

# Improvement of the Gas Pipe Structure Using the Flow Analysis in Ultra Large Container Vessel

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**Abstract**—The purpose of this research is to improve the gas pipe structure of Ultra Large Container Vessel by reducing ship's life and logistics costs, used for maritime logistics transportation. For this purpose, we define the basic structure of the gas pipe currently in use on the vessel. And we want to show the improved structure of gas pipes for application to vessels by modeling of the gas pipes. The modeling conditions for gas pipes for vessels used the basic conditions of the engine and thermal fluid pressure to be used. This gas flow analysis methods using the computer simulations with defined models. Based on the modelling results, we presented the new structure of gas pipe model for vessels.

**Keywords**—gas pipe; vessel; ship; engine; flow analysis

## I. INTRODUCTION

As oil prices rise and logistics diversification and size increase, each shipping company is gradually enlarging its container line to reduce costs. The ultra-large-scale of vessels should be increased the heavy engine, various operating equipment, piping and facilities that are mounted on ships better than conventional vessels.

The characteristics of the engine are very important factors for the effective operation of the ultra-large container vessel. The exhaust gas pipe according to the operating characteristics of the engine is increasing in proportion to the size of the hull. This is a very important factor affecting to the quality and life of the vessel as a whole, including hull and container cargo [1][2].

The aggravated environment due to the large scale and high efficiency of the vessel's engine indicates a compound deterioration of the engine parts and supporting structures operating under high temperature and high pressure. In particular, exhaust piping and supporting structures may exhibit performance, vibration and structural problems. Therefore, identified and optimal design of the problems are performed through structural analysis and measurement analysis [3].

The vessel's engine coupled to the hull, which reduces the life and quality of the ship by physically influencing the hull through engine-related facilities such as vibration, heat, and gas pressure. In particular, the emission gases generated by combustion of the engine contain harmful substances as a high-pressure gas, which has an unsuitable effect on the quality of the vessel along with engine vibration. Since the heat and pressure of emissions in particular directly affect the hull, the

design of the exhaust pipe requires an optimized design considering several factors.

For the optimized design of gas pipes, the following main issues were defined and the gas pipe modeling for ultra large vessel was studied through computer simulations.

## II. THE STRUCTURE OF ENGINE AND DRAIN SYSTEM

The engine and exhaust system installed in the container vessel consists of the main engine, the receiver and the boiler as shown in Figure 1. The exhaust gas from the main engine are released to the outside of the vessel through a gas pipe. In particular, the engine system used in ultra large vessels is equipped with an auxiliary equipment that can recycle thermal energy as shown in Figure 1 [4].

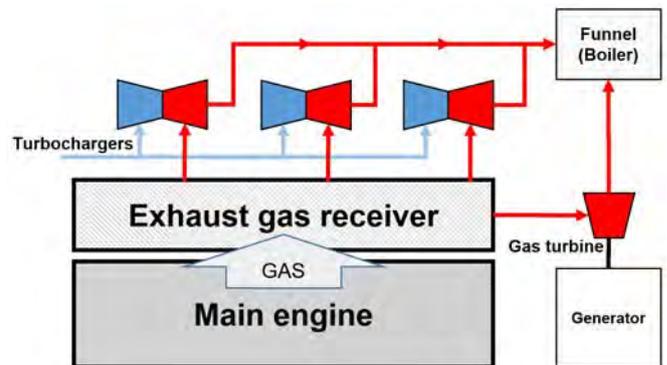


FIGURE I. CONFIGURATION OF VESSEL ENGINE

The main engine produces the power required for the operation of ships such as propulsion propellers, generators, and boilers. In particular, the main engine is mounted directly on the hull, so that natural vibration of the engine must be minimized. Ultra large container vessel are designed considering direct vibration on the hull to balance and balance the hull due to the loading of many containers. However, the engine manufacturer does not design the gas pipe separately considering the heat and pressure of the exhaust gas. Therefore, as shown in Figure 2, the gas pipe is attached directly between the engine and the gas pipe, and the receiver is installed between the engine and the gas pipe to collect the exhaust gas. The exhaust gas is discharged through

the turbo charger to maintain the gas pressure uniformly transmitted to the gas pipe.

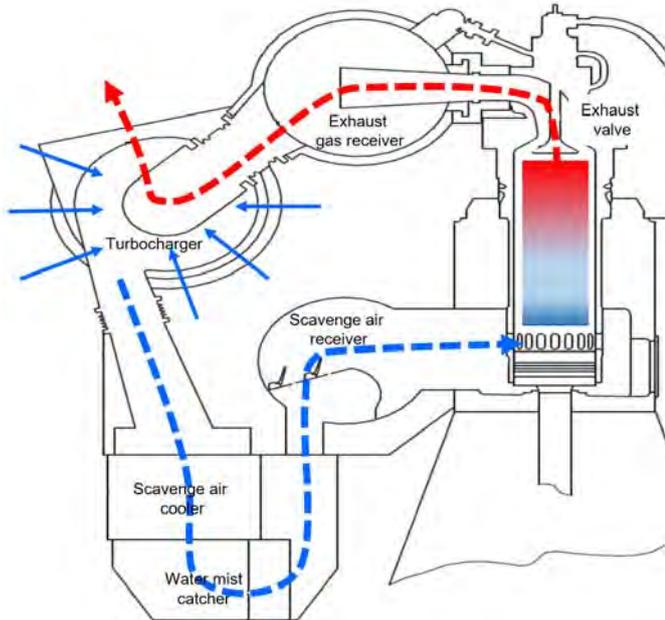


FIGURE II. EXHAUST GAS SYSTEM ENGINE

### III. DEFINITION OF THE ENGINE AND GAS PIPE CONDITION

The ultra large container vessel of this study was defined as the 21,100TEU class vessel of OOCL, the world's largest container ship manufactured in 2017, and the engine (MAN's 11G95ME-C9.5).

The maximum engine output is 61,530 (kW) and the flow rate of the engine exhaust gas per 1 (kW) of the output was assumed to be 10 (kg/h) using the average value of the exhaust gas flow rate according to the output of the marine engine [5]. In addition, the receiver and the turbochargers are mounted, so that the exhaust gas flow rate of the engine shows a uniform gas pressure state. Therefore, the conditions for modeling as shown in Table 1.

Table 1. Exhaust gas data of engine

Spec.		Value	Unit
Derating Maximum Continuous Rating		61,530	kW
Pressure	3 Piston	153,825	Kg/h
	5 Piston	256,375	
	Total	615,300	
Average Pressure		10	(kg/h)/kW

The gas pipe is a steel structure with a diameter of 2,600 mm and a weight of about 5 tons. It has four spherical shapes (3 input holes, 1 output hole) to which 3 turbochargers for connecting the engine to the gas pipe can be connected. It is a general purpose gas pipe which makes a large size by the gas pipe which is used in general large ship as shown in Figure 3.,

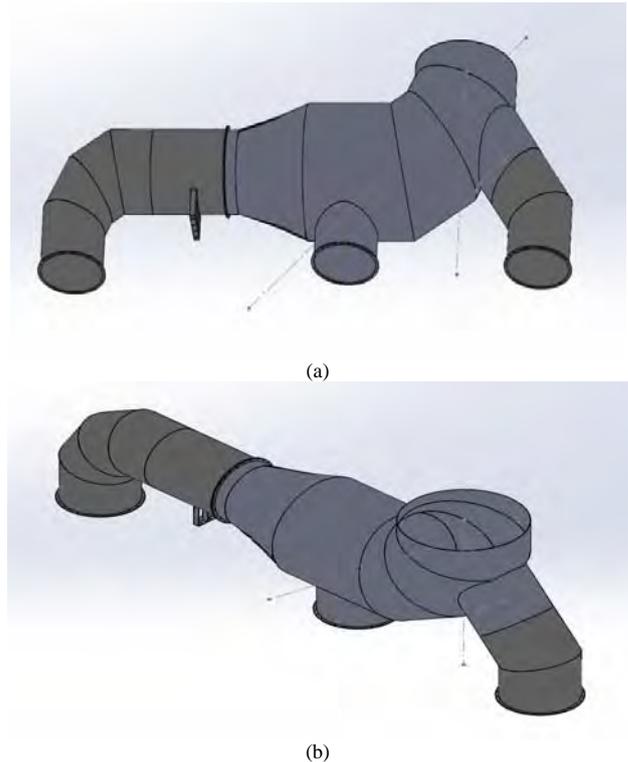


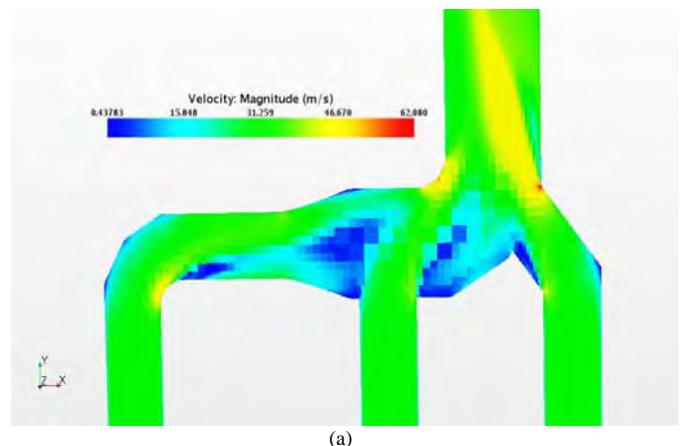
FIGURE III. GAS PIPE MODELING

### IV. GAS PIPE FLOW ANALYSIS

The conditions applied for gas pipe analysis are defined as follows.

- The flow rate of the pipe is assumed to be Steady.
- The pipe is in restrained state and does not consider vibration and shaking.
- Analyze by considering mass flow of pipe.

Using the given conditions, the gas flow in the gas pipe according to the flow rate simulated by modeling and boundary conditions. The results that can be seen through the results are shown in Figure 4.



(a)

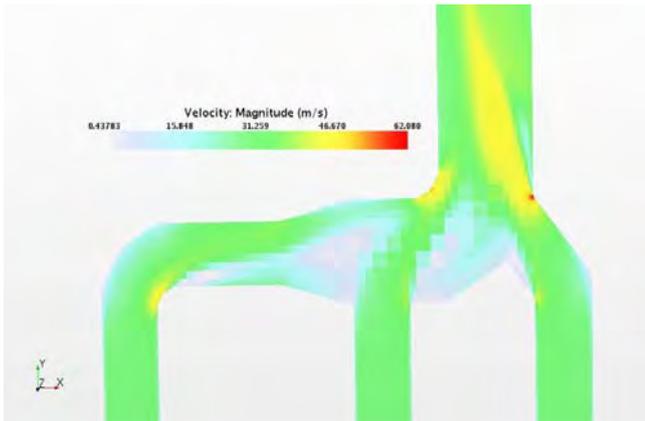


FIGURE IV. GAS PIPE FLOW ANALYSIS

Through the analysis of the gas pipe flow rate, it is confirmed that there is a region where the flow of the edge is concentrated and a dead zone where the exhaust gas passes below 10 m/s as shown in Figure 4. In addition, the difference in flow rate of exhaust gas from 62.1m/s to 0m/s was clearly observed.

It has been shown that the design of the gas pipe through the size change of the existing gas pipe is inefficient, and the quality and performance of the ship are deteriorated due to the increase of the weight and the flow due to the existence of the dead zone.

### V. GAS PIPE IMPROVEMENT

A new model was proposed by modifying the unnecessary section and excessive flow rate of the existing gas pipe. The shape of the improved gas pipe is shown in Figure 5. The unnecessary section was deleted and the maximum flow generation interval was changed to make it light and simple.

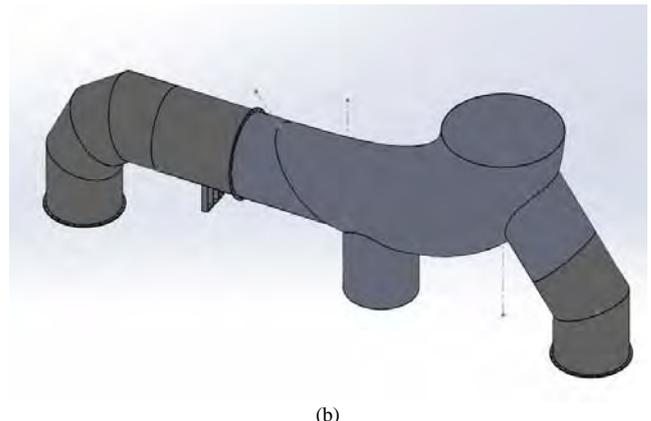
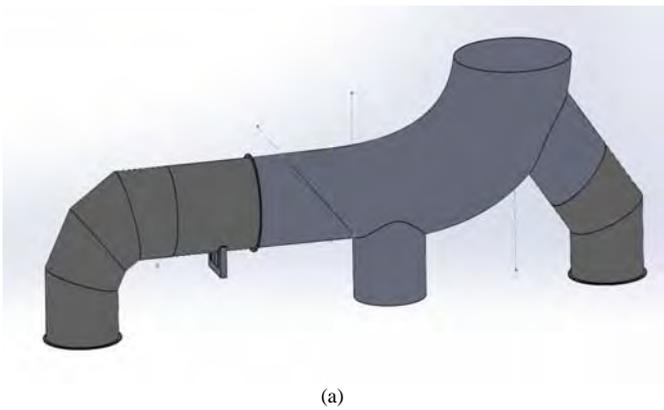


FIGURE V. IMPROVED GAS PIPE MODELING

The pipe was simulated under the same condition as the conventional one and the results are shown in Figure 6. It can be seen that the maximum flow rate is reduced by about 16.4% compared to the conventional model at 51.9m/s.

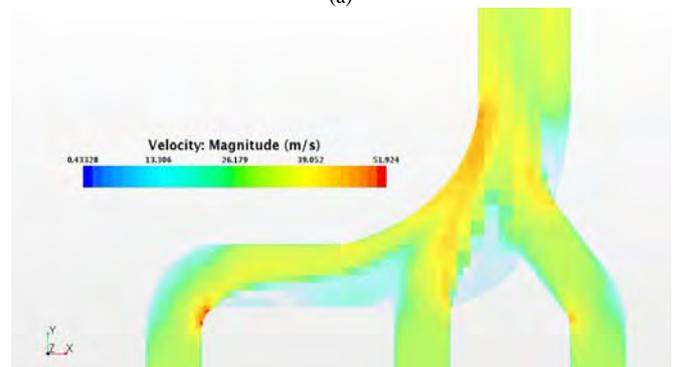
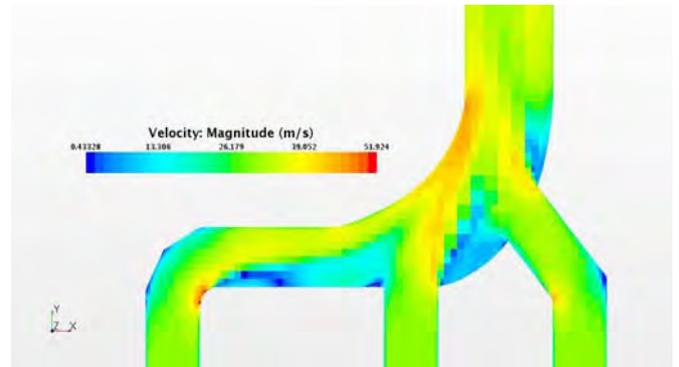


FIGURE VI. IMPROVED GAS PIPE FLOW ANALYSIS

### VI. CONCLUSION

The analysis of the gas pipes of ultra-large container vessels confirmed the characteristics of the flow rate. According to the engine output of vessels being operated, the fatigue of the gas pipe was increased. Given the shipping industry, which has been around for 365 days a year, the increase in fatigue will have a significant impact on the quality of its pipes and container

vessels. It is suggested that the proposed design model for flow concentrating and dropping section will be helpful for cost reduction and fuel cost reduction.

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