

Optimization of the Design of a 40,000-Liter Crude Palm Oil (CPO) Mobile Tanker to Anticipate Leakage Incidents

Reza Prasetya, Ismail Ismail

Master of Mechanical Engineering, Pancasila University, Jakarta, INDONESIA

E-mail: rezaa.ptg@gmail.com

| Submitted: January 29, 2026 | Revised: May 06, 2026 | Accepted: August 29, 2026 |

| Published: October 23, 2026 |

ABSTRACT

Mobile Truck Tankers are essential for distributing Crude Palm Oil (CPO) to meet industrial and community demands. However, 40,000 L CPO tankers often leak due to sloshing, which creates internal pressure, forces, and moments. Baffles are needed to mitigate this issue. This study provides design recommendations and optimizations for leaking tankers. The methodology involved analyzing tank wall thickness, fluid motion (sloshing), structural strength, material service life, and baffle effectiveness in reducing sloshing. The aim was to minimize leaks in CPO Mobile Tankers. Results show that fluid forces are a primary cause of leaks. The optimized design enhanced structural strength and extended service life from 24 to 28 months—a 17% improvement over the existing design. The most effective change is adding baffles at critical high-force points, serving as a key recommendation for tanker improvements.

Keywords: mobile tanker, baffles, Crude Palm Oil (CPO), sloshing.

INTRODUCTION

Regulation of the Minister of Energy and Mineral Resources (ESDM) Number 32 of 2008 concerning the Provision, Utilization, and Trade of Biofuel (Biofuel) as Alternative Fuel, has prompted industry players in Indonesia, especially those engaged in the energy sector, to compete in developing CPO as an alternative energy source [1]. This is marked by the development of CPO biofuel entering the B30 phase and will continue to be developed into B40 or B50. Based on this, considering how important palm oil is for life, special handling must be carried out in the distribution process from palm oil producers to collection stations. One of the distribution processes is by using mobile tankers. In reality, many mobile tankers experience leaks, so they can no longer operate, which of course can be a problem for the community. Therefore, in this study, we attempted to optimize the design of a 40,000-liter CPO mobile tanker, which has experienced many cases of leakage.

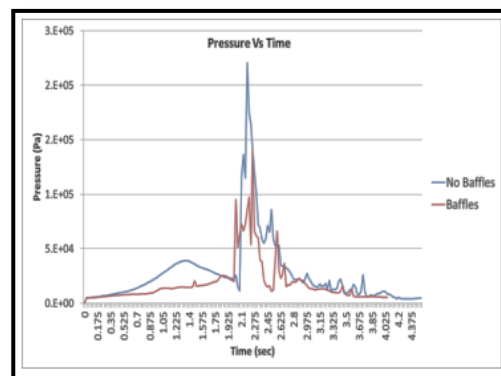
Mobile truck tankers are one of the most effective and efficient ways to transport fluids [2], but they are also highly dangerous vehicles [3], with several incidents occurring involving mobile truck tankers [4]. Therefore, they must be designed with a high level of precision and good balance during travel [5]. Research conducted by [6] specifically discusses failures in the design of mobile truck tankers that have resulted in fatalities and caused material and immaterial losses.

This design optimization will begin with mitigating the existing design to determine whether it complies with applicable codes and standards [7]. The codes and standards used for mobile truck tankers refer to the "ASME Boiler Pressure Vessel Code BPVC Section XII – Rules for Construction and Continued Service Transport Tanks" dated 2017. After that, an analysis of fluid movement inside the tank (sloshing) will be carried out, as well as an analysis of the strength of the tank material. The result of this research is to provide recommendations/design optimization for the case of a 40,000 L mobile truck tanker CPO leak. Much research has been conducted on mobile tankers, particularly in relation to baffles. Table 1 summarizes the research that has been conducted.

Table 1. Research Conducted Related to Baffles

Researcher	Without Using Baffles	With Using Baffles	Conclusion	
			With Baffles is Better	Without Baffles is Better
R. Ambade et al [8]	2,25 bar	1,4 bar	✓	
N. Ahmad, et al [9]	350.000 N	100.000 N	✓	
Hakim [10]	20.715 Pa	6.594 Pa	✓	
V. Singal [11]	Higher fluid movement (0.45s)	Lower fluid movement (0.45s)	✓	
Yash Deshmukh[12]	1.500 N	500 N	✓	
Ashar Khoirul Arsad [13]	86.208 kPa	87.544 kPa		✓
Akildiz [14]	0,0017 MPa	0,0012 MPa		✓

Research conducted by (Ambade & Kale, 2014) shows that an important part of a mobile truck tanker series is baffles. The research used the following parameters: the length of the tanker truck is 9.6 m, the maximum width of the ellipse is 2.85 m, while the minimum width of the ellipse is 1.81 m, the total volume of the tanker truck is 43.35 m³, the fluid volume inside is 40% of the total tank volume, 17.34 m³, the air density is 1.2250 kg/m³, the air viscosity is 1.7894 x 10⁻³ kg/ms, the density of kerosene is 780 kg/m³, and the viscosity of kerosene is 0.0024 kg/ms. The conclusion drawn from this study is that the use of baffles can reduce the pressure exerted on the tank walls caused by fluid movement inside the tank. Without baffles, the pressure is 2.25 bar, while with baffles, the pressure is reduced to 1.4 bar, as shown in Figure 1 on the effect of using baffles.

**Figure 1.** Effect of Baffle Use on Tank Trucks [15]

Research related to baffles was also conducted by (Ahmad et al., 2020). In this study, the use of baffles was compared with no baffles, with an emphasis on the direction and model of the baffles. The limitations of this study included the length of the tank truck, which was 10 m, the diameter of the tank, which was 2.5 m, the material of the tank and baffles was aluminum, the density of the fuel oil was 750 kg/m³, the viscosity was 0.0024 kg/ms, the lateral baffles had a hole diameter of 0.5 m, the bisectonal baffles had a hole diameter of 0.25 m, and the critical point when the truck was moving and then braking was 9.8 m/s². The conclusion drawn from this study is that using lateral baffles and bisectonal baffles on normal roads reduces the force and moment received by the tank wall by 50% and 130% during braking, respectively. These values represent the maximum reduction, as shown in Figure 2 comparing the use of baffles.

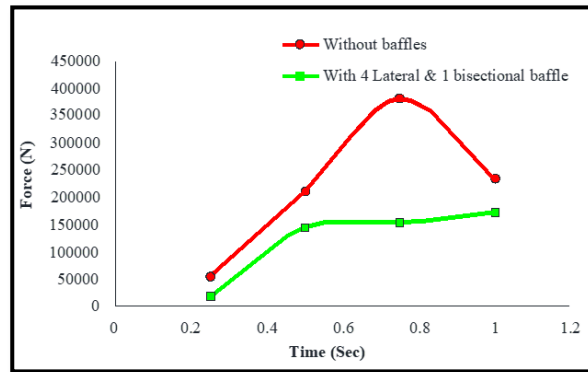


Figure 2. Comparison Without Baffles and With the Use of Baffles (Ahmad et al., 2020)

Research conducted by (Hakim, 2017), discusses various types of baffles. This research has several limitations, including operating pressure of 101.325 Pa, acceleration due to gravity of $X=0 \text{ m/s}^2$, $Y=-9.81 \text{ m/s}^2$, $Z=0 \text{ m/s}^2$, gasoline density of 1.2250 kg/m^3 , tank length of 8 m, and tank diameter of 2 m. The conclusion drawn from this study is that for a 40% filled tank truck, the best baffle is one with a large hole in the center with a horizontal ellipse, while for an 80% filled tank truck, the best baffle is one with a large hole in the center with a vertical ellipse.

Research related to baffles has also been conducted by (Arsad et al., 2013), but the test results stated that the use of baffles was no better than not using baffles because the baffle design was not higher than the fluid height, causing the pressure to increase. Research conducted by (Akyildiz, 2017) examined the use of horizontal baffles and concluded that the use of horizontally positioned baffles is ineffective in reducing pressure. The approach to be used is CFD because CFD has a higher level of accuracy, which is in line with the research conducted by [20] comparing CFD simulations with experimental evidence. Research conducted by [3] shows that designing a tank truck requires great precision. because tank trucks are a means of transportation that involve many dangers, especially if the fluid in the tank is flammable, so stability is required in designing tank trucks. The conclusion that can be drawn from this research is that in designing a tank truck, the balance of the fluid to be transported must be taken into account, as well as the distance between the wheel axles. The most important factor in balance is the lateral movement of the liquid being transported.

Research conducted by [21] discusses the analysis of leaks in LPG storage tanks, stating that it is very important to mitigate the lifetime of a storage tank. The method used in this study was to divide each part of the tank into several parts, namely 6 parts on the wall side, 2 parts at the end of the tank, and the corners were divided into 3 sections: 90° , 180° , and 270° . Table 1.5 shows the inspection specifications used in the study. After conducting the study, the conclusion obtained from the research using the Corrosion Allowance calculation was that the most critical part was on the head (end) of the tank with an estimate of 33.5 years, while the shell (wall) showed 98.9 years. Therefore, the author wishes to conduct research with the aim of optimizing the design of the 40,000 L CPO Mobile Truck Tanker using computer simulation with the PV Elite program and CFD analysis.

RESEARCH METHODS

The method used in this study began with analyzing the thickness of the tank, analyzing fluid movement inside the tank (sloshing), analyzing the strength structure and lifetime of the tank material, and analyzing effective baffles to reduce sloshing. This provided optimization for CPO mobile tanker leaks. This research was conducted based on the problem of leakage in mobile truck tankers. Therefore, the purpose of this research is to optimize the design for leakage cases in mobile truck tankers, with the hope of providing recommendations/optimization for these leakage cases so that units experiencing leakage can operate again, thereby providing benefits for the company and the community. Computational Fluid Dynamics (CFD) in this research uses Ansys Fluent software. The purpose of this activity is to obtain fluid movement (sloshing) caused by the mobility of the tanker truck. This activity began with creating a geometry according to the actual mobile truck (length, diameter, distance between baffles, and thickness of the tanker truck). This geometry was

created using Solidworks software, and after the geometry was completed, it was exported to Ansys software. After obtaining the CFD results, the data will be used as input data in the FEA phase. This activity is carried out to analyze which parts of the mobile tanker truck experience the highest maximum stress points. This can be analogized that the parts experiencing the highest maximum stress points are the parts that experience leakage. This research will also analyze the lifetime/service life of the tanker truck based on the load and force it receives with the help of the FEA program. By paying attention to the remaining service life of the tanker truck, it is hoped that users of mobile tanker trucks will be more aware.

RESULT AND DISCUSSION

Based on the results of research, leaks in mobile tankers can occur due to internal and external factors. The following are some of the factors that can cause leaks. Material failure analysis will be carried out when a case occurs in the field. This is done to identify and find solutions to the problems that arise. This study examines cases of leaks in 40,000-liter capacity mobile tankers. Leaks in mobile tankers can be caused by five aspects, namely manufacturing, materials, environment, operations, and design. Of these five aspects, this study will discuss the design aspect more comprehensively.

Manufacturing Aspects

There are several things related to material failure when viewed from a manufacturing perspective, namely:

Tank Plate Welding

Failures/defects in welded joints are an important factor in leaks, therefore this study investigates tank plate welding. In this study, welding was carried out in accordance with applicable standards and the welds were inspected with good results (the inspection report is in Appendix 3).

Installation/Assembly Factors

Installation/assembly procedures also play a role in causing mobile tanker leaks, therefore standard procedures are required for the installation/assembly of mobile tankers. In this study, the installation/assembly of mobile tankers was carried out by a competent company/manufacturer and the specifications of the assembly components were in accordance with the capacity of the mobile tanker itself. For more details, see Appendix 4.

SITE REPORT (DETAILS)		
O. Inspection Dates / Manday: _____		
P. Inspection Result:	☒ satisfactory ☐ conditionally accepted (see report details) ☐ non conforming (see report details) ☐ rejected (see report details) ☐ aborted inspection (see report details)	Q. NCR/Punch list issued: ☐ No ☐ Yes (see report details)
R. Inspection Summary & Short Conclusion:	It has been observed and deemed appropriate that all products and services provided in the contract are suitable.	
R.5.7. Others		
- Welded manufacturing procedures were examined and checked. - Pressure test report reviewed and checked. No non-conformities were observed. - Material certificates, product catalogue, painting certificate, tightness and pressure test report and kingpin certificate were reviewed and checked by our inspector.		

Figure 3. Testing and Inspection of Manufacturing and Installation

Material Aspects

A special study is required regarding the materials used, whether they are corrosion resistant or not. The materials used in the manufacture of mobile tankers must also be compatible with the characteristics of the fluid inside, so as to reduce the possibility of leakage from the mobile tanker. In this case, the material used is ST37 steel. ST37 material has good corrosion resistance, as researched by Taha Yasin et al., with results showing that ST37 steel material experienced a

thickness reduction (thinning) of 0.0006% to 0.0025%. From this research, it can be concluded that ST37 material can be used as the frame material for mobile tankers.

Environmental Aspects

A corrosive environment/area has a significant factor in the rate of corrosion of a material. In this study, the mobile tanker operates in Gabon (Central Africa), located approximately 1 km from the coastline, which could be one of the external causes of mobile tanker leaks. In addition, when viewed from its geographical location, the mobile tanker does operate approximately 1 km from the coast, but there is no erosion of the coastline in this area. However, protective measures have been taken in the manufacturing process of this mobile tanker, namely by adding a corrosion-resistant coating with a minimum thickness of 300 microns.

Operational/Usage Aspects

Regarding the operational/usage aspects of the mobile tanker, the manufacturer has provided operational standards and a maintenance system for the mobile tanker to minimize operational errors. For more details, refer to Appendix (3). Additionally, the mobile tanker drivers have received training and certification to operate the mobile tanker and hold the necessary permits to operate it.

Design Aspect

This design aspect will be the focus of this study. Therefore, comprehensive data is needed to analyze leaks caused by internal factors such as fluid movement/sloshing. The results of this study will provide recommendations/design optimizations for mobile tanker leak cases. Several things that can be analyzed include tank wall thickness and fluid movement/sloshing analysis in existing designs.

Tank Wall (Shell) Thickness Analysis

Mobile truck tankers that experience leaks will be simulated using PV Elite software to analyze whether the thickness of the plate material used complies with the applicable international codes and standards for truck tank design, referring to the “ASME Boiler Pressure Vessel Code BPVC Section VIII - Rules for Construction and Continued Service Transport Tanks”. Actual field data is required as a reference for calculations and will be used as calculation parameters. Table 2 shows the actual field leak locations for the leak that occurred in the 40,000 L CPO Mobile Tanker.

Table 2. Location of Leaks in Tanks

No.	Leak Location	Crack estimation (±)	Photo References
1	Bottom of the middle section of the tank	5 cm	Picture 4.2
2	Bottom of the front section of the tank	10 cm	Picture 4.4
3	Bottom of the front section of the tank	2 cm	Picture 4.6
4	Bottom of the front section of the tank	5 cm	Picture 4.7

Table 2 shows the actual measurements of the length of the leak that occurred in the mobile tanker. The tool used was a digital caliper, which allowed the location of the leak in the tank frame to be identified. To confirm the leak, a thorough observation of all parts of the mobile tanker was conducted, and it was found that the actual leak occurred at the bottom of the tank, as shown in Figure 4, which shows the Quality Control (QC) team conducting a visual inspection of the mobile tanker leak. After observing the tank frame, it was found that many leaks occurred at the bottom of the tank with varying leak widths, as can be seen in the inspection photos. After obtaining this data, an analysis of the leaks can be carried out, as well as design optimization.



Figure 4. Details of Leaks on the Lower Side of the Middle of the Tank

Figure 4 shows the details of the visual inspection conducted by the Quality Control (QC) team. Based on the observations, data was obtained showing that the leak was located on the lower side of the tank in a circular pattern with a leak length of 5 cm.



Figure 5. Leakage on the Bottom Side of the Front of the Tank

An inspection was also carried out on another case of mobile tanker leakage, as shown in Figure 4.6, which shows the leak point on the bottom side of the front of the tank. A visual inspection was also carried out by the Quality Control (QC) team, which obtained data showing a leak length of 10 cm with a vertical leak direction. For more details, see Figure 5. A visual inspection was also carried out on another leak case, as shown in Figure 6, which illustrates a mobile tanker leak occurring while the vehicle was in motion.



Figure 6. Details of the Leak on the Bottom of the Front of the Tank

After a visual inspection, it was found that the mobile tanker leak occurred while it was moving, with the leak point located on the bottom of the front of the tank and measuring 2 cm in length. This can be analogized to scenario 3. Figure 8 shows another case of a leak in a mobile tanker, in which the leak location was on the bottom of the front of the tank and the leak was 5 cm long.

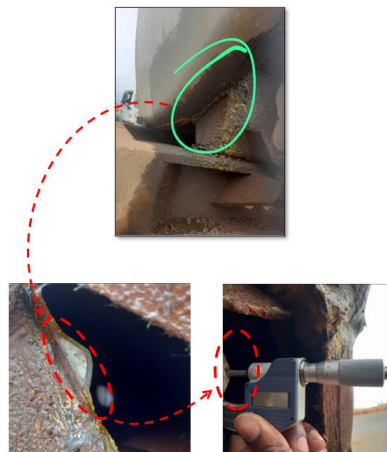


Figure 7. Details of the Leak on the Bottom Front of the Tank

To refine the actual field data, data was collected by damaging the tank's plate wall as shown in Figure 7. Data was collected by measuring the thickness of the tank plate using a screw micrometer as shown in Figure 7, and the data is shown in Table 3.

Table 3. Initial Actual Field Data

No.	Description	Plate Thickness	Material
1	Saddle plate thickness	3 mm	ST 37-2
2	Pad saddle plate thickness	6 mm	ST 37-2
3	Cover saddle plate thickness	3 mm	ST 37-2

Analysis of Fluid Movement (*Sloshing*) in Design Optimization.

After obtaining the highest fluid movement in the existing design, to obtain the best optimization results, this study used three scenarios, namely:

Addition of a baffle half the height of the tank diameter in a vertical direction (Scenario 1)

The tank volume and speed conditions are the same as in scenario 1, namely containing 25% fluid and a speed of 60 km/hour. In this subchapter, the difference is the addition of baffles half the height of the tank diameter in a vertical direction. With the addition of these baffles, it is hoped that the

fluid movement/sloshing and the forces that occur when the mobile tanker is operating can be reduced. The results of the scenario-1 analysis are shown in Figure 8.

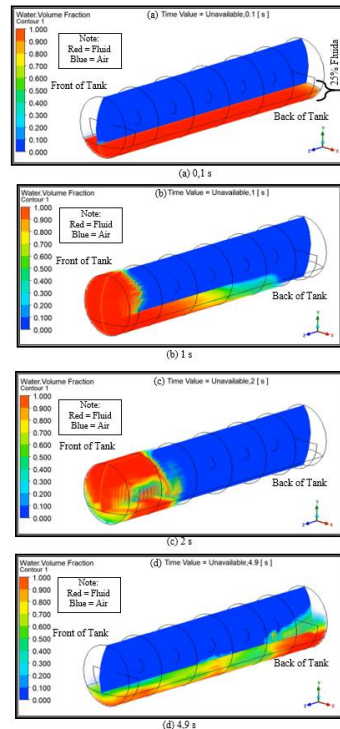


Figure 8. Fluid Movement in Scenario 1

The analysis results show red representing fluid with a value of 1 and blue representing air with a value of 0, while the other colors represent a mixture of fluid and air with values ranging from 0 to 1. The analysis results show that the fluid movement is directed toward the front of the mobile tanker. At 0 seconds, the fluid condition is still stable according to the initial volume of 25%. then at 1 s the water volume moves forward, then at 2 s the water falls and hits the bottom wall of the tank. It is at this position that the greatest force can cause leakage, then at 4.9 s the fluid condition reverses back. After adding half a baffle at the critical point (0.5 m from the tank wall), the fluid movement can be reduced.

Addition of a Baffle as High as the Tank Diameter in the Vertical Direction (Scenario 2)

The volume and speed conditions of the tank are the same as in scenario 1, namely containing 25% fluid and a speed of 60 km/h. The results of the scenario 2 analysis are shown in Figure 9.

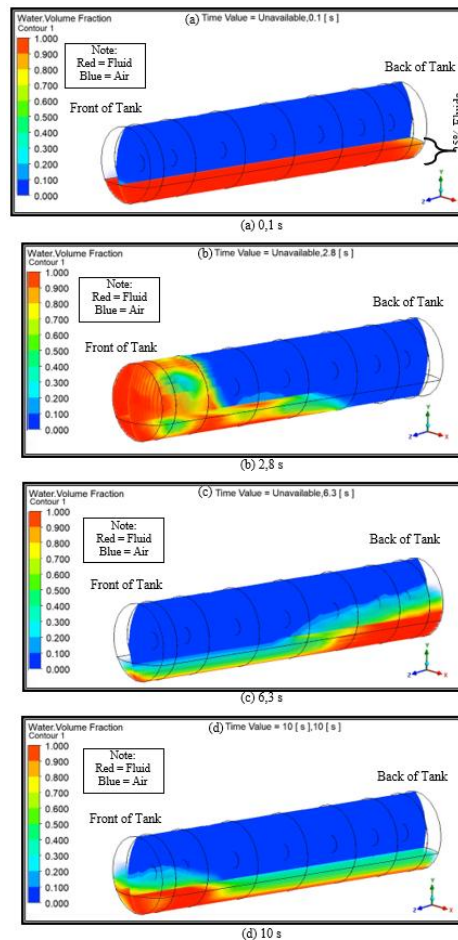


Figure 9. Fluid Movement in Scenario 2

The results of the analysis show that the initial condition of the mobile tanker with 25% of the tank filled with fluid or 0.6 m high at 0 s, then in part (b) shows that at 2.8 s, the initial condition of the water volume moves towards the front of the tank, then hits the front wall of the tank and the water spins upward and then back down due to the gravitational force and mass of the fluid, causing significant turbulence. After that, at 6.3 seconds, the water reverses back to the rear of the tank. The most critical water movement occurs at 2.8 seconds when the fluid hits the front wall of the tank, then swirls upward and falls back down, driven by gravity and the mass of the fluid, causing the fluid to accelerate. From the analysis results, it can be seen that the fluid movement moves towards the front of the mobile tanker. At 0 seconds, the fluid condition is still stable according to the initial volume of 25%. Then, at 1 second, the water volume moves forward, and at 2.8 seconds, the water falls and hits the bottom wall of the tank. It is at this position that the greatest force can cause leakage. After adding a baffle as high as the tank diameter at the critical point (0.5 m from the tank wall), the fluid movement can be reduced.

Addition of a Baffle Half the Diameter of the Tank but in a Horizontal Direction (Scenario 3).

The volume and speed conditions of the tank are the same as in scenarios 1 & 2, namely containing 25% fluid and a speed of 60 km/h. The results of the scenario 3 analysis are shown in Figure 10.

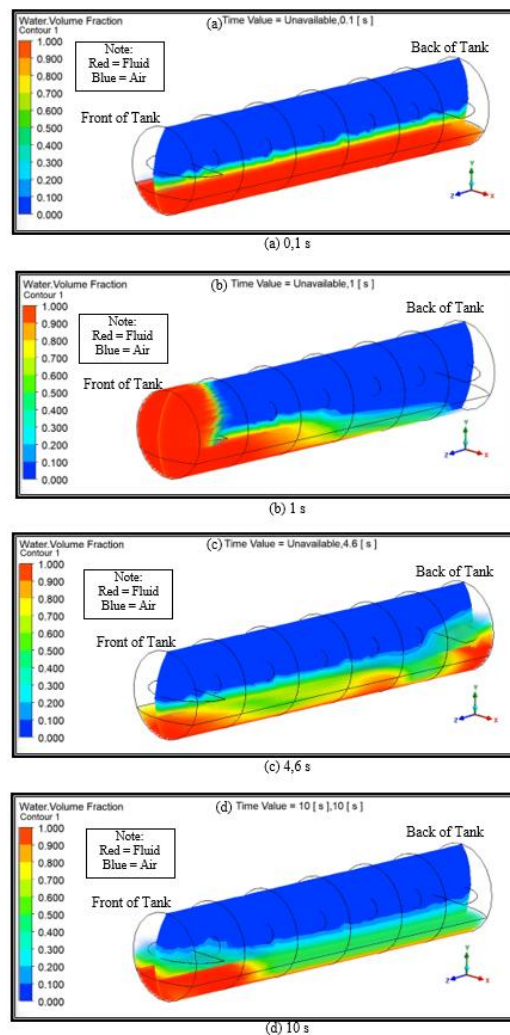


Figure 10. Fluid Movement in Scenario 3

The analysis results show red representing fluid with a value of 1 and blue representing air with a value of 0, while the other colors represent a mixture of fluid and air with a value range of 0 to 1. The most critical water movement occurs at 1 second when the fluid hits the front wall of the tank, then rotates upward and falls back down, driven by gravity and fluid mass, causing the fluid to accelerate. From the analysis results, it can be seen that the fluid movement moves towards the front of the mobile tanker. At 0 seconds, the fluid condition is still stable according to the initial volume of 25%. then at 1 second the water volume moves forward, then at 2 seconds the water falls and hits the bottom wall of the tank. It is at this position that the greatest force that can cause leakage occurs, then at 4.6 seconds the fluid condition reverses back. After adding a baffle half the diameter of the tank but in a horizontal direction at the critical point, it can reduce the fluid movement that occurs when the mobile tanker is moving.

Analysis of Forces Occurring Due to Fluid Movement (*Sloshing*)

After analyzing the movement of the fluid/*sloshing*, we can determine the forces caused by the movement of the fluid. These forces are assumed to be the main cause of leaks in *mobile tankers*. The following are the results of the analysis of the three fluid movement/*sloshing* scenarios.

Forces Occurring on the Mobile Tanker in Scenario 1

After adding a baffle half the height of the tank diameter, the force generated by the fluid movement can be reduced. The highest force generated by the forward fluid movement with a tank volume of

25% occurs at 2.8 seconds, amounting to 9,835,200 N with forward movement of the tank. Figure 11 shows the forces that occur after scenario 1.

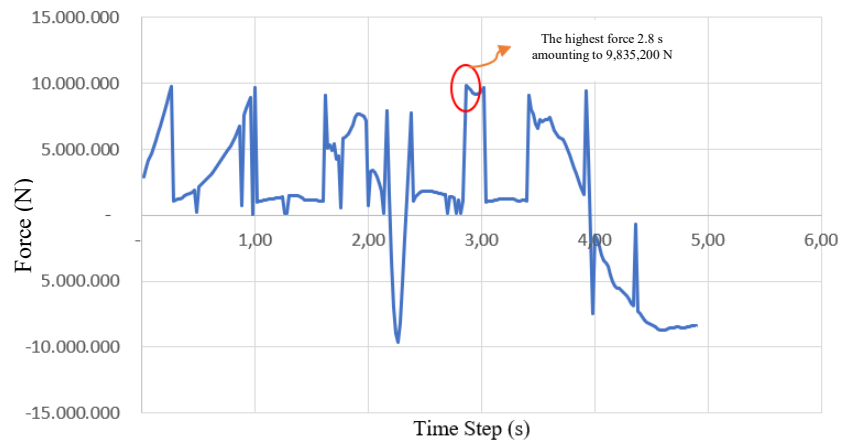


Figure 11. Forces in Scenario 1

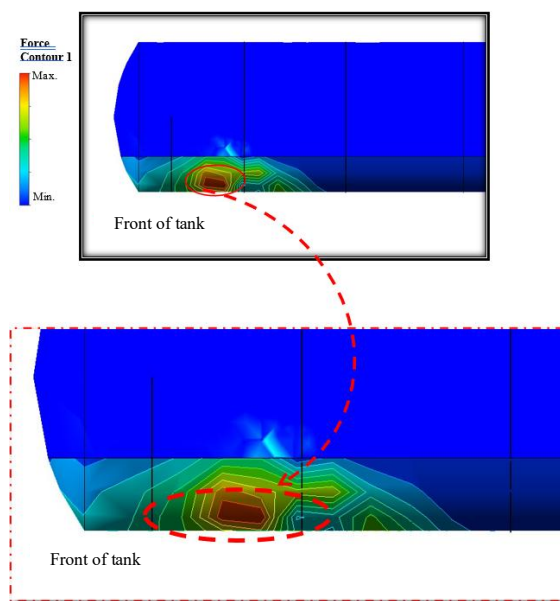
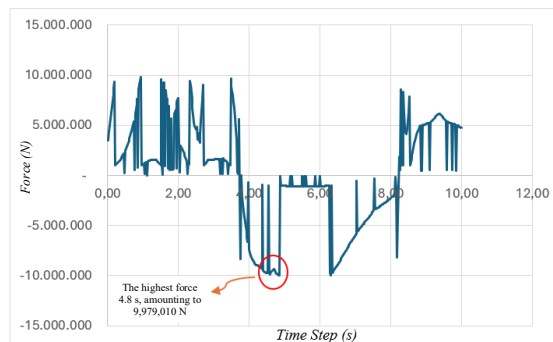
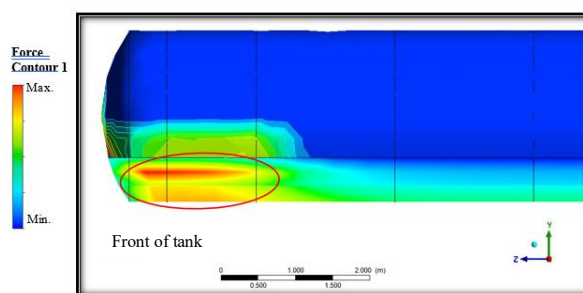


Figure 12. Location of the Highest Force in Scenario 1

Forces Occurring in the Mobile Tanker in Scenario 2

After adding a baffle half the height of the tank diameter, the force generated by the fluid movement can be reduced. The highest force generated by the forward fluid movement with a tank volume of 25% occurs at 4.8 seconds, amounting to 9,979,010 N with movement toward the front of the tank. Figure 13 shows the forces that occur after scenario 2.

**Figure 13.** Forces in Scenario 2**Figure 14.** Location of the Highest Force in Scenario 2

Forces Occurring in the Mobile Tanker in Scenario 3

After adding a baffle half the diameter of the tank but in a horizontal direction, the force generated by the fluid movement can be reduced. The highest force generated by the forward fluid movement with a tank volume of 25% occurs at 4.4 seconds, amounting to 9,963,261 N with movement towards the front of the tank. Figure 29 shows the forces that occur after scenario 3.

**Figure 15** Forces in Scenario 3

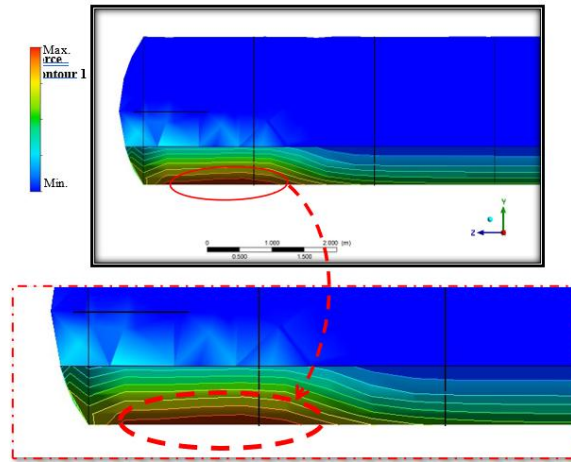


Figure 16. Location of the Highest Forces in Scenario 3

Analysis of Maximum Material Stress Due to Fluid Movement (*Sloshing*)

After obtaining the analysis of fluid movement/*sloshing* and the forces generated from the fluid movement, we can determine the distribution and maximum *stress* that occurs in the *mobile tanker*. The following are the results of the analysis of the most critical *existing* design and each scenario.

Maximum Stress in the Existing Design

Based on the results of the existing design analysis, it was found that the highest and most critical force occurred in simulation 3, namely when the mobile tanker moved forward with a tank volume of 25%. Therefore, an analysis was conducted on the stress that occurred in simulation 3. Table 4 shows the equivalent stress that occurred in the existing design.

Table 4. Maximum Stress in the Existing Design

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	5,3514e-007	207,44	7,7619

The maximum stress that occurred was 207.44 MPa. To see the location of the maximum stress that occurred on the mobile tanker, see Figure 17.

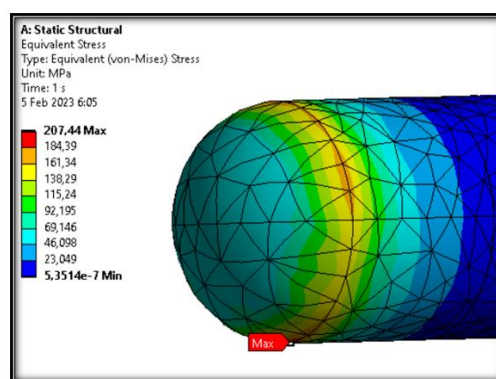


Figure 17. Maximum Stress in the *Existing* Design

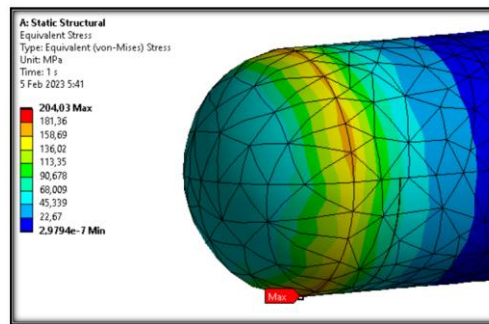
Maximum Stress in Scenario 1

The addition of a *baffle* in scenario 1 can reduce the stress occurring on the *mobile tanker*. The results of the simulation of the maximum stress values are shown in Table 5.

Table 5. Maximum Stress in Scenario 1

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	2,9794e-007	204,03	7,2099

The maximum stress that occurred was 204.03 MPa. The location of the maximum stress on the mobile tanker can be seen in Figure 18.

**Figure 18.** Maximum Stress in Scenario 1

In Figure 18, the maximum stress in scenario 1 occurred on the front side of the bottom of the tank, which is consistent with the actual location of the leak on the mobile tanker.

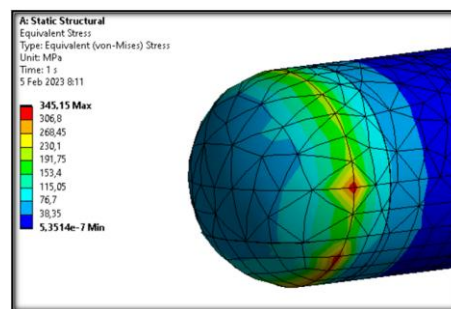
Maximum Stress in Scenario 2

The addition of a baffle in scenario 2 aims to reduce the stress occurring on the mobile tanker. The maximum stress values are shown in Table 6.

Table 6. Maximum Stress in Scenario 2

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	2,9794e-007	204,03	7,2099

The maximum stress that occurred was 345.15 MPa. The location of the maximum stress on the mobile tanker can be seen in Figure 19.

**Figure 19.** Maximum Stress in Scenario 2

In Figure 19, the maximum stress in scenario 2 occurred on the front side of the bottom of the tank and also on the side of the tank. This is in accordance with the actual location of the leak on the mobile tanker.

Maximum Stress in Scenario 3

The addition of a baffle in scenario 3 aims to reduce the stress occurring on the mobile tanker. The maximum stress values are shown in Table 7.

Table 7. Maximum Stress in Scenario 3

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	6,1801e-012	272,25	8,1737

The maximum stress that occurred was 272.25 MPa. To see the location of the maximum stress that occurred on the *Mobile Tanker*, see Figure 20.

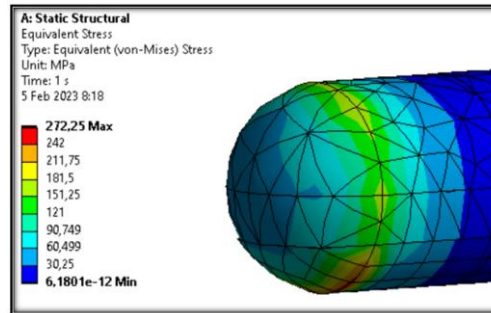


Figure 20. Maximum Stress in Scenario 3

In Figure 20, the maximum stress in scenario 3 occurs on the front side of the bottom of the tank and also on the side of the tank, which is in accordance with the actual location of the leak on the mobile tanker.

Life Time/Service Life

Life Time/service life is an analysis of the strength of a material due to reactions that occur in the system, such as fluid movement, temperature, and forces at work.

The analysis calculations were performed using software. The following are the results of the analysis of the most critical existing design and each scenario

Life Time/Service Life of Existing Design

The life time/service life of the existing design is shown in Table 8, which shows the average service life of the existing design.

Table 8. Life Time of Existing Design

Time [s]	Minimum	Maximum	Average
1	0,	1,e+006	4,3301e+005

Table 8 shows that the life time of the mobile tanker is 433,010 s. It experiences a force of 9,999,754 N 600 times. Assuming that the mobile tanker operates 8 hours/day, at a speed of 60 km/hour, it experiences resistance 600 times. The life time of the mobile tanker is 433,010 cycles.

Life Time/Service Life in Scenario 1

Life Time/service life in scenario 1 is shown in Table 4.32, which indicates the average service life of scenario 1.

Table 9. Life Time in Scenario 1

Time [s]	Minimum	Maximum	Average
1	0,	1,e+006	4,9961e+005

Table 9 shows that the life time of the mobile tanker is 499,610 s. It experiences a force of 9,835,200 N 600 times. Assuming that the mobile tanker operates 8 hours/day at a speed of 60 km/hour, it experiences 600 times of resistance. The life time of the mobile tanker is 499,610 cycles.

Life Time/Service Life in Scenario 2

Life Time/service life in scenario 2 is shown in Table 4.32, which shows the average service life of scenario 2.

Table 10. Life Time in Scenario 2

Time [s]	Minimum	Maximum	Average
1	0,	1,e+006	4,4084e+005

Table 10 shows that the life time of the mobile tanker is 440,840 s. It experiences a force of 9,979,010 N 600 times. Assuming that the mobile tanker operates 8 hours/day, at a speed of 60 km/hour, it experiences resistance 600 times. The life time of the mobile tanker is 440,840 cycles.

Life Time/Service Life in Scenario-3

Life Time/service life is an analysis of the strength of a material due to reactions that occur in the system, such as fluid movement, temperature, and forces acting on it. The analysis calculations are performed using *software*. Table 4.10 shows the results of the analysis for scenario-1.

Table 11. Life Time in Design Optimization

Time [s]	Minimum	Maximum	Average
1	0,	1,e+006	3,7837e+005

Table 11 shows that the life time of the mobile tanker is 378,370 s. It experiences a force of 9,963,261 N 600 times. Assuming that the mobile tanker operates 8 hours/day at a speed of 60 km/h, it experiences 600 cycles of resistance. The life time of the mobile tanker is 378,370 cycles. The material used in this study is ST 37-2. Based on ASME II Part D, this material is equivalent to A36 (ASTM A36) material. Figure 4.38 shows the equivalent grade standard.

Material St37 Equivalent Grades

DIN 1.0037 (material St37-2) equivalent to US ASTM AISI SAE, European standard EN, British standard BSI, France standard NF, ISO standard, Japanese standard JIS, Chinese GB standard and Indian IS standard. (For reference)

St37 Equivalent grade												
German		US		European Union		UK		France		Japan		China
Standard	Steel (Steel number)	Standard	Steel	Standard	Steel (Steel number)	Standard	Steel	Standard	Steel	Standard	Steel	Standard
DIN 17100: 1980 (EN 10025: 1993)	St 37-2 (1.0037)	ASTM A36; A283/A283M	A36; Grade D	EN 10025-2: 2005	S235JR (1.0038)	BS 4360	40B	NF A35-501	E24-2	JIS G3101; JIS G3106	SS400; SM400A	GB/T 700

Figure 21. Equivalent Grade of ST37 Material

The material properties of ASTM A36 are Allowable Stress 133 Mpa, Min Yield Strength 235 Mpa, Tensile Strength 460 Mpa.

Chemical composition							
Steel grade	Styles	Carbon, max, %	Silicon, %	Manganese, %	Phosphorus, max, %	Sulfur, max, %	Nitrogen, max, %
ST37-2	Steel Angles	0.20	0.15 - 0.35	0.35 - 0.75	0.050	0.050	0.011

Mechanical property				
Steel grade	Styles	Tensile strength, ksi [MPa]	Yield point, min, ksi [MPa]	Elongation, min, δ, %
ST37-2	Steel Angles	52 - 67 [360 - 460]	34 [235]	25

Figure 22. Mechanical Properties of ST37-2 Material

Based on the results of the structural analysis, the actual maximum stress is 207 MPa. Therefore, the stress ratio is 1.5. Since the stress ratio value is greater than 1, this means that the actual stress exceeds the design criteria. After analyzing the fluid movement/sloshing and the forces occurring in the three scenarios, the most optimal design data was obtained by adding half a vertical baffle at the point of maximum force. Figure 23 shows the most optimal design recommendation/optimization.

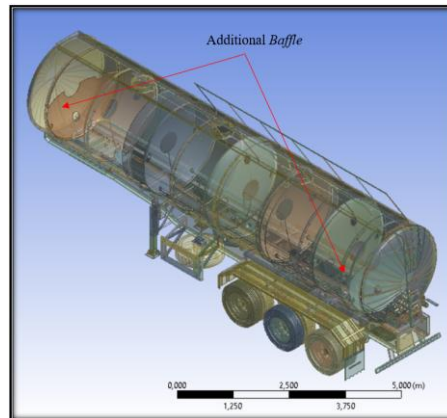


Figure 23. Design Recommendation/Optimization

CONCLUSION

Based on the results of this study, it can be concluded that the most optimal condition is scenario 1. This is because adding a baffle half the height of the tank diameter in the vertical direction can serve to reduce the force generated by fluid movement when the mobile tanker is moving. One of the causes of leakage in the 40,000 L CPO Mobile Truck Tanker is the force that occurs when fluid movement/sloshing occurs inside the tank. The material strength structure and lifetime of the tanker truck with this design optimization increased from 24 months to 28 months, or 17% of the existing design conditions. Based on the most optimal existing design optimization that can be done in this study is to add a baffle at the critical point where the maximum force occurs. This can be used as a recommendation for improving the existing design.

REFERENCES

- [1] ESDM, "Peraturan Menteri Energi dan Sumber Daya Mineral Nomor 32 Tahun 2008 tentang Penyediaan, Pemanfaatan dan Tata Niaga Bahan Bakar Nabati (Biofuel) Sebagai Bahan Bakar Lain," pp. 1–18, 2008.
- [2] M. L. Hosain, U. Sand, and R. B. Fdhila, "Numerical Investigation of Liquid Sloshing in Carrier Ship Fuel Tanks," *IFAC-PapersOnLine*, vol. 51, no. 2, pp. 583–588, 2018.
- [3] M. Guillermo, S. Flórez, and B. Ramón, "Stability of tanker trucks using the Davies method," *Journal of Applied Engineering Science*, vol. 20, no. 2, pp. 602–609, 2022.
- [4] E. R. Vaidogas and O. Survilė, "Trench Fires Resulting From Accidental Releases From Tanker Trucks: Assessing the Thermal Effect on Roadside Territory," *Baltic Journal of Road and Bridge Engineering*, vol. 17, no. 1, pp. 189–212, 2022.
- [5] V. D. Alessandro, "Modeling of tank vehicle dynamics by fluid sloshing coupled simulation," p. 195, 2011.
- [6] S. Lyu, S. Zhang, X. Huang, S. Peng, and J. Li, "Investigation and modeling of the LPG tank truck accident in Wenling, China," *Process Safety and Environmental Protection*, vol. 157, pp. 493–508, 2022.
- [7] ASME, "ASME Boiler Pressure Vessel Code BPVC Section XII – Rules for Construction and Continued Service Transport Tanks, Section xii 2017," 2017.

- [8] R. Ambade and R. Kale, "CFD Analysis of Sloshing Within Tank," *International Journal of Innovative Research in Technology & Science*, vol. 2, no. 3, p. 6, 2014.
- [9] N. Ahmad, M. Varshney, and M. H. Farooqi, "Design and CFD analysis of baffles of fuel tanker trucks for normal and grade highway conditions," *International Journal of Forensic Engineering and Management*, vol. 1, no. 1, p. 76, 2020.
- [10] P. L. Hakim, "Analisa Penambahan Kontruksi Baffles di Dalam Tanki Kapal tanker 17500 DWT Dengan Simulasi Computation Fluid Dynamic (CFD)," 2017.
- [11] V. Singal, J. Bajaj, N. Awalgaonkar, and S. Tibdewal, "CFD Analysis of a Kerosene Fuel Tank to Reduce Liquid Sloshing," *Procedia Engineering*, vol. 69, pp. 1365–1371, 2014.
- [12] Y. Deshmukh, S. Shridhar, P. Anjana, K. Patil, R. Patil, and Dr. E. Perumal, "Optimization and Reduction of Sloshing in the Fuel Tank," *International Journal for Research in Applied Science & Engineering Technology*, pp. 2–11, 2022.
- [13] A. K. Arsad, A. Sulisetyono, M. A. Sc, and D. Ph, "Studi Gerakan Sloshing terhadap Tangki Kotak (Rectangular Tank) Dengan dan Tanpa Pelat Memanjang (Baffle) Akibat Gerakan Rolling Kapal Dengan Metode Computational Fluid Dynamics (CFD)," vol. 2, no. 1, 2013.
- [14] H. Akyildiz, "With a Horizontal Perforated Plate Sloshing In a Rectangular Storage Tank With a Horizontal Perforated Plate," pp. 3–18, 2017.
- [15] R. Ambade and R. Kale, "CFD Analysis of Sloshing Within Tank," *International Journal of Innovative Research in Technology & Science*, vol. 2, no. 3, p. 6, 2014.
- [16] N. Ahmad, M. Varshney, and M. H. Farooqi, "Design and CFD analysis of baffles of fuel tanker trucks for normal and grade highway conditions," *International Journal of Forensic Engineering and Management*, vol. 1, no. 1, p. 76, 2020.
- [17] P. L. Hakim, "Analisa Penambahan Kontruksi Baffles di Dalam Tanki Kapal tanker 17500 DWT Dengan Simulasi Computation Fluid Dynamic (CFD)," 2017.
- [18] A. K. Arsad, A. Sulisetyono, M. A. Sc, and D. Ph, "Studi Gerakan Sloshing terhadap Tangki Kotak (Rectangular Tank) Dengan dan Tanpa Pelat Memanjang (Baffle) Akibat Gerakan Rolling Kapal Dengan Metode Computational Fluid Dynamics (CFD)," vol. 2, no. 1, 2013.
- [19] H. Akyildiz, "With a Horizontal Perforated Plate Sloshing In a Rectangular Storage Tank With a Horizontal Perforated Plate," pp. 3–18, 2017.
- [20] G. S. Brar and S. Singh, "An Experimental and CFD Analysis of Sloshing in a Tanker," *Procedia Technology*, vol. 14, pp. 490–496, 2014.
- [21] S. Munahar *et al.*, "Risk-Based Leak Analysis of an LPG Storage Tank: A Case Study," *Indonesian Journal of Science and Technology*, vol. 7, no. 1, pp. 37–64, 2022.