The solution of pollution prevention in container transportation

Yefeng Sun 1, Bingyan Wang 2, Aixue Cui 3, Jiangbo Zhu 1

1 School of shipping, Wuhan University of Technology, Wuhan 430063, China
2 School of Tourism Management, Liaoning Modern Service Vocational and Technical College, Shenyang 110000, China
3 School of Economics, Wuhan University of Technology, Wuhan 430063, China

Abstract. For most containers drop during transportation, it may be due to bad weather conditions, bad channel conditions, a cluster of vessel traffic flow distribution, and the operation of ship's personnel container water, causing water pollution, such as floats the water pollution situation, design a kind of container transportation of container water pollution prevention plan. The first is to modify the original container, and install GSP positioning device and transmission module for data transmission in the container. In addition, a mesh air bag is arranged on the outside of the container and a self-starting device is installed on the outside of the container. When the container accidentally falls into the water, the self-starting device in the water contact with the water to start, and open the air valve mesh air bag to inflate to provide buoyancy, collision protection and content leakage for the falling water container. After all devices are started, the GSP positioning device locates every 10 minutes and sends location information to the fishing center through the transmission module of data transmission. In the fishing center, the distribution map of the falling container in the target water area can be formed to facilitate the salvage of the falling container.

1. Introduction

In the process of container transportation, container drop accidents often occur due to adverse weather conditions, adverse channel conditions, dense ship traffic flow distribution, as well as operational errors of ship drivers and other reasons. For example, on the night of January 2, 2019, local time in Europe, an ultra-large container ship "MSC ZOE" belonging to Maersk and MSC alliance with a capacity of 19224TEU was involved in a serious accident in the North Sea waters of Europe due to bad weather. More than 270 containers fell into the water. Many of the 270 containers were filled with hazardous chemicals, and three contained dangerous organic peroxides. These three containers decompose or explode rapidly when exposed to slight heat, friction, mechanical shock or contamination from incompatible materials. In addition, if other containers are damaged, the contents will leak out and form a large area of floating garbage belt in the water area, which may produce huge pollution.

In order to solve the accident of the water pollution caused by the container falling into the water, we make this paper to put forward a method to solve the water pollution caused by the container falling into the water. GSP positioning device and transmission module for data transmission are installed in the container. An airbag is installed outside the container. When the container falls into the water, the airbag will automatically inflate to provide buoyancy for the container so that it does not sink to the bottom. After the air bag is inflated, the GSP positioning device starts and transmits its position information to the fishing center at regular intervals.
2. Related work

In view of the pollution caused by container falling into the water, the current solution is mainly in the container after falling into the water, the relevant departments will organize salvage as soon as possible. This process is mainly divided into three stages \(^{[1]}\), namely, positioning of falling water container, salvage of falling water container and recovery after salvage. The difficulty of the salvage of the falling water container lies in the positioning of the falling water container and the salvage of the damaged container. In terms of the positioning of the falling water container, the existing technology can be roughly divided into two categories: active detection method and floating method. Active detection class usually adopt \(^{[2]}\), or laser imaging or sonar imaging for underwater detection \(^{[3]}\) the water container, floating method is achieved by which has the function of water automatic inflatable float on the water container position \(^{[4]}\), after the container water, need before the sinking of the container in time will float thrown into the water container, the container sinking buoy automatic inflatable floating on the surface of the water in the process, through the connection between the float and container rope can function the positioning of the container. There is no effective solution for the salvage of damaged containers.

3. Design of anti-pollution solution for container falling water

3.1 Airbag design

To increase buoyancy of the falling container, a mesh air bag is added on the outside of the container. According to the different sizes of the container, the diameter of the mesh air bag is 1cm–1.5cm before refilling. When the container accidentally falls into the water, the protective air bag begins to inflate, and the status after being filled with air is shown.

Mesh bag after filling in can provide buoyancy make container not be submerged in the water, and can provide protection for the container, to prevent the container drift under the state of collision with other container or other hard objects, lead to damaged container body, contents leak after the polluted water, on the surface of the water formed a large area of garbage floating. In addition, reverse valves are installed at several key nodes of the mesh air bag. Therefore, in order to protect the damaged air bag of container body in collision, only part of the air bag leaks and loses its function, but the whole mesh air bag is still complete. You can keep working.

3.2 Self-starting device for water entry

The self-starting device is mainly composed of high-pressure gas pipe, high dissolution rate solid, bolt, spring, supporting vertical plate, self-starting device shell and water hole, etc. The solids with high dissolution rate in the self-starting device are cubic solids that can be rapidly dissolved or decomposed in water and are non-toxic and pollution-free after special selection. After the container into the water, water through the through hole to the interior from the start switch, high speed of dissolved solids in water dissolve quickly, soft spring release of elastic energy to drive pin move in the direction of high speed dissolved solids, compressed gas cylinder valve open by bolt's mobile, high pressure gas by high pressure gas pipe began to constantly inflatable jacket, inflatable or power in areas such as the antenna.

3.3 GPS positioning device and data transmission module

We make GPS positioning device and data transmission module to ensure the real-time grasp of the location of the falling container, in order to quickly salvage. A GPS positioning \(^{[5]}\) module and a transmission module for data transmission are installed inside the container. See the attachment for its working principle diagram. The function of GPS positioning module is to receive the satellite signal and convert it into the position information that can be recognized by the terminal equipment. Data transmission module using mobile network of GPRS network \(^{[6]}\), "the position of the container information and container itself (such as the size of the container, content, species, the shipper information, etc.) transferred to the salvage center data processing terminal, or 2 times per minute
frequency send the sides of the container can be accepted by the receiver information.

According to the different routes of container transportation, the working modes of GPS positioning module and data transmission module can be divided into two types, namely, the inland river route working mode that can receive GPRS network signal in real time in the route and the ocean route working mode that cannot receive GPRS network signal in real time in the route. In the operation mode of inland waterway, once the container falls into the water, the GPS positioning module and the data transmission module start to work. According to the preset frequency, the GPS positioning module receives a satellite signal every 10 minutes to locate the container, and the data transmission module is uploaded to the data processing terminal of the salvage center. In the ocean route operation mode, once the container falls into the water, the GPS positioning module and the data transmission module start to work. According to the preset frequency, the container information that can be accepted by the receiver will be sent around the container every 30 seconds.

When the salvage ship enters the signal receiving range, it can receive the signal transmitted by the data transmission module. In order to ensure the distance of signal transmission, the strengthened transmission module can be added on the original basis, and the data transmission distance can reach 2 nautical miles after the addition.

3.4 Distribution map of falling containers in target waters

When the rivers, lakes, reservoirs and other mobile phone signal of inland waters covered container water occurs, container emergency system began to work, GPS positioning module every 15 minutes for a position, and through the data transmission device will be the location of the container into the information and the position of the container into the information together to send to the fishing center. The data processing terminal of the salvage center first Numbers the data uploaded by each drowning container, and stores the location information of the drowning container and the location information of the drowning container in two parts. At the same time, an intelligent drawing system of SAS [7] was used to draw the map near the falling water of containers and mark the positions of each falling water container on the map to simulate the distribution map of the falling water containers in the target waters. The distribution diagram of falling containers in the target waters is shown in Figure 1.

![Fig.1 distribution diagram of falling containers in target waters](image-url)
4. Asibility analysis

4.1 The rationality of adopting mesh air bag structure
The diameter of the mesh air bag before inflation is only 1cm, and according to the data inquired, the minimum distance between the upper and lower containers is generally 2.8cm \[^8\], while the minimum horizontal distance between containers is not less than 13cm \[^9\]. The mesh air bag will not affect the normal stacking of the container before it is inflated, nor will it block the important marks and information on the container. In addition, the use of mesh air bags will not cause water accumulation between the air bags and the outer wall of the container due to the impact of waves and rainfall. Mesh air bag can effectively prevent the leakage of contents other than powder and liquid.

4.2 Buoyancy analysis provided by inflating an air bag
Take the 20-foot standard container as an example. The 20-foot standard container is 5898mm long, 2352mm wide and 2393mm high. The design has 26 air bags in the direction of length and 10 air bags in the direction of width and height. The diameter of the air bag after inflation is 12mm. Therefore, the maximum drainage volume \( V \) of the air bag after inflation is.

\[
V = [5.898 \times 40 + (2.352 + 2.393) \times 46] \times 0.11 \times 0.11 \times \pi = 17.25 m^3
\]  
(1)

In general, the average load of a 20-foot standard container of zoom lion is 17 tons, which is smaller than the maximum volume \( V \) of the air bag after inflation. Therefore, the air bag can provide enough buoyancy for the container to float on the water surface stably after inflation.

4.3 Analysis of airbag filling speed
According to the maximum displacement volume \( V \) calculated in the buoyancy analysis provided by 4.2 air bag after inflation, the volume of air bag after inflation is 17.25m\(^3\). In order to ensure the speed of inflation, inflation is taken at the same time. Let's say it's simultaneously inflated at 132. That is, each air bag is inflated separately. The formula for calculating the mass of \( CO_2 \) in the aerated cylinder of each air bag is as follows \[^{10}\].

\[
m = \frac{VMp}{RT}
\]  
(2)

Where, \( V \) -- volume of air bag (0.0265m\(^3\));
\( M \) -- molar mass (44g/mol);
\( R \) -- gas constant (8.3144J/mol·K)

\[
m = \frac{17.25 \times 44 \times 10^5}{8.31 \times 273 \times 132} = 33.88 kg
\]  
(3)

With 0 ° C (273 k) as the calculation of the initial state, before completely vaporized liquid inside the bottle to keep constant pressure (3.15 MPa). It is assumed that \( CO_2 \) in the cylinder is an ideal gas, which flows out of the infinite volume with zero initial velocity through the contraction nozzle, and the velocity in the contraction mouth is much higher than the heat exchange velocity. The energy loss when the gas flows through the nozzle can be ignored. Therefore, the flow in the nozzle can be regarded as a isentropic flow. The maximum pressure of the air bag (\( P_1 \) at the outlet) is 1 atmosphere in absolute value, and \( P_2 \) at the inlet is 3.15MPa. So, the pressure ratio is equal to \( P_1 / P_2 < 0.528 \). Is the flow in the supercritical state, and the mass flow can be calculated from the following equation:

\[
Q_m = A_p \sqrt{\frac{\gamma}{R_mT}} \left\{ \frac{2}{\gamma + 1} \right\}^{\frac{\gamma + 1}{2(\gamma - 1)}}
\]  
(4)

\( \gamma \)--specific heat ratio (= 1.1);
\( R_m \)--gas constant (8.31J/mol·K);
P2—absolute pressure upstream of nozzle (3.15mpa);
Ae=μA—effective cross-sectional area of nozzle, flow coefficient, = 0.6;
A—is the flow area (m²) of the nozzle section, and A=10 10 3.14(mm²);
T—absolute temperature.

After substituting the above constant into equation, we can get:

$$Q_m = 0.029 \frac{AP}{\sqrt{T}} (kg \ s) = 1.87 \times 10^{-3} \ kg \ / \ s$$

(5)

Then the time required for all gases in the bottle to be released is:

$$t = \frac{0.26}{1.87 \times 10^{-3}} = 137s$$

To sum up, the protective airbag can be inflated in 137 seconds.

5. Conclusions
The solution designed to solve the pollution caused by container falling water in container transportation can effectively solve the pollution caused by container falling water. The designed protective airbag provides sufficient anti-collision protection for the container's cabinet, so that the contents of the container will not easily leak; the self-starting device designed for water entry can start the protective air bag to inflate at the first time when the container falls into the water. A positioning device is designed to provide the salvage center with the location of the container and its own customs information. The generated distribution map of falling containers in the target waters can further accelerate the speed of container salvage. The solution described in this paper can effectively reduce the damage of the container after falling into the water, speed up the salvage speed, and reduce the pollution caused by the content leakage of the container after falling into the water.

Acknowledgement
The research presented here was sponsored by the National Key Research & Development Program (Grant No. 2018YFC1407405, 2018YFC0213904), and a grant from National Science Foundation of China (Grant No. 41801375).

Reference
[1] He sanlan, Xie dongqin, He zhijian. Discussion on the disposal method of container falling water in port [J]. Pearl river water transport,2014(01):86-87.
[2] Wang jiu, Cao jingtao, Lu bingwu, He bangtao. Equipment application and development trend of underwater target detection project [J]. Pearl river water transport,2016(11):43-44.
[3] Chen chao, Yang hongru, Wu lei, Li gaoping. Underwater target photoelectric detection technology and its progress [J]. Applied optics,2011,32(06):1059-1066.
[4] Deng yanjie, Cao wensheng, Li wenran, et al. Container falling water detection and positioning device and its detection method [P]. Beijing: CN103950521A, 2014-07-30.
[5] Bajaj R, Ranaweera S L, Agrawal D P. GPS: location-tracking Technology[J]. Computer, 2002, 35(4):92-94.
[6] Qiao xinkai. Water quality monitoring system based on GPRS wireless communication module [D]. Nanjing university,2018
[7] Pseudoacronym. Statistical Analysis System.[J]. Unison Rebels of Rhythm & Dance.
[8] Wu bin. New requirements for safety fastening of container ships [J]. Ship,2016,27(03):90-95.
[9] Zhang quan, dynasty, Wu jingyi. Container ship mooring system and its design essentials [J]. Containerization, 2008,29(02):24-27.
[10] Liang qibai, sun x d. technical analysis of inflating process of a mechanically triggered anti-collision airbag [J]. Machinery development,1998(04):47-49+80. (in Chinese)