential dangers. Hazop can also be used to see if process variations can lead to unintended consequences or accidents (Kotek & Tabas, 2012).

Indonesia is a maritime nation with a large ocean expanse separating it from the rest of the world (Yuliati, 2016). This country has a lot of promise for the shipbuilding industry (Prasetyo, 2016). However, multiple studies have found that the risk of work accidents in Indonesian shipyards is relatively high. (Permana & Handayani, 2022; Sangaji et al., 2018; Tjendera et al., 2018; Wuandari, 2017). Referring to the International Labor Organization (ILO), 2.78 million workers die each year on account of workplace accidents and PAK. Occupational diseases caused almost 2.4 million (86.3%) of these deaths, whereas work accidents caused more than 380,000 (13.7%). Non-fatal work accidents occur roughly a thousand times more frequently than fatal work accidents each year. Non-fatal workplace accidents are estimated every year; 374 million workers are injured, and many of these incidents have substantial financial effects.

The number of work accidents in Indonesia in 2019 was 114,235, according to the Social Security Administering Body of Employment (BPJS). Meanwhile, from January to October 2020, the BPJS documented 177,161 work accidents and 53 occurrences of occupational disorders, 11 of which were Covid-19 cases. The number of potential workplace dangers depends on the requirement for a health and safety management system (Fridayanti et al., 2021; Yuliani, 2017).

The most common risk factors for work accidents include unsafe behavior *(unsafe action*) by 88%, unsafe environmental situations (*unsafe conditions)* by 10%, or both items happening at the same time. Workplace accidents are generated directly by risky behavior *(unsafe behavior*) and unsafe conditions (*unsafe conditions),* which result in the discontinuation of human and equipment operational activities (Simanjuntak & Abdullah, 2017).

Several work procedures are used in the production of Phinisi ships, including keel work, ship wall construction, ship hull construction, ship stern installation, sail installation, and finishing processes. The hazard and risk task analysis for each of these shipbuilding processes is different (Tsoukalas & Fragiadakis, 2016). Knowing the potential dangers that exist in the ship's facilities and procedures will aid efforts to create occupational safety and health components to improve the quality of life for all employees (Efe, 2019).

Based on the initial survey conducted through observation and interviews, it was discovered that workers at the keel, ship wall, hull, stern, layer, and finishing processes did not use personal protective equipment (PPE) within hours, indicating that occupational safety and health hazards and risks are extremely high and that several workers had work accidents.

As a result, risk management efforts in the work process are one of the most effective ways to prevent work accidents among Phinisi ship workers. The Hazop approach is one way of analyzing and identifying risks in an activity that is now commonly utilized in business.

Several studies have used Hazop to identify accident risk and worker safety (de la Oherrera et al., 2015; Ishtique et al., 2019; Khamidi et al., 2015; Noriyati et al., 2015). However, no research has been done to investigate the likelihood of accidents for shipbuilders who use certain procedures. Studies on the cost-benefit analysis (CBA) approach on shipbuilders in Bangladesh (Thiede & Thiede, 2015), the climate scale method and work stress on shipbuilders in Korea (Kim et al., 2017), and *the fuzzy inference system* (ANFIS) method in the shipbuilding industry have all been conducted (Fragiadakis et al., 2014), To the author's knowledge, this is the first time the Hazop approach has been used on traditional Phinisi shipbuilders. This study aims to find out how to control occupational health and safety risks for industrial workers in the Pinisi industry.

METHODS

This current study was conducted using a quantitative approach with a descriptive research design because *the Hazard and Operability* (HAZOP) technique was used to offer an overview of the risk of work accidents in the Phinisi Industry in Tanah Lemo Village, Bonto Bahari District, Bulukumba Regency. This study took place in Tanah Lemo Village, Bonto Bahari District, Bulukumba Regency, in January 2022. This area is still popularly recognized as the home of the Pinisi Boat, with craftsmen carrying on the tradition of building the boat.

The Phinisi ship laborers in the Tanah Lemo Village, Bonto Bahari Subdistrict, Bulukumba Regency, numbering up to 48 people, were the respondents of this study. The workers at the Phinisi ship industry in Tanah Lemo, Bonto Bahari District, made up the sample for this study, which included 40 laborers and eight head craftsmen. Total sampling was utilized, which means that the research sample was drawn from the entire population.

The HAZOP Work Sheet and AS/NZS 4360:2004, as well as a questionnaire to explain the work safety risk assessment,

Table 1
The Characteristic of Respondents of Phinisi Ship Workers

Category	Freq.	%
Age		
<25 years	16	33.3
26-35 years	13	27.1
36-45 years	17	35.4
>45 years	2	4.2
Education		
Elementary School	19	39.5
Junior High School	15	31.1
Senior High School	14	29.2
Job Experience		
<5 years	14	29.2
>5 years	34	70.8
Total	48	100

were employed as study instruments. Primary data was collected from observations of equipment/machinery, materials, and work stages using validated and tested questionnaires. In addition, the interviews were performed by inquiring about respondents' willingness through informed consent. The Bulukumba district profile, literature studies, and past studies linked to occupational risk assessment and the construction of Phinisi boats provided secondary data for this study.

The data was analyzed using a semi-quantitative method, in which the probabilities and effects were multiplied to get a risk value, which was then classified into risk levels. Using *the HAZOP work sheet*, steps can be taken to figure out the risks that come with each type of work and activity and to estimate how likely each risk is.

RESULTS

Table 1 clearly depicts that the most common age range was 36–45 years, with 17 workers (35.4 percent), and the least common age range was > 45 years, with two workers (4.2 percent). The penultimate level of education was dominated by elementary schools, which accounted for 19 people (39.5%). There were 14 workers with a work history of more than five years (29.2%), with a maximum of 34 individuals with a work history of more than five years (70.8%).

Hazards at all stages of manufacture, according to table 2, suggest that workers had an assessment at all stages of work. As many as 35 respondents reported danger at

Table 2
Identification of Phinisi Shipbuilding Hazards

Hazard Identification	Work Step 1		Work Step 2		Work Step 3		Work Step 4		Work Step 5		Work Step 6	
	n	%	n	%	n	%	n	%	n	%	n	%
Identified	29	60	30	63	28	58	28	58	35	73	27	56
Not identified	19	40	18	38	20	42	20	42	13	27	21	44

Table 3
Risk Analysis in Phinisi Shipbuilding

Variabel	Work Step 1		Work Step 2		Work Step 3		Work Step 4		Work Step 5		Work Step 6	
	n	%	n	%	n	%	n	%	n	%	n	%
Work Step												
Unsafe Action	14	48	10	33	13	46	15	54	20	57	12	44
Unsafe Condition	15	52	20	67	15	53	13	46	15	43	15	56
Source of Danger												
Physical	10	35	11	37	7	25	12	43	10	29	8	30
Chemical	7	24	4	13	5	18	3	11	0	0	4	15
Biology	0	0	0	0	2	7.1	0	0	0	0	7	26
Mechanic	12	41	6	20	8	29	8	29	21	60	3	11
Physiology	0	0	9	30	6	21	5	18	4	11	5	19
Likelihood Level												
Almost Happened	6	13	6	13	41	85	2	4.2	0	0	0	0
Tend to Occur	26	54	42	88	7	15	9	19	1	2.1	0	0
Unusual	7	15	0	0	0	0	36	75	46	96	46	96
Small Chance	8	17	0	0	0	0	1	2.1	1	2.1	2	4.2
Rarely occurs	1	2.1	0	0	0	0	0	0	0	0	0	0
Exposure Level												
Sometimes	3	6.3	45	94	46	96	0	0	0	0	0	0
Not often	45	94	3	6.3	2	4.2	48	100	8	17	3	6.3
Seldom	0	0	0	0	0	0	0	0	39	81	45	94
Very rarely	0	0	0	0	0	0	0	0	1	2.1	0	0
Severity												
Disaster	0	0	0	0	0	0	0	0	1	2.1	0	0
Very serious	0	0	0	0	1	2.1	0	0	47	98	0	0
Important	46	96	46	96	1	2.1	45	94	0	0	0	0
Looks like an injury	2	4.2	2	4.2	46	96	3	6.2	0	0	48	100

the highest labor stage, namely the fifth work phase (screen installation) (72.9%).

Table 3 demonstrates the stages of work with the main risky action categories that occurred in the fourth and fifth work steps of shipbuilding, while the lowest was in the sixth work step (finishing process). The first, second, third, and sixth shipbuilding work steps all had the major dangerous condition category. In the fifth labor phase of shipbuilding, many responders were exposed to mechanical dangers. The percentage of possible danger that almost occurred in the third working phase was roughly 85.4 percent. At the level of exposure that sometimes occurs, most of them were in the second work step, comprising 93.8%, and in the third work step, 95.8 percent at the amount of exposure that occasionally occurs. The degree of very serious severity was at the fifth work phase or 97.9%.

Table 4 demonstrates that the fabrication of ivory or ship hulls has a very high level of potential danger (452 points), while the stages of installing sails (145 points) and completion have significant potential risks (140 points). Shipbuilding (141 points), ivory or hull construction (142 points), and anchorage and stern installation (96 points) all have a high-risk severity. The step of installing the sail (1225 points) has a very high level of risk, whereas the stage of manufacturing ivory or ship hulls has a high level of difficulty (76 points).

Tabel 4
Risk Assessment in Phinisi Shipbuilding

Work Step	Probability Level	Exposure Level	Severity
Ship Completion	245.5 (Priority 1)	99 (Priority 3)	232 (Priority 1)
The Construction of Ship Walls	312 (Priority 1)	141 (Substantial)	232 (Priority 1)
The Manufacture of Ivory Ship	452 (Very High)	142 (Substantial)	76 (Substantial)
Installation of the Hoop and Stern of the Ship	182 (Priority 1)	96 (Substantial)	228 (Priority 1)
Screen Installation	145 (Substantial)	55 (Priority 3)	1225 (Very High)
Finishing	140 (Substantial)	51 (Priority 3)	48 (Priority 3)

DISCUSSION

The process of constructing the Phinisi ship takes approximately nine to two years. The length of the flexible work period is determined by the size of the ship to be built as well as the availability of ship tools and materials. The majority of the ship's tools and materials are imported from outside of Sulawesi or even from other countries. The Phinisi shipbuilding work method does not use a work shift system. Thus, all panrita Lopi contribute to every step of shipbuilding; in other words, all panrita lopi work at the same time. The number of panrita lopi used by each organization varies as well, ranging from 7 to 14. Several Phinisi shipbuilding enterprises continue to use a daily worker system. Phinisi shipbuilding runs from 7.30 a.m. to 5.30 p.m., with a break between 11 a.m. and 1.30 p.m., particularly in job tasks where a variety of possible risks are at risk of arising, resulting in health and safety issues at work. The following are the stages of working on a Phinisi ship:

Ship Completion

At the completion stage, there are three working processes: cutting the rudder, cutting the rudder with a saw, and cutting the rudder with a chain saw machine. Most responders said the risk assessment was in the slanted category during various stages of the ship's construction. The worker starts cutting the wood that will be utilized at this point. This wood cutting technique is completed only once till the rudder is correctly cut. As a result, it consumes more energy in its manufacture, but it also exposes Phinisi ship workers to work accidents caused by mechanical risks induced by a failure to utilize Personal Protective Equipment (PPE).

Then, in the second stage, when the rudder and keel have been connected by drilling holes and putting steel nuts and bolts coated with *epoxy* glue on each beam spacing to connect each beam, the (baru') bark generated from dried tree bark is added. The level of risk analysis exposure in this process is in the category of not often or occurs only once a month, and only a few of the workers have experienced such a work accident resulting from physical hazards such as fingers pinched and exposed to *epoxy* glue, and there are also workers who are exposed to fine dust from wood or sawdust.

Smoothing the rudder, improving the ship's size and symmetrical design, and prioritizing the comfort of ship users are the final stages. A saw machine is used in this industrial procedure, which produces chemical dangers due to the usage of diesel or gasoline fuel. Some of the respondents experienced work accidents such as cuts to their hands or feet when exposed to a saw, irritation, and allergies to their skin and eyes, as well as respiratory and lung problems because of the severity or impact caused by the completion of the risk assessment from the first stage to the end. - coughing, red, painful eyes, and lungs

According to Yusuf et al. (2019), the potential risks of accidents that can occur during the welding and cutting process include the danger of electric current, the danger of sparks in welding/grinding work, working in a small space, falling material, working at heights, the danger of dust/ smoke, and ergonomic problems like muscle complaints while working.

The Construction of Ship Walls

There are three working activities at this stage, namely, the installation of boards on the ship's walls, utilizing work tools such as measuring tools, chisels, saws, nails, and drills. The process of lifting and laying the keel (wood) states that the risk assessment in the category tends to occur, and the possible risk for Phinisi workers comes from physical hazards such as spine or knee injuries if they do not pay attention to ergonomic work positions and do not consider excessive wood loads. The concern at this point is that inhaling wood dust contains chemical risks that can cause ailments like asthma and red eyes.

Work tools like measuring tools, chisels, and saws are used in the second stage, namely the connecting of the ship-boards, and fuel is used to burn wood or boards first to bend the boards. The risk analysis in this procedure might expose workers exposed to mechanical dangers such as the risk of Phinisi workers being harmed, pinching fingers, and burning skin on a weekly basis.

In this technique, pegs are manufactured and installed using chisels, drills, measuring instruments, and saws. This procedure has a severity or impact degree, such as the possibility of Phinisi workers suffering from spinal injuries if they do not pay attention to ergonomic work positions. Psychological dangers such as tripping over boards or wood, cables, and other work instruments, as well as non-ergonomic working positions, can cause MSDS fatigue, arm and shoulder discomfort and require medical treatment at this stage.

Risk control measures are implemented to reduce the possible hazard, such as the use of personal protective equipment (PPE) to safeguard workers, the provision of APAR/sand drums to prevent fires and the installation of posters promoting excellent and right (ergonomic) work positions. According to Kurniasari (2017), working with inappropriate body position and movement for a long period causes discomfort, which can lead to weariness, poor concentration, lower productivity, performance, and human error.

The Manufacture of The Ivory Ship

There are two labor processes at this stage: the installation of the deck frame (header) and the use of Phinisi workers' tools such as chain saws, electricity, drills, and measuring tools in the installation of the deck frame (header). Mechanical hazards that can cause deafness or hearing loss (ears); electric shock, which can create fires; sensory nerve abnormalities; and the usage of *epoxy* glue, which leads workers to experience disruptions in their work, are all risks that can arise during this process. Chemical dangers are inhaled. This is consistent with research of Pradipta (2016), which found that the risk of opening the chain saw blade is very likely to occur in the workplace.

The penultimate stage of this procedure is the installation of boards on the deck wall; in this process, danger at work occurs once a week on average, with many workers experiencing work accidents on Phinisi workers, which are mostly caused by physical hazards such as injuries or mild diseases. Bruising of body parts, minor damage, and temporary cessation of work processes, such as being punctured by work materials, slipping of the feet, injuries, fractures/ sprains, red and sore eyes, injuries to muscle joints, work materials, and the process of bending boards by burning or roasting, all result from biological hazards, such as workers experiencing respiratory problems in consequence of immediate expulsion, which can harm the environment.

Installation of The Hoop and Stern

The *dek, lepe, pacocorang,* and udder are being installed while the kalang and stern are being installed. Among other components, screws, nails, and connecting bolts are used in this installation process. Workers are exposed to potential dangers on a regular basis. Nevertheless, only a small percentage of workers are exposed to work-related risks monthly. Chemical hazards such as inhaled sawdust; mechanical sources of danger such as being stabbed by sharp objects; physiologic sources of danger such as workers being hit by as many work materials/tools as possible; vibrations and noise from work tools; as well as physical hazards including workers falling or tripping due to scattered work tools/materials and sources of danger.

Risk control is carried out by posting signs or hazard warnings and properly arranging work materials and tools in place after usage to reduce potential hazards.

Screen Installation

The Phinisi ship features seven sails and two masts; the three leading sails are known *as cocoro pantara, cocoro tangnga, and tarengke*, and are triangular, while the two huge trapezoidal sails are known as *sombala bakka* (on the front screen) and *sombala ri boko* (on the back screen). Triangular-shaped sails called *tampasere* adorn the tops of the two poles.

Saws, planers, drills, sewing machines, and pliers are some of the common work tool exposures, all of which have the potential to be deadly, allowing the unexpected to happen. Physiological dangers, such as falling from a height, are the most dangerous at this stage of the job. Furthermore, the level of exposure or impact caused by Panrita Lopi is threatened by sources of danger such as being pierced by sharp objects, falling on work materials/ tools, vibration and noise from work tools, and workers experiencing accidents because of not wearing PPE that protects them from physical hazards such as pinched hands during the process installation. Risk control is done by wearing PPE such as safety garments, gloves, earplugs, or other ear protection and employing handling equipment for at least 3-5 individuals to reduce the possible hazard.

Finishing

The finishing stage consists of three processing steps: interior installation, painting, and finishing. Only electrical activities, room arrangement, client facilities, smoothing, sanding, polishing, and coloring on the ship's surface are included in the process of establishing the ship's interior. Workers may be exposed to mechanics only once a month at this stage, such as dust from wood, chemicals such as fungi and germs from wood, and eye irritation. Workers with health issues such as cancer, cataracts, a loss of smell, and lung problems are among those who are affected.

Moreover, the process of installing the steering wheel and propeller poses a risk of injury or minor illness due to physical hazards, such as lifting excessive propeller loads, non-ergonomic body positions, and lifting excessive weights, all of which can result in injury or minor illnesses such as fractures, pain, and muscle damage.

Referring to Mardatillah (2021) research, the dangers that arise during the welding process on the ship's rudder are prompted by a lack of personal protective equipment (PPE) in the work process, resulting in various industrial accidents. Finally, the source of physiologic danger in the process of delivering (new') bark, namely, in this procedure, is in the form of work accidents that are regularly experienced, such as falls, respiratory diseases, injuries due to pinched fingers, and epoxy glue exposure. Risk control is carried out by lengthening the B3 wood stain material symbol, making recommendations for washing hands after using paint, varnish, and wood stain, keeping flammable materials and materials away, and wearing personal protective equipment (PPE) such as safety clothes, gloves, footwear, and earplugs or other ear protection.

CONCLUSION

In the process of making a Phinisi ship, there are identified hazards such as physical, chemical, mechanical, and physiological hazards. The risk of danger occurring during the construction of this ship is noticeable at the stage of producing ivory or ship hulls, while the severity (consequences) is noticeable at the stage of fixing the sails. At the stages of keel work, sail installation, and sail installation, the level of exposure takes third place. This is the first study to look at hazard analysis utilizing the Hazop approach, which evaluates every stage of traditional boat building in Indonesia so that deviations from the potential risks may be determined. This study should be supplemented with the findings of observation and analysis of overall occupational safety and health hazards at each stage of the Phinisi shipbuilding job, as well as comparisons of the usage of various risk analysis methodologies in other regions with different individual characteristics.

The management of the Phinisi ship industry should conduct routine checks on the potential hazards revealed in this study, according to the findings. Every Phinisi boat builder is required to wear personal protective equipment (PPE) at work, and standard operating procedures (SOPs) must be developed to serve as guides in every step of the Phinisi boat building process.

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