JOURNAL OF ADVANCED INDUSTRIAL TECHNOLOGY AND APPLICATION
e-ISSN: 2716-7097

JAITA

Vol. 4 No. 2 (2023) 66-79
https://publisher.uthm.edu.my/ojs/index.php/jaita

Design Evaluation of Air Receiver Tank for Gas Power Plant Using Finite Element Analysis

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DOI: https://doi.org/10.30880/jaita.2023.04.02.006

Article Info

Received: 4 September 2023
Accepted: 20 November 2023
Available online: 12 December 2023

Keywords

Air receiver tank, gas power plant, hydrostatic testing

Abstract

In order to improve the power capacity in Bali, an air receiver tank is required, which is a tank used to store compressed air produced by an air compressor. The design of this air receiver tank aims to analyze the performance of the existing air receiver tank and compare it with the proposed design in this research. The analysis includes the impact of various factors on the design of the air receiver tank regarding its performance. Several components were created during the fabrication process, including the shell, bottom head, top head, and several instruments of the required components with design pressures of 10, 12, and 1.6 MPa. The research process is mapped using three methods: manual calculations based on ASME Section VIII Division I standards, finite element analysis simulation using the SolidWorks application, and hydrostatic testing. The manual calculation results indicate a shell thickness of 7.57868 mm and head top and bottom thicknesses of 7.53 mm, which are capable of accommodating the maximum pressure with MAWP (Maximum Allowable Working Pressure) values of 1.38 MPa for both the shell and head. The design script support calculation yields a result of 0.3 mm. Based on the finite element analysis simulation using the SolidWorks application, the results show that the tank can withstand a load of up to 1.6 MPa, with material stresses at the head top being 90.0 MPa, head bottom at 0.1 MPa, and shell at 15.5 MPa, with a Min-Max value of 192.0 MPa. Hydrostatic testing with variations in time indicates that the tank can handle a pressure of up to 1.6 MPa, as shown by pressure gauge II-III and temperature gauge II and III, maintaining a stable reading of 1.6 MPa and 76°F.

1. Introduction

In the development of the Gas Power Plant (PLTG) system in Bali, the government has decided to relocate the Gas Power Plant from East Java to enhance the electricity supply. The process of transferring equipment involves the replacement of several components that are no longer usable due to strength and age factors. One of the components that needs replacement is the air receiver tank, which is utilized to store compressed air generated by the air compressor. A precise design for the air receiver tank is crucial to ensure the optimal performance of the power generation system and reduce potential losses. Initially, the material used for the air receiver tank was SPV 355. However, after conducting field studies, it was discovered that this material is no longer in production. If the company insists on using this material, a special order with a minimum of 150 tons of sheet metal would be required, while the actual material needed for the air receiver tank is only around 3000 liters. Based on previous research, it has been established that SA 516 Gr 70 is a suitable replacement for SPV

355, and it is known that SA 516 Gr 70 is commonly used in the fabrication of air receiver tanks due to its superior effectiveness compared to the original material, SPV 355 [1-3]. In this study, the design analysis of the air receiver tank with a pressure of 1 MPa for the Gas Power Plant (PLTG) is conducted using the reverse engineering method of a manufacturing company. This method combines theoretical analysis, Finite Element Analysis (FEA) simulation, and Equipment Testing (Hydro Static). Firstly, theoretical analysis is performed to determine design criteria, including the thickness of the shell, head top, and head bottom that meet the desired design specifications. Secondly, Finite Element Analysis (FEA) simulation is carried out to assess the proposed design's strength performance and find an optimal design through several simulations with pressures of 1 MPa, 1.2 MPa, and 1.6 MPa using the SolidWorks application. Finally, Hydro Static testing is conducted on the air receiver tank. By combining theoretical analysis, Finite Element Analysis (FEA) simulation, and Hydro Static equipment testing, this study aims to provide a more comprehensive solution for an optimal air receiver tank design. The results of this research are expected to contribute significantly to the development of the Gas Power Plant's power generation system. Previous research has revealed the calculated thickness of the shell and head for various specifications of SA-516 Gr 70 material. For instance, in a study with an internal pressure specification of 3.846 MPa, an operating temperature of 65°C, and a corrosion limit of 1mm, the calculated shell thickness was 15.9 mm, while the head thickness was 15.27 mm. In another study with an internal pressure specification of 1.1 MPa and a corrosion limit of 2.0 mm, the calculated shell thickness was 13.3 mm, and the toripherical head thickness was 17.3 mm. By referring to previous research findings, the calculated thickness of the shell and head for different specifications can be compared to determine the optimal specifications for the design of the air receiver tank [4-6]. This research is expected to make a significant contribution to the development of the Gas Power Plant's power generation system.

2. Methodology

The data used in the design of this air receiver tank follows the reverse engineering data of the QCQA air receiver tank from a manufacturing company.

2.1 Specific Data

The specific data for the design of the air receiver tank can be seen in Table 1.

Table 1 *Data specific air receiver tank [2]*

Parameter	Value
Working Fluids	1.2 kg/m3
Air Density	1 MPa
Operating Pressure	1 MPa
Design Temperature	40 oC
Material Density	7850 kg/m3
Welding Joint Efficiency	0.80%
Corrosion Allowance	1 mm
Vessel Length	2975 mm
Vessel Inner Diameter	1200 mm

This table provides specific data for the air receiver tank, including details about the working fluid, air density, operating pressure, design temperature, material density, welding joint efficiency, corrosion allowance, vessel length, and vessel inner diameter. Construction data for the design can be found in Table 2.

Table 2 *Air receiver tank construction data [2]*

Section	Type
Head	2:1 Elipsoidal
Support	Skirt

"Head" refers to the tank head shape, which, in this case, is a 2:1 ellipsoidal head. "Support" refers to the method of support used, which is a "Skirt" support. Construction material data for the design can be found in Table 3.

Table 3 *Air receiver tank construction material data [2]*

Component	Material type
Sheel	SA 516 Gr 70
Head	SA 516 Gr 70
Support skirt	SA 36

The "Component" column specifies the different parts of the tank, along with their respective "Material type." The tank "Shell" is made of SA 516 Gr 70 material, the "Head" is also constructed from SA 516 Gr 70 material, and the "Support skirt" is made of SA 36 material.

Table 4 *Mechanical properties*

Component	SA 516 Gr 70 [4]	SA 36 [5]
Tensile strength (MPa)	482-620	400-550
Yield strength (MPa)	260	250

This data presents the tensile strength and yield strength values for two different materials. "SA 516 Gr 70" has a tensile strength range of 482-620 MPa and a yield strength of 260 MPa, while "SA 36" exhibits a tensile strength range of 400-550 MPa and a yield strength of 250 MPa. In gathering data, the research process conducted serves as a reference for data collection and analysis for the compilation of this paper. The planning process for the execution of this paper is depicted in Fig.1 below.

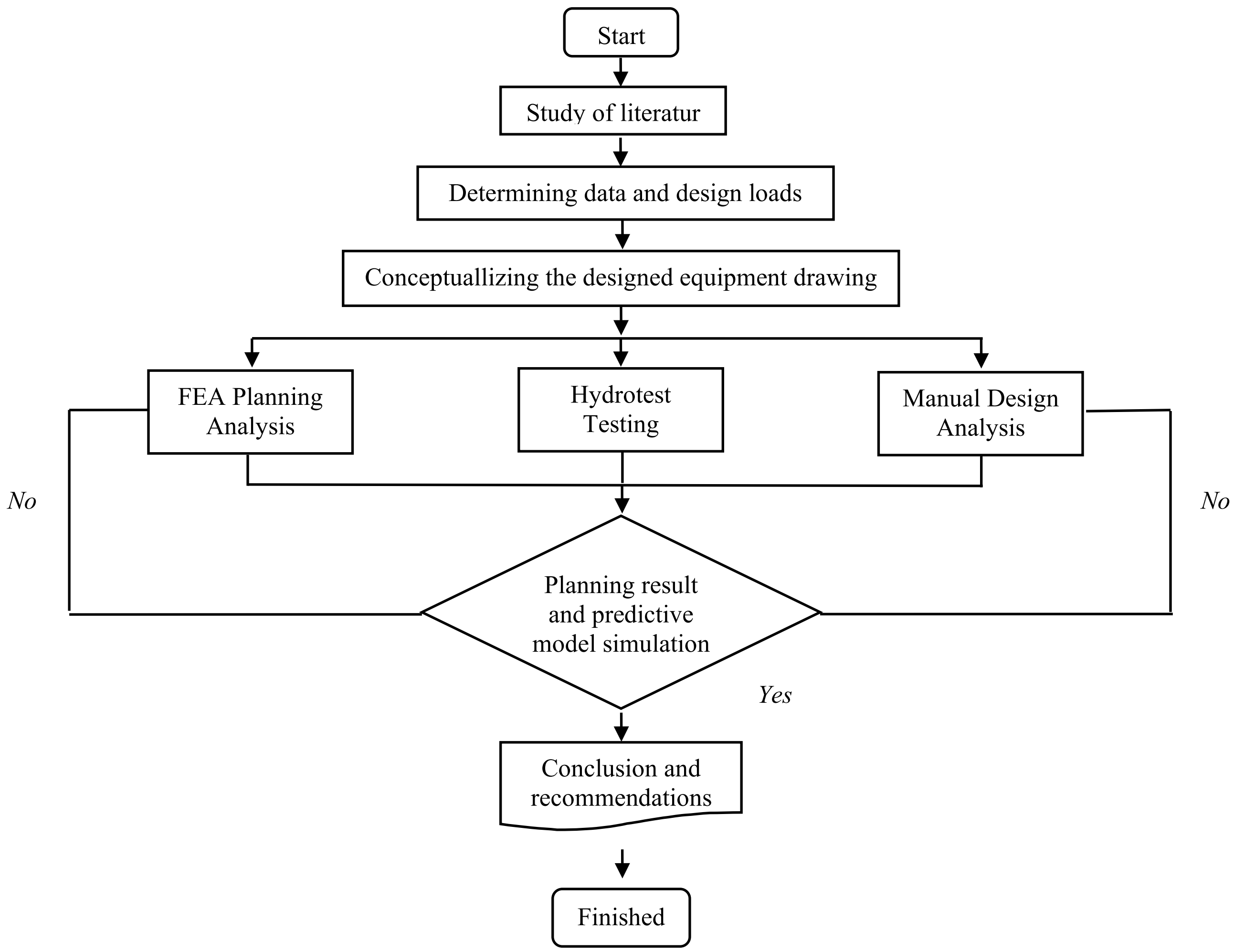

Fig. 1 *Flowchart*

In Fig. 1, the process flow of the above research is explained, consisting of several sequential stages. The first stage involves conducting a literature review related to the design of the air receiver tank and finite element analysis methods. Subsequently, data determination and planning loads needed to design the air receiver tank according to requirements are carried out. The next stages involve conceptualizing the design of the air receiver tank and conducting manual planning analysis. Additionally, hydrostatic testing is performed on the air receiver tank to ensure its proper functionality. To obtain more accurate results, the subsequent stage involves finite element simulation analysis using Solidworks application. Once all these stages are successfully completed, conclusions and recommendations are drawn based on the analysis results.

In the final stage, the thesis work is considered complete after the successful execution of all the above stages and obtaining satisfactory results. Finite Element Analysis Simulation on Air Receiver Tank. The following is a flowchart diagram illustrating the process of conducting finite element analysis simulation on the air receiver tank using Solidworks software.

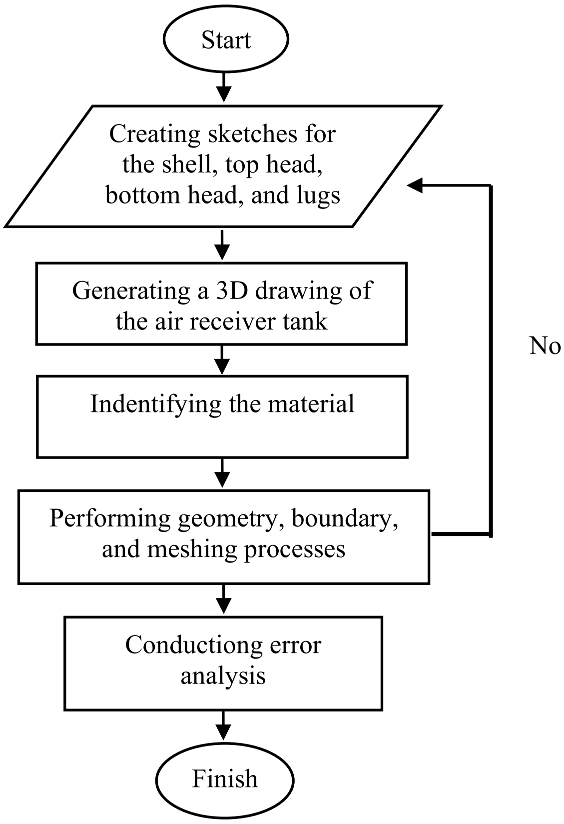

Fig. 2 *Flowchart finite element analysis process*

Creating sketches for the shell, top head, bottom head, and legs. The initial step in creating the drawing is by sketching the components of the shell, top head, bottom head, and legs. This is a crucial stage to design and visualize how the drawing will appear as a whole before proceeding to the next steps. Creating a 3D model of the air receiver tank After the sketching phase is completed, the next step involves creating a 3D model using Solidworks application for the components including the shell, top head, bottom head, and legs.

2.2 Identifying the Material

Upon completion of the 3D model, the third step involves identifying the type of material to be used for the air receiver tank. This is done by accessing the material properties within the SolidWorks application. Within the material properties, various material types are available for selection based on the requirements and specifications of the intended air receiver tank. The chosen material type should consider factors such as strength, durability, and the associated costs. After selecting the material type, the next step is to perform simulations on the created 3D model. The simulation is carried out to ensure that the air receiver tank can function effectively and safely under the desired conditions. In the simulation, various factors such as pressure, temperature, and strength will be tested to ensure that the design of the air receiver tank can perform optimally. Once the simulation process is completed, the subsequent stage involves refining and optimizing the design before proceeding to the physical fabrication of the air receiver tank. Meshing is the process of discretizing a continuous fluid domain into a discrete computational domain, enabling the solution of equations (in this case fluid flow equations) within it to produce a solution. The following is a flowchart diagram illustrating the hydrostatic testing process on the air receiver tank.

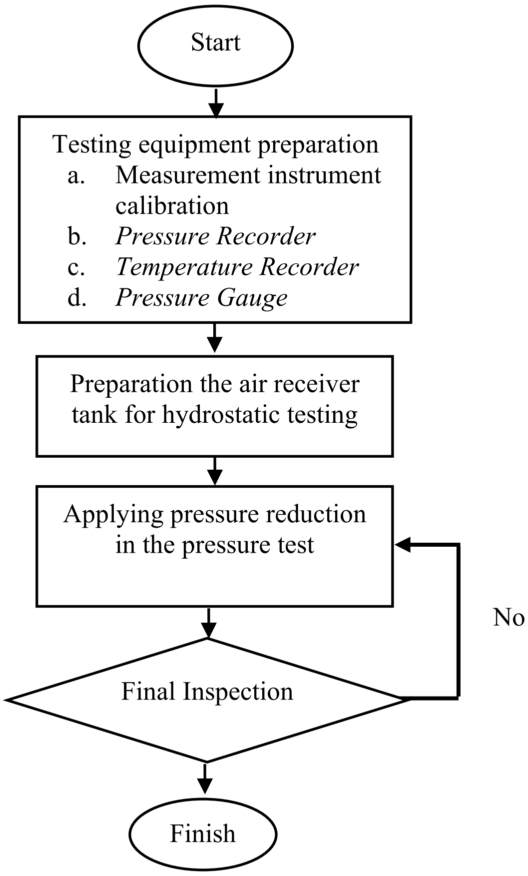

Fig. 3 *Flowchart hydrostatic test*

2.3 Hydrotest Equipment Preparation

Before conducting the hydrostatic test, the necessary steps involve calibrating the instruments used in the hydrostatic testing process to achieve in the testing procedure. The calibrated instruments include:

Pressure recorder
Specifications:
Capacity : 0-500 Psi
Model Type : -
Serial Number : 202E-334412
Brand : ITT Barton
Resolution : 10 Psi
Temperature recorder

Table 5 *Calibration corticate*

ATTACHMENT OF CALIBRATION CERTIFATE
Certificate Number : SN.1255-956/XI/ILS/2021

RESULT OF CALIBRATION

Equipment Indicated (psi)	Correction (psi) Up	Correction (psi) Down	Measurement Uncertainty (psi)
0	0.0	0.0	±3.9
50	+2.3	+2.4	
100	+2.6	+2.7	
150	+3.2	+3.4	
200	+3.4	+3.6	
250	+3.7	+3.7	
300	+4.6	+4.7	
350	+4.8	+5.0	
400	+5.4	+5.5	
450	+5.4	+5.6	

500	+5.8	+6.0
Note: The reported measurement uncertainty has a confidence level of 95% with a coverage factor k=2.01.		

Temperature recorder
Specifications:
Capacity : 0-200oF
Model Type : -
Serial Number : 202E-334412
Brand : ITT Barton
Resolution : 4oF

Table 6 *Pressure recorder calibration*

ATTACHMENT OF CALIBRATION CERTIFATE
Certificate Number : SN.1255-956/XI/ILS/2021
RESULT OF CALIBRATION

Equipment Indicated (oF)	Correction (oF)	Measurement Uncertainty (oF)
30	+1.2	±0.8
50	+1.2	
70	+1.2	
90	+1.2	
110	+1.4	
130	+1.4	
150	+1.6	
170	+1.8	
190	+2.2	
195	+2.4	

Note: The reported measurement uncertainty has a confidence level of 95% with a coverage factor k=2.01.

Pressure Gauge
Specifications:
Capacity : 0-600oF
Model Type : -
Serial Number : PG-600-25
Brand : ASCRHOFT
Resolution : 4oF

Table 7 *Temperature recorder calibration result*

ATTACHMENT OF CALIBRATION CERTIFATE
Certificate Number : SN.1255-956/XI/ILS/2021

RESULT OF CALIBRATION

Equipment Indicated (psi)	Correction (psi)		Measurement Uncertainty (psi)
	Up	Down	
0	0.0	0.0	±2.4
60	+1.3	+1.4	
120	+1.2	+1.3	
180	+1.4	+1.6	
240	+1.5	+1.7	
300	+1.5	+1.7	
360	+1.7	+1.8	
420	+1.8	+1.8	
480	+2.2	+2.4	
540	+2.4	+2.8	
600	+2.5	+2.8	

Note: The reported measurement uncertainty has a confidence level of 95%

with a coverage factor k=2.01.

Preparing hydrotest medium
The hydrostatic test requires the use of clean water, and the temperature of the water should be above 60oF.

Fig. 4 *Hydrotest medium preparation process*

Applying and reducing pressure in the pressure test application pressure. After the specified time period, gradually reduce the pressure within the tank by opening the pressure release valve. Ensure that the pressure inside the tank decreases slowly, avoiding rapid or sudden changes.

Table 8 *Static pressure during testing*

	Pressure	
Recorder	Gauge 1	Gauge 2
(MPa)	(MPa)	(MPa)
0	0	0
1.2	1.2	1.2
1.2	1.2	1.2
1.5	1.5	1.5
1.5	1.5	1.5
1.5	1.5	1.5
1.6	1.6	1.6
1.6	1.6	1.6
1.6	1.6	1.6
1.0	1.0	1.0
1.0	1.0	1.0
0	0	0

Pressure application process: Gradually increase the pressure to reach point (1-2) of the test pressure and hold for a 5-minute interval for inspection. Next, increase the pressure to reach point (3-4) of the test pressure and maintain for 5 minutes. Then, further increase the pressure to reach point (4-9) and maintain for 1 hour for inspection. Gradually decrease the pressure to reach point (9-12) of the test pressure and maintain for 5 minutes for inspection.

Finas Inspection: After the pressure has been reduced, thoroughly examine the vessel to ensure that there are no leaks or damages in the sections connected to the piping system.

3. Results and Discussion

Manual calculation of air receiver tank: calculating the thickness of the shell and head in an air receiver tank is a crucial step in the design of the tank. The design thickness of the shell and head must be carefully considered to ensure the shell's and head's ability to withstand the given pressure and loads.

Shell thickness

$$t\ shell = \frac{P\ x\ R}{S\ x\ E - 0{,}6\ x\ P} + CA$$

t shell $= \frac{1,2\ MPa\ x\ 601,00\ mm}{138\frac{N}{mm}\ x\ 0,80\%\ -0,6\ x\ 1,2\ MPa} + 1\ mm$
= 7.5768mm

The calculation of the maximum allowable working pressure for the shell can be performed using the following formula:

P $= \frac{S\ x\ E\ x\ t}{R + 0,60\ x\ t} + Ps$

P $= \frac{138\frac{N}{mm} x\ 0,80\%\ x\ 7,5768\ mm}{601,00\ mm + 0,60\ x\ 7,5768\ mm} + 0,0000$

P = 1.38 MPa

The calculation result above indicates that the MAWP of the shell is 1.38 MPa, which is greater than the design pressure of 1 MPa. This demonstrates that the shell wall

Head thickness

K $= \frac{1}{6}\ x\ (2 + \frac{D}{(2\ x\ h)^2})$

K $= \frac{1}{6}\ x\ (2 + \frac{1200\ mm}{(2\ x\ 301\ mm)^2})$

K = 0,997785

t head $= \frac{P\ x\ D\ x\ K}{2\ x\ S\ x\ E - 0,2\ x\ P} + CA$

t head $= \frac{1,2\ MPa\ x\ 1202\ mm\ x\ 0,997785}{2\ x\ 138\frac{N}{mm} x\ 0,80\% - 0,2\ x\ 1,2\ MPa}$ + 1 mm

t head = 7.53 mm

The calculation of the maximum allowable working pressure for the shell can be performed using the following formula:

P $= \frac{2\ x\ S\ x\ E\ x\ t}{K\ x\ D + 0,2\ x\ t} + Ps$

P $= \frac{2\ x\ 138\frac{N}{mm} x\ 0,80\%\ x\ 7,53\ mm}{0,997785\ x\ 1200\ mm + 0,2\ x\ 7,53\ mm} + 0,0000$

P = 1.38 MPa

The calculation result above indicates that the MAWP of the shell is 1.38 MPa, which is greater than design pressure of 1 MPa. This demonstrates that the head wall thickness of 7.53 mm is sufficiently safe.

Determining the thickness of the skirt

t $= \frac{-0,6\ x\ W}{(\pi\ x\ D\ x\ St\ x\ E)} + \frac{48\ x\ M}{(\pi\ x\ D2\ x\ St\ x\ E}$

t $= \frac{-0,6\ x\ 1632,94}{(3,14\ x\ x\ 994\ x\ 1162,476\ x\ 100\ x\ 0x8)} + \frac{48\ x\ 37,8}{(3x14\ x\ 994(2)\ x\ 100\ x\ 0,8}$

t = 0.03 mm

Finite Element Analysis Simulation: The conducting finite element analysis using the Solidworks application, several samples were taken for testing to identify any error analysis in the designed structure. The applied pressure during the element analysis testing were 1 MPa, 1.2 MPa, and 1.6 MPa. Testing with 1 MPa Pressure Calculation of 1 MPa material stress result and displacement result

Table 9 *Material stress result at 1 MPa*

Pressure (MPa)	Stress Material (N/mm^2 (MPa)		
	Head Top	Head Bottom	Sheel
1	10.9	0.1	9.8
Min	0.0		
Max	119.7		

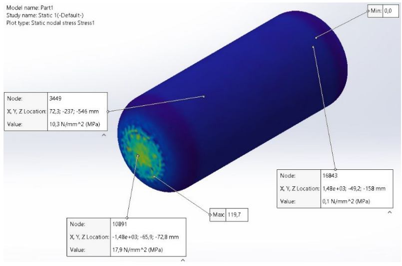

Fig. 5 *Material stress at 1 MPa Pressure*

Table 10 *Displacement result at 1 MPa*

Pressure (MPa)	Displacement (2,299 mm)		
	Head Top (mm)	Head Bottom (mm)	Sheel (mm)
1	2.266	0.1102	1.323

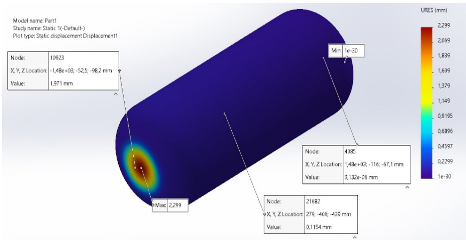

Fig. 6 *Displacement result at 1 MPa*

Based on the simulation results at a pressure of 1 MPa, it can be concluded that the water receiver tank made of SA516 Grade 70 material possesses sufficient strength to withstand the applied pressure on the head top, head bottom, and shell sections. The maximum stress experienced by the material is 119.7 MPa, which is below the yield strength of the material, thus not exceeding the material's strength limit. Displacement on Head Top: The simulation results reveal that the head top section experiences a displacement of 2.266 mm. This displacement indicates a change in position or deformation that occurs at the upper part of the tank due to the applied pressure or load. Displacement on head bottom: The simulation results indicate that the head bottom section undergoes a displacement of 0.1102 mm. This displacement illustrates the deformation or positional change at the lower part of the tank caused by the acting load on the structure. Displacement on Shell: The simulation results demonstrate that the shell undergoes a displacement of 1.323 mm. This displacement reflects the deformation or positional change in the tank's wall as a response to the applied load. Testing with 1.2 MPa pressure. Calculation of 1.2 MPa material stress result and displacement result

Table 11 *Material stress result at 1.2 MPa*

Pressure (MPa)	Stress Material (N/mm^2 (MPa)		
	Head Top	Head Bottom	Sheel
1.2	54.5	12.3	0.1
Min	0.0		
Max	143.7		

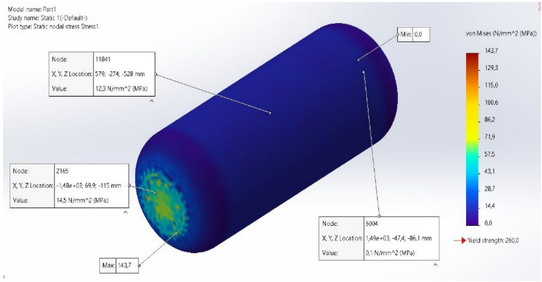

Fig. 7 *Material stress at 1.2 MPa Pressure*

Table 12 *Displacement result at 1.2 MPa*

Pressure (MPa)	Displacement (2,299 mm)		
	Head Top (mm)	Head Bottom (mm)	Sheel (mm)
1.2	1.563	0.1506	1e-30

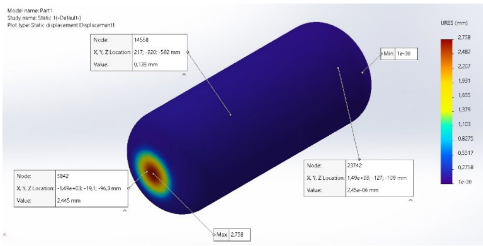

Fig. 8 *Displacement result at 1.2 MPa*

Based on the simulation results, it can be concluded that the water receiver tank made of SA516 Grade 70 material possesses sufficient strength to withstand the pressure applied to the head top, head bottom, and shell sections. The maximum stress experienced by the material is 143.7 MPa, which is below the yield strength of the material. Therefore, it does not exceed the designated material strength limit. Displacement on head top: The simulation results reveal that the head top section experiences a displacement of 1.563 mm. This displacement indicates a change in position or deformation occurring at the upper part of the tank due to the applied pressure or load. Displacement on head bottom: The simulation results indicate that the head bottom section undergoes a displacement of 0.1506 mm. This displacement illustrates the deformation or positional change at the lower part of the tank caused by the load acting on the structure. Displacement on shell: The simulation results show that the shell undergoes an extremely small displacement of 1e-30 mm. This displacement reflects the deformation or positional change in the tank's wall as a response to the applied load. The value of 1e-30 mm can be considered practically negligible, as it is very close to zero in a practical context.

Testing with 1.6 MPa pressure calculation of 1.6 MPa material stress result and displacement result

Table 13 *Material stress result at 1.2 MPa*

Pressure (MPa)	Stress Material (N/mm^2 (MPa)		
	Head Top	Head Bottom	Sheel
1.6	90.0	0.1	15.5
Min	0,0		
Max	192,0		

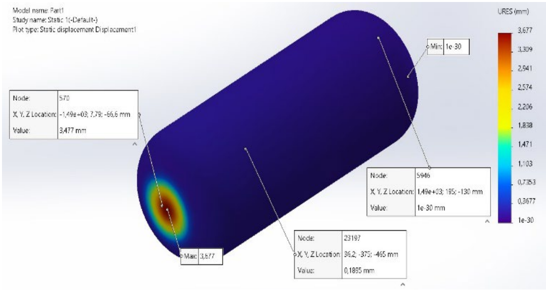

Fig. 9 *Material stress at 1.6 MPa Pressure*

Table 14 *Displacement result at 1.6 MPa*

Pressure (MPa)	Displacement (3,677 mm)		
	Head Top (mm)	Head Bottom (mm)	Sheel (mm)
1.6	2.039	1.374	0.1938

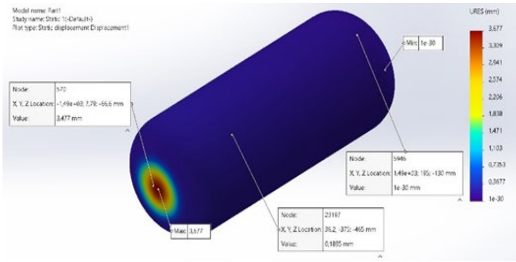

Fig 10 *Displacement result at 1.6 MPa*

Based on the simulation results, it can be concluded that the water receiver tank made of SA516 Grade 70 material possesses sufficient strength to withstand the pressure applied to the head top, head bottom, and shell sections. The maximum stress experienced by the material is 192.0 MPa, which is below the yield strength of the material. Therefore, it does not exceed the designated material strength limit.

Displacement on head top: the simulation results reveal that the head top section undergoes a displacement of 12.039 mm. This displacement indicates a change in position or deformation occurring at the head top section due to the applied pressure or load. Displacement on head bottom: The simulation results indicate that the head bottom section experiences a displacement of 1.374 mm. This displacement illustrates the deformation or positional change at the lower part of the tank caused by the load acting on the structure. Displacement on shell: The simulation results show that the shell undergoes a displacement of 0.1938 mm. This displacement reflects the deformation or positional change in the tank's wall as a response to the applied load. Error analysis testing: Calculation of 2.5 MPa material stress result and displacement result

Table 15 *Material stress result at 1.2 MPa*

Pressure (MPa)	Stress Material (N/mm^2 (MPa)		
	Head Top	Head Bottom	Sheel
2.5	171.0	0.2	25.6
Min	0.0		
Max	298.2		

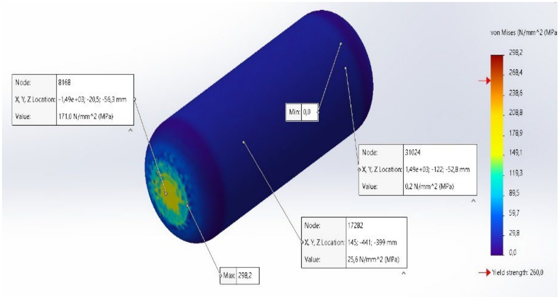

Fig 11 *Material stress at 2.5 MPa Pressure*

Table 16 *Displacement result at 2.5 MPa*

Pressure (MPa)	Displacement (7,042 mm)		
	Head Top (mm)	Head Bottom (mm)	Sheel (mm)
2.5	6.742	0.3244	2.01

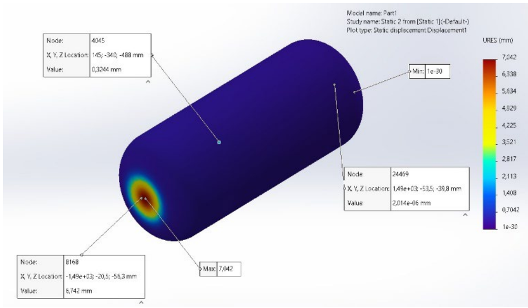

Fig 12 *Displacement result at 2.5 MPa*

Based on the simulation results, it can be concluded that the water receiver tank made of SA516 grade 70 material with a yield strength of 260 MPa is unable to withstand a pressure of 2.5 MPa due to the obtained yield strength of 298.2 MPa. Displacement on head top: The simulation results reveal that the Head Top section undergoes a displacement of 6.742 mm. This displacement indicates a change in position or deformation occurring at the upper part of the tank due to the applied pressure or load. Displacement on head bottom: the simulation results indicate that the lower part of the tank (head bottom) experiences a displacement of 0.3244 mm. This displacement illustrates the deformation or positional change at the bottom part of the tank caused by the load acting on the structure. Displacement on shell: The simulation results show that the Shell of the tank undergoes a displacement of 2.01 mm. This displacement reflects the deformation or positional change in the tank's wall as a response to the applied load.

3.1 Hydrostatic Testing Result

The following table presents the recorded data from the hydrostatic testing results

Table 17 *Hydrostatic testing result data record*

Hydrostatic Test Report									
O	TIME	Pressure			Temperature			DWT	REMARKS
		Recorder (MPa)	Gauge I (MPa)	Gauge II (MPa)	Recorder oC	Water oC	Ambient oC		
	11.04	0	0	0	22	2 2	23		Start Press UP
	11.05	1.2	1.2	1.2	22	2 2	23		Steep O.P
	11.15	1.2	1.2	1.2	22	2 3	23		
	11.18	1.5	1.5	1.5	23	2	23		Start test press

						3		
	11.30	1.5	1.5	1.5	23	23	23	Holding time
	11.45	1.5	1.5	1.5	23	23	23	
	12.00	1.6	1.6	1.6	24	24	24	
	12.15	1.6	1.6	1.6	24	24	24	
	21.22	1.6	1.6	1.6	24	24	24	Release
0	12.23	1.2	1.2	1.2	24	24	24	Steep O.P
1	12.37	1.2	1.2	1.2	24	24	24	
2	12.38	0	0	0	24	24	24	Test Completed

At 11:04 AM, the tank pressure was recorded at 0 MPa, with the recorded temperature reading 22°C on the recorder and 22°C in the water, while the ambient temperature stood at 23°C. At this point, the pressurization process commenced. Just a minute later, precisely at 11:05 AM WIB, the tank pressure was increased to 1.2 MPa. The pressure reading from the water also registered 1.2 MPa, and the ambient pressure was in line at 1.2 MPa. The recorded temperature on the recorder remained at 22°C, while the water and ambient temperatures were 22°C and 23°C, respectively. This phase marks the steep overpressure stage. By 11:15 AM WIB, the tank pressure remained at 1.2 MPa on the recorder, with the water and ambient pressures also at 1.2 MPa. The temperature recorded on the recorder held steady at 22°C, while the water and ambient temperatures increased to 23°C. At 11:18 AM WIB, the tank pressure reached 1.5 MPa on the recorder, water, and ambient pressure gauges. The recorded temperature on the recorder, water, and ambient remained at 23°C. This signifies the beginning of the pressure test. At 11:30 AM WIB, the tank pressure was maintained at 1.5 MPa on the recorder, water, and ambient pressure gauges. The temperature also remained at 23°C. This phase represents the pressure holding period. At 11:45 AM WIB, the tank pressure remained at 1.5 MPa on the recorder, water, and ambient pressure gauges, with the temperature also staying at 23°C. By 12:00 PM WIB, the tank pressure was increased to 1.6 MPa on the recorder. The temperature readings on the recorder, in the water, and in the ambient environment were 24°C. At 12:15 PM WIB, the tank pressure remained stable at 1.6 MPa on the recorder, water, and ambient pressure gauges. The temperature remained at 23°C. At 12:22 PM WIB, the tank pressure held at 1.6 MPa on the recorder, water, and ambient pressure gauges, with the temperature also remaining stable at 23°C. This signifies the commencement of the pressure release process. At 12:23 PM WIB, the tank pressure was lowered to 1.2 MPa on the recorder, water, and ambient pressure gauges. The temperature remained at 24°C, marking the steep overpressure stage. By 12:37 PM WIB, the tank pressure remained at 1.2 MPa on the recorder, water, and ambient pressure gauges, with the temperature remaining stable at 24°C. At 12:38 PM, the pressure was lowered back to 0 bar on the recorder, water, and ambient pressure gauges, with the temperature remaining stable at 24°C.

4. Conclusion

The conclusions drawn from the redesign of the air receiver tank through manual calculations, Finite Element The results obtained from the air receiver tank design using calculations in accordance with ASME Section VIII Division I standards yielded the following outcomes. Based on manual calculations, the shell thickness of 7.57868 mm and head top and bottom thickness of 7.53 mm were found to withstand the maximum pressure according to the MAWP calculations, which were 1.38 MPa for both the shell and the head. The calculated design for the skirt support resulted in a thickness of 0.3 mm. The Finite Element Analysis simulation using the SolidWorks application demonstrated that the tank could withstand loads up to 1.6 MPa. The material stress results indicated 90.0 MPa for the head top, 0.1 MPa for the head bottom, and 15.5 MPa for the shell, with a Min-Max range of 192.0 MPa.The hydrostatic testing results, involving varying time intervals, demonstrated that the tank could withstand pressures of up to 1.6 MPa. The pressure gauge I-II and temperature water-ambient consistently showed stable readings of 1.6 MPa and 76°F during the testing.

Acknowledgement

The author extends gratitude to Mercu Buana University for providing the opportunity to conduct in the study of air receiver tank. The author also expresses appreciation to Mr. Dafit Feriyanto, as the author`s mentor in crafting this journal paper.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

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