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**Research Article**

# Fore Poppet Design and Optimization to Apply on Norway type Trawler Fishing Ships

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**Abstract:**

In the classical sea landing methods of ships, aquaplaning and slipway support systems are used. In Norwegian Type Trawler Fishing vessels, the outer shell surface geometry is very delicate. Therefore; the incoming forces are extreme and the use of wooden poppets by these forces in normal sea landings is insufficient. This work; It includes two different steel fore poppet designs and analyses for the Norwegian type trawler fishing vessel, which cannot be launched with conventional slipway support systems after landing calculations. Within the scope of this study, two different steel fore poppets were designed. After the analyses and examinations, it was decided that the Norwegian type trawler fishing vessel, which is the subject of the article, with which steel fore poppet design will be launched without any problems. Studies carried out in this context; Two different steel fore poppet designs were made using the Rhinoceros analysis program, which is a 3D design program. Rhinoceros Scan & Solve analysis was performed and simulation was run by applying forces to the designed steel fore poppets. A force of 3e+06N, including gravity, was applied to both designed structures. As a result of this; In the first steel fore poppet structure, a maximum displacement of 1.18611mm occurred. In structures designed under a force of 3e+06N; In the first structure, the maximum Von Mises Stress value was found to be 505.761MPa. In the second structure, the maximum Von Mises Stress value was found to be 163.142MPa.

## 1. Introduction

The shipbuilding industry, which constitutes an important part of maritime activities, is a production, repair and assembly industry, and is an important industry branch where manpower and labour are most needed. In economy; the shipbuilding industry, which replaces foreign exchange, develops sub-industry, attracts technology transfer, provides employment, supports the national naval fleet, and contributes significantly to the defense needs of the country, is a locomotive sector. This branch of industry is a manufacturing industry that includes a combination of many industrial products. The 'Ship', a product of the shipbuilding industry, emerges as a result of the combination of steel industry, machinery industry, electrical-electronic industry, paint industry, plastic industry branch products.

Ships are usually built on land or in dry dock due to the difficulties of building at sea. Building in dry dock is preferable, as the construction of large ships on a slipway can present difficulties. Thus, the dangers and difficulties caused by sea launching are eliminated. However, dry construction costs are high and these pools can be operated more profitably for docking services. Construction on slipway is the most preferred method, and ships built in this way are launched by either stern or side launching methods. Side loading is more risky and is applied in river or gulf shipyards with limited sea area. Stern launching is the most commonly used method [1]. The Norwegian type Trawler fishing vessel, which is the subject of this study, was built on a slipway and then launched from the stern.

Different kinds of loads may be experienced by the ship due to handling. During launching, the ship undergoes stress changes from concentrated loading at the supports on land to concentrated loading on fore poppet during stern lift or tipping at the way ends [2].

Designing a ship is not just doing the calculations to realise the eventual vessel, there are other activities necessary to get the ship to sea. Literally, one set of activities is those tasks to get it in the water and this can be risky if not done adequately [3].

Predictions of the movement are vital to ship's safe control. A set of six curves is prepared to predict the behaviour of the ship during launch (Figure 1). They are curves plotted against the distance of travel down the slipway for end launching process [4].

- Weight, Buoyancy
- Moment of Weight about fore poppet and Moment of Buoyancy about fore poppet
- Moment of Weight about after end of groundways and Moment of Buoyancy about aft end of groundways.

The Important features of these curves are as follows;

- At the point at which the moment of buoyancy about the fore poppet equals the moment of weight about the fore poppet, the stern lifts.
- The difference between the weight and buoyancy curves at the position of stern lift is the maximum force on the fore poppet.
- The curve of the moment of buoyancy about the aft end of the ways must lie wholly above the curve of the moment of weight; the least distance between the two curves of the moment about the aft end of ways; gives the least moment against tipping about the end of ways.
- Crossing of the weight and buoyancy curves before the after end of ways, indicates that the fore poppet will not drop off the end of the ways.

Slipway is the concrete surface and used for the new ship building or thats launching. The sled must have an inclined angle. The slope of the Slipway must be able to produce a force large enough to overcome the friction between the slides and the slide surface. The slipway slopes that should be selected according to the size of the newly built ships are given in Table-1.

Longitudinal oil slipway launching is one of the oldest forms of launching systems. Using this system, the ship descends into the water by being translated in the direction of the longitudinal symmetry axis under a slipway and its own weight. Oil is used to assist the gliding process. Longitudinal launching can be carried out in two ways, from the fore and the stern. Longitudinal launching can be carried out in two ways, fore and stern. In the launching process, the fore of the ship enters the water first. In the stern launch, the stern enters the water first. Launching from the stern is performed in a shorter time than launching from the fore. Because the ship is mostly trimmed to the stern during launching. The main advantage of both methods is the use of simple equipment and for ships of different tonnage and type [5].

To exemplify some of the reasons that require a ship to be lowered from the stern;

- The stern of the ships is more rounded than the fore/stern profiles that have aerodynamic features. Therefore, it creates greater resistance when entering the water and therefore provides a better braking force.
- The stern of the ship provides a faster buoyancy than the fore in lifting the ship from the cradle or bed. Thus, there may be a more gradual separation from the slipways towards the sea.

As a result; The wider stern arch of the ship helps to keep the ship diagonally stable during immersion [6]. Another important reason is the installation of very sensitive devices such as the steering gear and shaft lines that need to be centered towards the stern. Any major deformation can prevent these devices from working, thus increasing the ship's construction process and cost [7].

The stern launch devices consist of a part connected to the ship and moving with it, and a fixed part on which this part moves. The moving part consists of one or more sliding parts attached to the ship [8]. The length of the slipway is approximately 80% of the length of the ship, and the ends of these slipways at the fore and stern are called for poppet and stern poppet. The stationary part consists of a sled attached to the ground, inclined towards the water. The part that moves with the ship is called a sliding sled, the part that is connected to the ground is called a fixed sled, and the part of the sled in the water is called a wet sled. The movable sliding slides can easily move on the fixed slides, as their contact surfaces are lubricated with oil. Fixed slides extend from land to sea with a small slope (α) [1].

The schematic representation of the stern launch process is shown in Figure 2. The movement of the ship during landing and the forces acting on the ship during this can be examined step by step. Each stage begins with a change in motion or the beginning of a new force (or the disappearance of a force acting on the ship).

The stage from the calm state of the ship to the entrance to the sea can be defined as the first stage. It continues from the moment the movement starts with the effect of gravity until the front end of the slide slides touch the water. At this stage, its own weight and the reaction force of the stationary slide act on the system.

The stage from the ship's entrance to the sea until it starts to turn can be defined as the second stage. At this stage, when the ship enters the sea, a buoyancy force will occur and the moment created by this buoyancy force will try to lift the ship from the slipway. When the moment of the buoyant force relative to the fore rib is equal to or greater than the moment of the gravity force with respect to the same point, the ship will start to rotate around the fore rib. In the meantime, great pressures may occur on the fore poppet and these pressures may damage both the slipways and the ship. At this stage, the system is affected by its own weight, the reaction of the fixed slide and the water pressure force. The phase between the ship starting to turn and floating can be defined as the third. This stage is the time between when the ship starts to turn around the fore poppet and when it leaves the sled and begins to swim freely. At this stage, the system is affected by its own weight, the response of the stationary slide and the water pressure. The stage in which the ship starts to swim freely can be called the final stage. It is the time elapsed between when the ship starts to float and when it comes to a complete stop. At this stage, its own weight and water pressure affect the system. During the launching of the ship on the inclined slipway; After a while the ship enters the water, the ship starts to turn on its fore side and in the meantime, great forces come to the fore of the ship. In order to eliminate the effect of these large forces, steel-reinforced wooden constructions are added to the hull sides of the fore of the ship to increase the turning surface. This construction is called “Fore Poppet”[6].

At the moment the stern of the ship starts to rise in the sea, the load on the fore thruster gets the maximum value. This value is called poppet pressure. The poppet pressure is approximately 1/3 of the landing weight. Its schematic is shared in Figure 3. While the ship is being launched on the inclined slipway, it is under the influence of its own weight and the buoyancy force and other relatively small forces as it starts to enter the water. As the ship continues to slide on the slipway, due to the effect of these forces, the moment value that initiates the rotation of the ship is called the “tipping moment”.

The most important value that determines the value of the turning moment is the length of the in-sea section of the inclined slipway. This length is related to the ship's length and the location of the ship's center of gravity. In Figure 4, the rotational moment of the ship at sea is shown.

## 2. Material and Methods

The Norwegian type trawler fishing vessel, which is the subject of the study, continued to be equipped on the slipway, since it stayed on the slipway longer than normal. This is the launching condition; the landing weight defined as the light weight and the weight of the ship were caused by the excessive weight of the ship.

***Table 1.*** *Slipway slope, which should be selected according to the size of the ship.*

| Ship Type | Tan α |
|---|---|
| Small ships | 1/12 ↔ 1/16 |
| Medium-sized ships | 1/14 ↔ 1/20 |
| Big ships | 1/18 ↔ 1/24 |

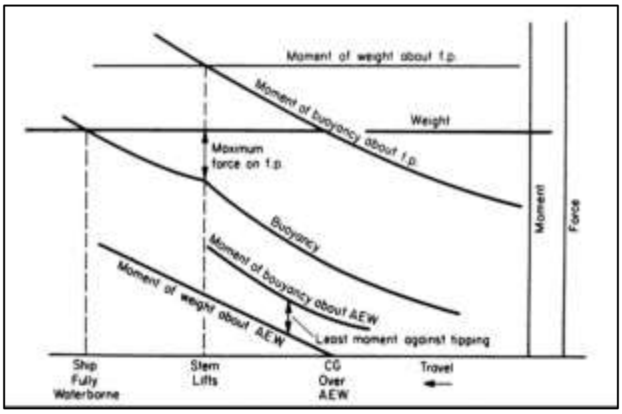



***Figure 1.*** *Basic Ship Theory [1]*

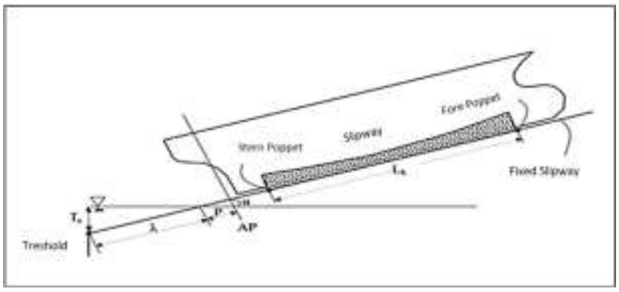



***Figure 2.*** *The schematic representation of the stern launch process*

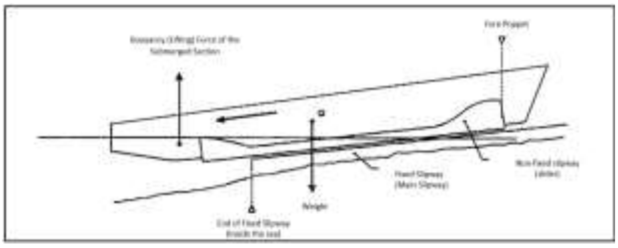



***Figure 3.*** *Fore poppet*

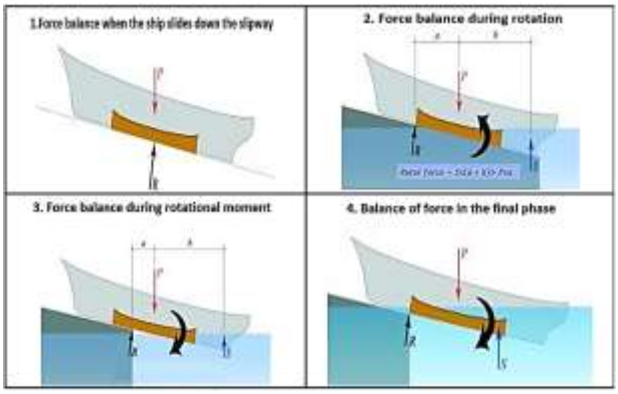



***Figure 4.*** *Rotational moment (Torque)*

This caused the ship's center of gravity to be too close to the stern. Thus, it required the ship to extend the length of the sliding slipway both at the fore and stern. In the sea landing calculations; head load should not exceed the maximum 550 tons, which is the slipway carrying capacity of in-sea barges. For this reason, the slider slipway length is adjusted at the head. The Norwegian trawler type fishing vessel cannot be landed using conventional slipway support systems. Because the incoming forces are extreme, as it is not possible for the wooden poppet systems in normal ship landings to meet these forces, making a steel fore poppet is necessary for a safe lowering of the ship. Within the scope of this study, two different steel fore poppets were designed. The first fore poppet design is shared in Figure 5 and the second fore poppet design in Figure 6. Analyzes were applied to both designed papers using the Rhinoceros scan & solve analysis program. As a result of the data obtained, it was decided with which steel fore poppet the ship would be launched safely. Static analysis was applied under the determined loads to determine the safety of the design. The data were changed many times to compare the applied force requirements, and the position and force analysis were performed repeatedly until the specified criteria were met. By using Rhinoceros workbench, static structural analysis of steel fore poppets designed with Rhinoceros, the displacements of the structure, the stresses caused by gravity and external loads have been determined. For the analysis of the design of the steel fore poppets, the material was chosen considering the research and quality standards. The mechanical and physical properties of the selected material are given in Table 2. The designed fixation points, force and force direction were selected in Figure 7 and 8. Rhinoceros scan&solve was chosen for this study as it is an analysis program that fully automates basic structural simulation on multiple surfaces, extrusions and meshes.

## 3. Results and Discussions

The displacement of the designed object was determined by measuring the distance between the first and last position, and the original position was accepted as a reference. The steel fore poppet is fixed to their design at the specified points. A force of 3e+06N, including gravity, was applied to both designed structures. As a result of this; In the first steel fore poppet structure, a maximum displacement of 1.18611 mm occurred. The data obtained as a result of the analysis are shared in Figure 9. In the second designed steel fore poppet structure, a displacement of 1.22784mm occurred. The data of this analysis are shared in Figure 10. The response of the structure designed with stress-strain analysis under certain loads was examined. In Figure 11 and Figure 12, the stresses obtained in the structures designed under a force of 3e+06N are shared. In the first structure, the maximum Von Mises Stress value was found to be 505.761MPa, the maximum Von Mises Stress value occurring in the second steel fore poppet design was found to be 163.142MPa.

***Table 2.*** *Properties of the selected material (ST44&S275JR)*

| Property | Value |
|---|---|
| Description | Steel, Cast Carbon |
| Density | 7.8e-09 Mg/mm$^3$ |
| Elastic Modulus | 200000 MPa |
| Poisson Ratio | 0.32 |
| Default Failure Criterion | Von Mises |
| Tensile Yield Strength | 241.68 MPa |

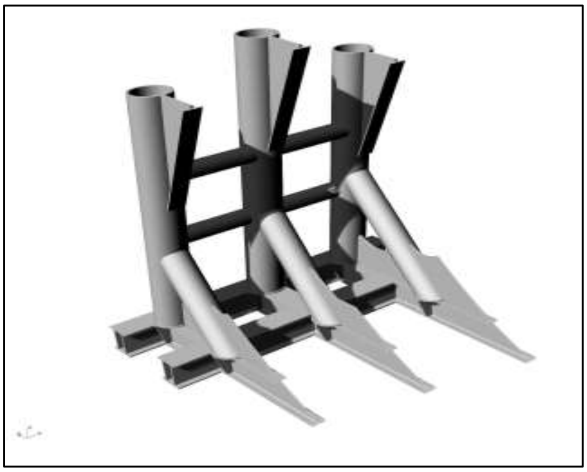


***Figure 5.*** *First steel fore poppet design (weight 947.92 kg)*

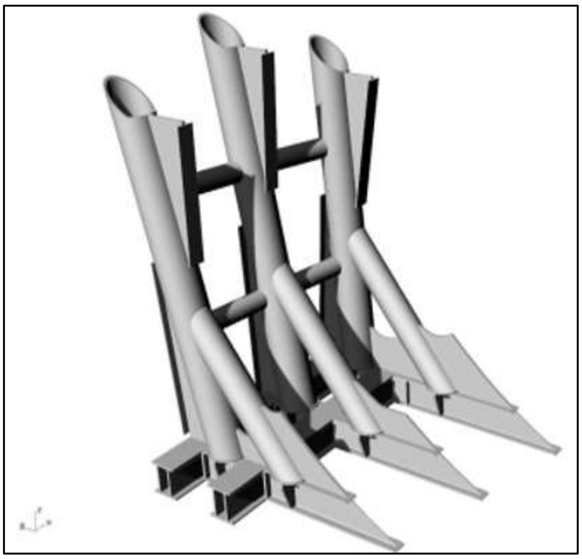


***Figure 6.*** *Second steel fore poppet design (weight 1030.45 kg)*


| Description | Type | Definition |
|---|---|---|
| Load 0 | Scalar Force | 3e+06 N |
| Body Load | Gravity | (0, 0, -9806.65) mm/s$^2$ |

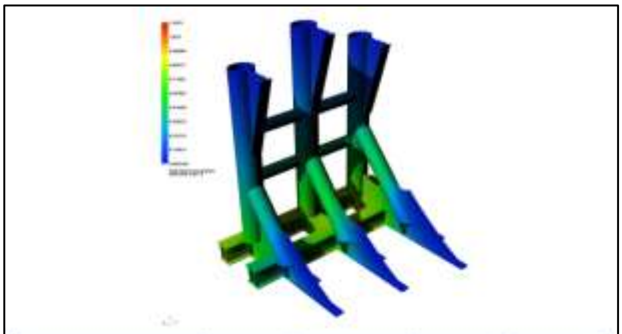
| Description | Definition |
|---|---|
| Restraint 0 | X-Fixed, Y-Fixed, Z-Fixed |

***Figure 7.*** *The force applied to the first steel fore poppet design and the places to be fixed*


| Description | Type | Definition |
|---|---|---|
| Load 0 | Scalar Force | 3e+06 N |
| Body Load | Gravity | (0, 0, -9806.65) mm/s$^2$ |

| Description | Definition |
|---|---|
| Restraint 0 | X-Fixed, Y-Fixed, Z-Fixed |

***Figure 8.*** *The force to be applied to the second steel fore poppet design and the places where it will be fixed*

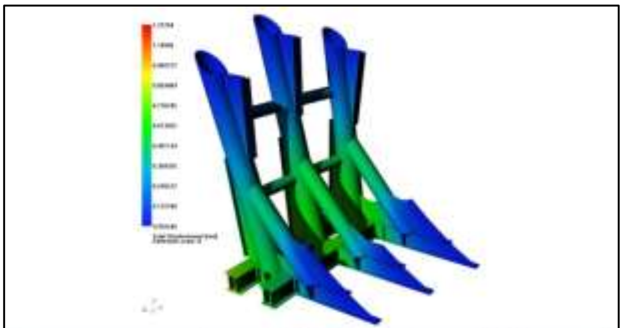


| | Amount | Location |
|---|---|---|
| Minimum | 3.0925e-06 mm | (168411,1637.08,1170.8) |
| Maximum | 1.18611 mm | (169336,2942,1001.2) |

***Figure 9.*** *Displacement in our first steel fore poppet design*

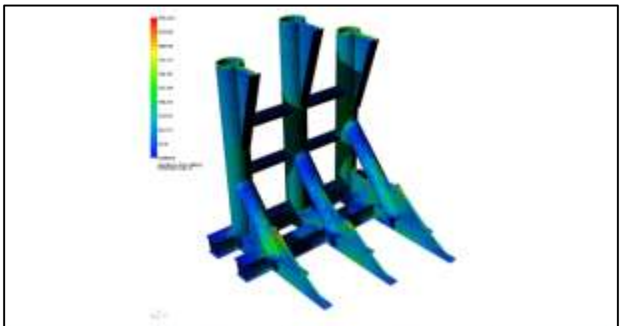
## 4. Conclusions

It is seen from Table 2 that the tensile yield stress of the material used in steel fore poppet designs is 241.68MPa. In order for steel fore poppet designs to be considered safe, a value of 241.68 MPa is accepted as the upper limit in the analysis study. Thus; In order for the steel fore poppet design to be considered safe, as a result of the analysis, the maximum Von Mises Stress value occurring in the structures should be under 241.68MPa.



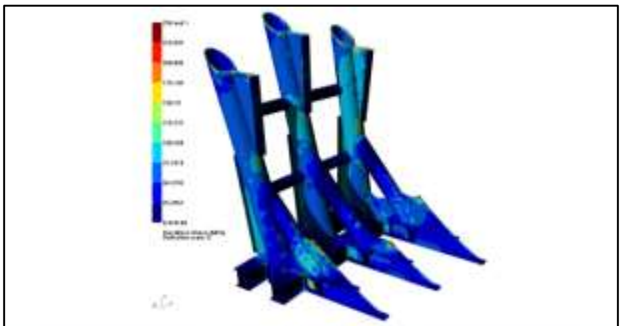
| | Amount | Location |
|---|---|---|
| Minimum | 4.932e-06 mm | (167800,1484.9,1001.2) |
| Maximum | 1.22784 mm | (169336,2942,1001.2) |

***Figure 10.*** *Displacement in our second steel fore poppet design*



| | Minimum | Maximum |
|---|---|---|
| X-Displacement | -0.0607794 mm | 0.210656 mm |
| Y-Displacement | -0.133347 mm | 0.282461 mm |
| Z-Displacement | -0.00318926 mm | 1.14246 mm |
| Total Displacement | 3.0925e-06 mm | 1.18611 mm |
| Von Mises Stress | 0.388874 MPa | 505.761 MPa |
| Max. Principal Stress | -219.364 MPa | 278.547 MPa |
| Mid. Principal Stress | -271.383 MPa | 168.361 MPa |
| Min. Principal Stress | -674.39 MPa | 99.994 MPa |
| Danger Level (von Mises) | 0.00160905 | Criterion Limit Exceeded |
| Danger Level (Max. Shear Stress) | 0.00171898 | Criterion Limit Exceeded |

***Figure 11.*** *Stresses occurring in the first steel fore poppet design*



| | Minimum | Maximum |
|---|---|---|
| X-Displacement | -0.0891376 mm | 0.194311 mm |
| Y-Displacement | -0.177128 mm | 0.209849 mm |
| Z-Displacement | -0.00358299 mm | 1.20361 mm |
| Total Displacement | 4.932e-06 mm | 1.22784 mm |
| Von Mises Stress | 0.476148 MPa | 163.542 MPa |
| Max. Principal Stress | -190.086 MPa | 179.255 MPa |
| Mid. Principal Stress | -231.767 MPa | 105.772 MPa |
| Min. Principal Stress | -599.051 MPa | 57.3098 MPa |
| Danger Level (von Mises) | 0.00190188 | 0.67503 |
| Danger Level (Max. Shear Stress) | 0.00215542 | 0.75638 |

***Figure 12.*** *Stresses occurring in the second steel fore poppet design*

As a result of the analysis of the first steel fore poppet, the maximum Von Mises Stress value of 505.761MPa is obtained. As a result of the analysis of the second steel head blade, the maximum Von Mises Stress value is obtained as 163.142MPa.
As a result of the evaluation of the obtained data, our second design problem has been solved. The steel fore poppet system seen in Figure 5 is positioned on the ship's hull, including frames 113 and 119. It is decided that the Norwegian type trawler fishing vessel, which is the subject of this study, can be safely launched into the sea.

## Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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