Strength Analysis of a Container Lashing on the Container Ship by using Finite Element Method

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Abstract: Lashing is a safety equipment on the ship which is used to tie containers. Lashing system is divided into two parts, they are turnbuckle and lashing bars. The purpose of this study is to find the lashing strength value when the ship conditions are on an even keel and tilted with angles 10º, 20º, 30º and 40º using finite element method. In addition to tilted angles, the calculations are varied against the rotation of small, medium and large turnbuckles. The results are shown in stress value. The minimum force which obtained is 230,000 N with a variation of rotation reach the minimum tensile force is small turnbuckle on rotation 398.45°, medium turnbuckle 318.76° and large turnbuckle 227.69°. On small turnbuckle, when the ship tilted up to 40º, the rotation limit which added from minimum tensile strength is about 120° with stress value 766.86 MPa. On medium turnbuckle, the rotation limit is about 60º with stress value 713.48 MPa. On large turnbuckle, the rotation limit is about 60º with stress value 749.22 MPa. From all those three sizes of the turnbuckle, the most suitable turnbuckle for lashing system on 1 tier container 20 feet is medium turnbuckle.

1 INTRODUCTION

Almost Every year ships in Indonesia are problematic which results in an accident. One of the accidents that are stability factor from moving load. Around one year ago exactly March 2016 were accidents at Bali Strait which results seven people died. That is KMP Rosalia II who had an accident when sailing from Java to Bali. This is the fourth ship to sink at that area, previous accidents occurred in 1960, 1994 and 2000. KMP Rosalia sank because it was alleged that the sailing permit was uncertain, overloaded, and unstable when sailing because the cargo was not in accordance with the procedure.

Some literature tells about the power, including the wing tank strength of the tanker ship can be said to be effective, if the calculation of stress results in small condition (Sanjaya, et.al, 2017). Installation two part of wave bulkhead be resulted in big stress better more than the stress of one part, in this research can relations between lashing bars and turnbuckle (Rabbani, et.al, 2017). If stress results do not meet the standard, stress can be compared with the yield strength of material (Chabibi, 2013). Material strength can be said to be safe if it meets maximum stress criteria (Pramono, et.al, 2016).

In this research the calculation of lashing strength on ship container when even keel condition and tilted condition. The stress of lashing have strong pull force and back be original condition have press force. In Park Journal the stress of lashing adjusts with pull force for rotate system element which has on the turnbuckle, but the principle turnbuckle is conventional whose can't force pull calculation without certain measurement equipment. So, in this research that is calculation lashing stress when even keel and tilted condition because rotate of turnbuckle on a container ship and can know who better effective turnbuckle for the strength of lashing.

2 LITERATURE REVIEWS

Lashing function by SOLAS Chapter VI Regulation 5 is Cargo and cargo units carried on or under deck shall be so loaded, stowed and secured as to prevent as far as is practicable, throughout the voyage, damage or hazard to the ship and the persons on board, and loss of cargo overboard. Fastening from lashing have four points and two sides on the container. Part of lashing that is lashing bars on the

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top and turnbuckle on the bottom of lashing which useful tighten and locked when cruising Firmansah and Yulianto, 2013).

The turnbuckle is fastening of the container which can be loosened and tighten of lashing system container. Turncbukle used too rigging for steel or steel rope. Turnbuckle must be used in a line. The specification must be given to prevent overloading. During tension, turnbuckle strength must avoid whose can deformation. If turnbuckle begins deformed, tension must be reduced immediately and every part broke to be replaced. When the worst situation, this is must be calculated when choosing product correctly which used for application Park, 2016).

Lashing bars is one of equipment safety used for fastening container when cruise which will be connected with turnbuckle (Australian Standard, 2001).

2.1 Stress-strain

If Δ is a total extension of long begin L which reviewed then extension per unit epsilon (ε) of long is as follow:

$$\varepsilon = \frac{\Delta}{L} \qquad (1)$$

Extension of stem or system can be obtained from:

$$\Delta = \frac{\delta}{360} P \qquad (2)$$

The force of intensity which perpendicular or normal for the normal stress of one point, the symbol with σ (ASTM, 2001). The result of stress more than big because of the rotation of turnbuckle against lashing. So that must have been adjustments stress to the rotation system of the turnbuckle. A certain Stress is considered true for one point, mathematically defined as follows:

$$\sigma = \frac{F}{A} \qquad (3)$$

Where:

σ = Stress (N/m²)
F = Force (N)
A = Area (m²)

2.2 Permissible Stress

Determination of stress will not be meaningful at all without carrying out physical testing of material in the laboratory which provides information about the resistance of a material to stress. In the test mentioned a rod is given a tensile stress by being given a load until it finally breaks, the force needed to break is called ultimate load. For the design of parts of the structure of stress level is called the permit stress is made lower than ultimate strength obtained from a safety factor. Permit stress is set so that the material strength is in a safe state. If stress exceeds stress permit material properties will approach plastic which cannot return to its original shape. The maximum material will be damaged when stress reaches the ultimate stress (Shoberg, 2016).

$$Permit\ Stress = \frac{Ultimate\ Stress}{Safety\ Factor(n)} \qquad (4)$$

Permit stress can be calculated with having safety factor which result must more than 1 so that fail can be avoided. A safety factor of lashing is 1.4 (Shoberg, 2016).

In this research, it is known that tensile strength of lashing 870 MPa and ultimate stress worth 1080 MPa. The permissible stress with 1.4 of safety factor is 771.43 MPa.

2.3 Turnbuckle

Turnbuckle as shown in Figure 1. Lashing stress is adjusted with tensile force to the element of rotation at the turnbuckle, but principally turnbuckle tend conventionally cannot calculate tensile stress without equipment specific calculation.

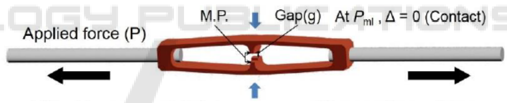

Figure 1: Turnbuckle

The principle of the turnbuckle for tightening of lashing with rotation indicated by the red color part at Figure 1. The result of rotation is part of P or stem which will be near or away from each other (Popov, 1984).

3 METHODOLOGY

3.1 Finite Element Modeling

The finite element model in this research is turnbuckle and lashing bars. Turnbuckle use jaw type. When making turnbuckle model, it is divided into 4 part that is jaw, body, nut, and bolt. Finite element model of turnbuckle as shown in Figure 2.

After modeling every part, next process assembly on a gradually. Part modeling before will assembly together. The result of assembly every part turnbuckle and lashing bars as shown in Figure 2.

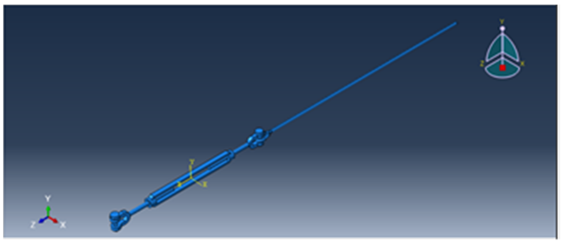

Figure 2: Finite Element Model

Meshing is a process to divide small element between the model. The size of element used when smaller is better. The trial of lashing is method hex element.

Convergence is carried out to the model lashing between turnbuckle and lashing rod with 15 mm element size to 5 mm element size. Model when convergence proses to do with considering computer requirement so that meshing proses can running smoothly. The result of convergence as shown in Table 1.

Table 1: Result of Convergence

No	Element Size (mm)	Nodes	The Number of element	Stress (Mpa)
1	15	65804	16682	163.61
2	14	85845	23688	177.4
3	13	102854	28594	194.56
4	12	115112	30681	186.19
5	11	163093	46085	171.98
6	10	189109	49354	180.28
7	9	254603	71786	185.91
8	8	373380	100948	227.54
9	7	522478	148517	264.54
10	6	758847	206684	264.66

Based on the Table 1 it can be seen that modeling convergence when element sized 7, and the element will use for determined of stress is element sized 7. From the result of convergence, size of an element using every variant of the turnbuckle.

3.2 Loading

First loading was found of strength obtained on Germanisher Llyod Rules (GL, 2013). First force of lashing has same value every turnbuckle. First force value at 240 kN when the rotation of turnbuckle differently. The force as shown in Table 2.

Table 2. Minimum Force on Rotation of Turnbuckle

Turnbuckle	Turnbuckle Rotation (β)
Small	398.45
Medium	318.76
Large	227.69

On the Table 2 show turnbuckle rotation to reach maximum worth 230 kN. The value has a certain rotation so that maximum result meet the permissible stress when rolling ship. Stress, calculated until angle 40 for ship length of under 100 M (Kobylinski, 2005).

4 Result and discussion

Lashing of stress showed when shipping even keel and tilted ship for shipping. When even keel condition there is force first of minimum turnbuckle worth 230 kN. Force of rotation is an increase until 300 rotate off the turnbuckle. The increase of turnbuckle is in multiples 60 and maximum when 300 of rotation. Different rotation because different of the pitch is from variant turnbuckle which results in different lashing stress on the same rotation. The stress results are shown in the following figure.

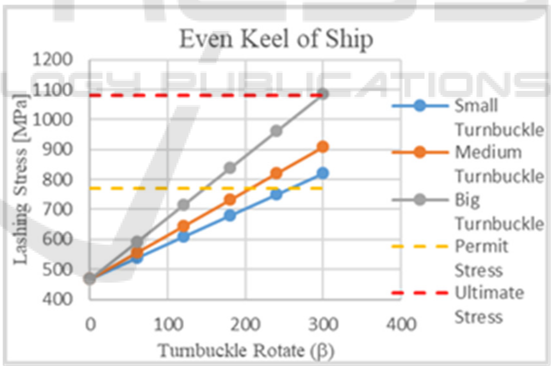

Figure 3: Lashing Stress in the Even Keel Condition

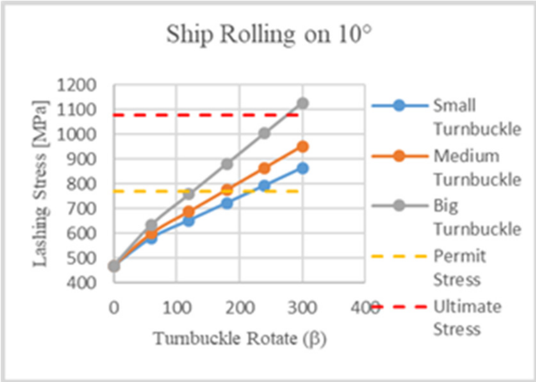

Figure 4: Lashing Stress in the Ship Rolling on 10º

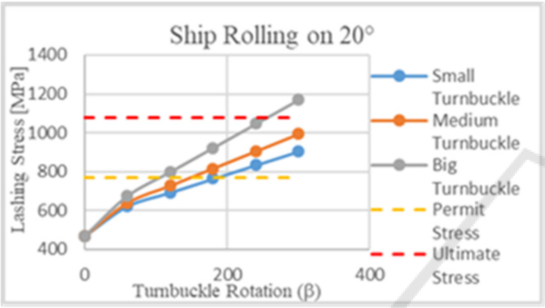

Figure 5: Lashing Stress in the Ship Rolling on 20º

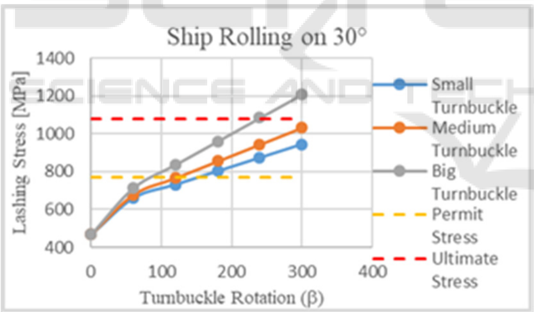

Figure 6: Lashing Stress in the Ship Rolling on 30º

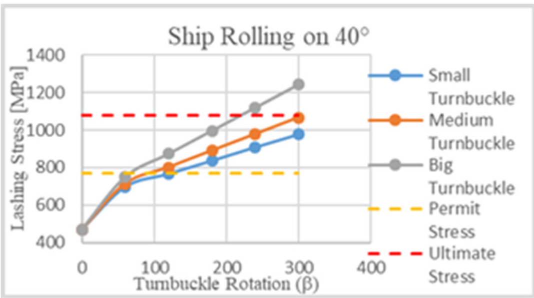

Figure 7: Lashing Stress in the Ship Rolling on 40º

The result of highest lashing is variant of big turnbuckle rotation compared small turnbuckle and medium turnbuckle that can be seen in Figure 3 up to Figure 7. This is because one value of rotation big turnbuckle is biggest if compared with the other. When rolling ship condition value of stress on lashing has increased more than even keel condition, because when the rolling ship has increased load cause weight of the container. Increasingly angle of the rolling ship, higher stress will result.

Variation of turnbuckle which has on catalogue has a different length. Different length not yet can use for all size of lashing bars whose size 2400 mm. From all size different, long of turnbuckle must adjust to long of lashing bars

For adjusting between the turnbuckle and lashing bars when the jaw turnbuckle opens half produces a different length. For length selection when the turnbuckle is open halfway with the length of lashing during the 20 feet container binding, the most suitable can be seen in Table 3.

Variation of size small turnbuckle opens half, the result of long when installed lashing bars sized reduced 3580.07 that can be seen Table 3. If binding container 20 feet condition with 1 tier, from 3 variation size of turnbuckle which meets calculation container 200 feet can be used medium turnbuckle variation. That is because of medium turnbuckle if compared with small turnbuckle can meet requirement long when combined with lashing bars and fastening upper 3580.07 mm and tilted condition 40 result of stress still below permit stress that is 731.48 MPa.

Table 3: Comparison of turnbuckle variation

Turnbuckle variant	Length of lashing for binding container [mm]	The length required [mm]	Rotation of turnbuckle on 60º [MPa]
Small	3580.07	470.07	696.55
Medium	3580.07	143.43	713.48
Large	3580.07	271.93	749.22

5 CONCLUSION

According to the analysis and results, this research can be concluded as follows:

1. A minimum force of lashing is 230000 N with variation rotation of turnbuckle reach tensile force minimum that is small turnbuckle when 398.45° rotation, medium turnbuckle 319.76° rotation and big turnbuckle 227.69° rotation.
2. On small turnbuckle when tilted ship until 40° rotation limit which increases of tensile force

minimum is 120° rotation with the value of stress 766.86 MPa. For medium turnbuckle worth 60° with a value of stress 713.48 MPa. Big turnbuckle of angle rotation which can fulfill is 60° with a value of stress 749.22 MPa.

3. The most suitable for one tier container 20 feet is medium turnbuckle size.

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