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The Analyses of Approaches related to Safety Enhancement of Dangerous Goods Transportation in a Science Perspective

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Abstract:

Nowadays, the demand for dangerous goods and their transportation is increasing daily. Consequently, the accidents that are caused by it are also becoming more and more common, since those accidents related to dangerous goods' transportation are usually extremely harmful and have many adverse consequences, enhancing its safety is now therefore becoming very critical. Subsequently, in this paper, three possible approaches that are possible to enhance the transportation safety of three certain kinds of dangerous goods, which are corrosive goods, explosive and flammable goods, and radioactive goods, have been brought and analyzed. A brief introduction to each approach is provided, and each of those introductions will be followed by an alanylation including but not limited to the pros and cons of those approaches, the feasibility of them, and also the further optimizing methods for them. By conducting those eventually optimized approaches, combined with other approaches, perhaps a non-scientific perspective approach, plenty of those dangerous-goods'-transportations-related accidents can be prevented, and the safety of it and the safety issues related to it can also be enhanced to a great extent.

Keywords: Dangerous Goods, Dangerous Goods' Transportation, Safety Enhancement, Material Science, Thermal Treatment

1. Introduction

Dangerous Goods, as its name implies, are goods or substances that possess one or more harmful properties that may cause serious damage to human beings, environments, or human properties, etc. However, most of those substances are incredibly important to the modern human society, for example, sulfuric acid, as a kind of substance that is extremely corrosive, can be used very widely in many fields, such as industries or pharmacies, etc.

Moreover, it's very unlikely that those useful dangerous goods (DGs) can be produced and used in the same spot, the transportation of those will therefore

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be necessary. When transportation is being conducted, the occurrence of some accidents may become inevitable, according to research, in the year 2016, more than 0.1% of road accidents were related to dangerous goods transportation (DGTs), although this number seems to be very small, it should be noticed that road accident is a very broad concept and the consequences caused by those accidents can also be extremely serious [1]. For example, explosions may be caused by explosive goods, harmful substances may be leaked into the environment, and more seriously, extreme health problems may be caused if radioactive substances have been leaked. Thus, considering about the importance and necessity of DGs and DGTs, and the adverse consequences that may be caused by DGTs, effective improvements have to be conducted to ensure the safety of DGTs and so on.

Currently, the risks that caused by DGTs are still significant, nevertheless, related personnel around the world are constantly focusing on finding effective and efficient corresponding to the DGTs-related accidents, which is one of the methods to reduce the harm caused by them, and some methods have already been developed, but most of them are still improvements to emergency response to accidents [2]. It's indeed true that those methods can have some certain effects, but their uncertainties and some other properties make them can't eliminate the harm caused by accidents of DGTs completely, some preventions to the accidents are still required to truly eliminate the harm of accidents of DGTs to the maximum extent.

Further due to the reason that a lot of well-developed regulatory methods have been brought in plenty of research, such as one that was conducted in 2015 has given some very practical and feasible methods by analyzing the DGTs problem in a certain area in Latin America [3]. The main aim of this research project will be finding and gathering some currently existing approaches to prevent the occurrences of accidents during the transportation of DGs in a physics, chemistry, and martial sciences perspective. Then analyze its plausibility, or in other words, whether they are practical, effective, and efficient enough. And if available, further optimize them. By conducting the measures that bring from this research that have been considered available, it's possible that the risks of DGTs can be declined and the problems caused by DGTs can be mitigated to a very great extent. This research has mainly focused on three main types of DGs, which are corrosive goods, explosive and flammable goods, and radioactive goods, these three types of goods are relatively common and important in the human society, and they will cause relatively serious problems when accidents occurred during their transportations, therefore, by giving preventions to these three types of DGs' transportation, a big percentage of accidents caused by DGTs can be prevented. Nonetheless, the prevention of some other kinds of substances will also be introduced, but it won't be very detailed.

2. Corrosive Goods

2.1 Approach

Corrosive goods, mostly acids, and bases, are vital to the human society, however, as mentioned above, they can also lead to some adverse consequences when accidents occur during its transportation. A big part of those accidents is caused by the destruction of the container. Thus, one approach that can effectively prevent the incidents is to improve the material used to make those containers.

Currently, some major kinds of materials that can be made for corrosive goods' transportation tanks are fiberglass, some kinds of stainless steel, polyethylene, polypropylene, etc.

Among those materials, a combination of acid-resistant steel and carbon steel is a very common option for its considerable universality and cheapness. Nevertheless, considering the metal fatigue problem and the fact that metals are relatively easy to corrode, this option is therefore unable to be considered optimal at this time.

However, according to a recent study, a plausible approach that can increase both the corrosion resistance and hardness properties of carbon steel, which is a very common substance that is used to make the lining of a corrosive goods transportation container, has been developed [4].

Generally, this approach is a modification of the microstructure of carbon steel by the occurrence of heat, specifically by heating the steel with a certain heating curve. In that research, it has been shown that after the heat treatment, the hardness properties and corrosion resistance have both increased significantly. As data shows, after a two-hour heat treatment that increases the temperature by 6 degrees Celsius per second, a certain type of carbon steel's surface roughness depth (a measurement of the steel's corrosion resistance) has increased by 328 nanometers, and its hardness has decreased by 3 [4], observing only on the result of this research, it can be concluded that this heat treatment will have unignorable benefits on the ability to hold corrosive goods of this kind of steel.

2.2 Feasibility Analysis

Currently, there is seldom research that shows there are negative effects on the ability to hold corrosive goods of (stainless) steels after a heat-involving process. However,

one research aims to use temperature and strain rate on a type of steel that is used to produce automobiles to simulate the circumstance that when a car accident happens has shown that with the occurrence of heat, the strength of that kind of steel will be affected [5]. But in this research, the temperature is much lower than the temperature in the heat treatment mentioned above, also, the situation and result in this research may seem to have seldom direct relationship with heat treatment. Still, the result of this research will be in contradiction with the previous heat treatment that this research suggests that heat may negatively affect steel's strength while the previous one shows that heat treatment will enhance steel's hardness properties. (which may be because of the difference in the types of steel)

Furthermore, even if the heat treatment will have no negative effect on the steels themself, there is still one existing problem which is this method may not be very practical. This can be primarily attributed to the fact that conducting this heat treatment requires a highly advanced device that can accurately manage the temperature to let it maintain on the heating curve. Moreover, only a relatively small number of steels can be managed in a single heating treatment, knowing the high demand for the corrosive goods' transportation container caused by the increasingly important and prevalent needs of corrosive goods' transportation, the conclusion of the unpracticalness of this heating treatment can therefore be made.

Nonetheless, although this method seems not available for a large-scale implementation, it still can be conducted on a smaller scale regardless of the size of benefits.

In summary, it's certain that the financial cost of this approach is currently relatively high, with no related data, it can't be easily concluded that whether significant enough environmental benefits can be brought to offset the great cost of this method. In a word, this method is now worth for an experimental "try" but a lot more further dedications are required to optimize it for a large-scale implementation.

2.3 Further Suggestions

For letting this approach finally put into a large-scale implementation and truly benefit the DGTs business and the environment, this review holds the belief that further research and experiments should focus on the following subjects.

Firstly, as mentioned above, a detailed investigation of all the effects, both positively and negatively, that high temperature can bring to a certain type of steel should be conducted to conduct a further analysis of advantages and drawbacks.

Moreover, methods that can ease the cost and increase the universality of this approach should be developed to increase the practicality of it and eventually rebound it to be implemented more broadly.

Furthermore, testing the appearance or performance of different types of steel after the heat treatment is necessary, for that it's possible that the heat treatment is only plausible in that only certain one kind of steel.

Still, other methods that parallel to this one should also be dedicated to finding for various reasons. A combination of multiple approaches will be very possible to have more effect and benefit than using only one. Certainly, there are a lot of other approaches exist that should be keep finding and testing, for example, there is research conducted in 2011 that analyzed the possibility of using a certain type of alloy (alloy 59) to produce the holder of corrosive goods, which is also seems very feasible [6]. Finally, it should be aware that all of those approaches are worth for some dedication.

3. Explosive and Flammable Goods

3.1 Approach

Explosive and flammable goods are also kinds of goods that are enormously important to the human society, those kinds of goods have been applied to various of human industries, including but not limited to mining, construction, and military, etc. in addition, for that those explosive and flammable goods are often chemicals related with nitrogen, plenty of chemistry-related industries, such as pharmacy, will also possess demands for them.

It's a well-known fact that accidents related to the transportation of those kinds of goods are certainly serious. Currently, plenty of solutions focusing on this have been developed, however, a large percentage of them are administrative and political. Research conducted in 2018 has integrated the data from seven different agencies from different countries that shown between 1990 to 2015, 69 marine transportation accidents related to explosive goods occurred and caused the death of 137 persons, among those accidents, over one-third were caused by thermal reaction and mechanical failure as shown in fig.1 [7]. This can therefore indicate that using a physics, chemistry, and martial sciences perspective to find methods to enhance the safety of transporting explosive and flammable goods is also crucial for further enhancing the DGTs' safety.

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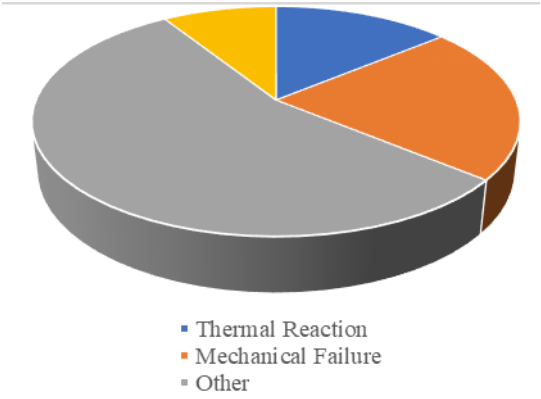

Fig. 1 The causes of accidents between 1990 to 2015 in maritime transportation of explosive goods [7]

Most of the accidents that happened during the transportation of explosive and flammable goods can be attributed to the explosion of those materials. Nowadays, there are not many methods that can effectively prevent the occurrence of accidents, but a paper has suggested that using a special kind of container with an openable top and an explosion-proof wall around it can mitigate the consequences when the accident happens [8].

The chief principle of this method (container) is that when an explosion occurs, the openable top can make the energy go directly up into the air instead of horizontally spread; and the explosion-proof wall can hold the product of the explosion, such as the shockwave, and the crumbled fragments, preventing them from spreading to the surrounding environment [8].

3.2 Feasibility Analysis

Physically, this method is theoretically available to mitigate the adverse consequences of accidents of transportation of explosives and flammables, and it has several advantages.

For example, this device from that research paper is relatively easy to produce, therefore the cost will also be relatively low; the implication of this method is also very easy; and current technologies can already satisfy the requirement of this method; etc.

However, it still has plenty of problems. First of all, there is a problem with the “openable top”. Obviously, the openable top has to open in order to reach its purpose, without the related introduction in that research paper and considering the mechanical difficulty of this devise, it can’t be ensured that whether the openable top will normally function when the explosion occurs. Also, even if the top is successfully opened, all the energy and those rapidly expanding gases created by the explosion will gush out of the opening in just a sudden, and there will therefore be a possibility that the tremendous pressure created by this phenomenon will break the structure near the opening and eventually destruct the entire container, which will have a same or even worse consequence than an explosion in a regular container.

Furthermore, with this opening top, it means that the sealing ability of the container has been decreased, as a result, a tinder will more easily to enter the container and cause an explosion that wouldn’t happened originally.

To sum up, it seems that this method has too many problems that can’t be ignored, and with only the advantages of its practicality, an optimization of this method is unquestionably required.

3.3 Further Suggestions

To deal with the sealing ability problem of the openable top container method, this research (I) advises that instead of using the openable top device, using a relatively strong material to build the main body of the container, and using a relatively wick material to build the top of the container. While maintaining a safe sealing ability, this method can have a similar effect with the openable top method for that when an explosion happens, the high pressure inside the container will force the gases and energy to find the weakest part of the container and escape it from that place.

Moreover, since that only the fragments created by the explosion can be tremendously hazardous and injurious, it’s critical to conduct some research to find an ideal shape, structure, and material for the explosion-proof wall in order to make it available to withstand the powerful impact force of those fragments.

Still, this research suggests that more research about more advanced alternative materials should be conducted, finding a new type of material that is much stronger is very important since a strong container can greatly reduce the harm caused by explosions.

Also, as mentioned above, preventing accidents is always better than dealing with them after the occurrence of the accidents, therefore lots of more research and experiments focusing on finding prevention methods for the transportation of explosive and flammable goods should be conducted to decrease the amount of those related incidents.

4. Radioactive Goods

4.1 Approach

Radioactive goods are those types of materials with high radioactivity, in our human society, they are mostly used in medication, scientific research, industry, and even agriculture. Although it seems that the usage of radioactive

goods is relatively low compared with the other two kinds of goods that mentioned above, the demand for its transportation is still very high. Furthermore, considering the tremendously high environmental and health hazards of radioactive materials, preventing the transportation accidents related to it is unquestionably necessary.

Presently, plenty of approaches aimed at preventing this kind of accident that use a regulate-or-policy-related has been perfectly developed, and among them there are a lot of very practical and effective ones [9], here in this paper, an approach using a science perspective will be introduced. Eventually, with the combination of multiple approaches, those accidents can theoretically be well prevented.

It's a well-known fact that those radioactive materials can harm a person's health if that person is constantly in contact with those substances, even if the dose is low. Nonetheless, the drivers or pilots (hereinafter referred to as drivers) of the radioactive materials transporting vehicles are matched with this situation. Due to the fact that those people are contacting with those extremely harmful substances almost every day, even if the container is strong enough, a small amount of those harmful particles can still manage out of the container and hurt the people, lasting for a period of time, this may finally cause diseases to a human, and lots of those diseases are acute, such as acute leukemia. Unfortunately, a considerable percentage of those acute diseases will affect the drivers' driving ability to a great extent, or even completely incapacitate the driver, and dangerous accidents will therefore be brought.

To prevent this problem, this paper suggests that one available way is to use a certain radiation protection material to cover the cockpit of the transportation vehicles. That material can't be metals like lead for that its high density will cause a severe weight to increase to the vehicle and affect its transportation capacity and power. Opportunely, a recent research has analyzed polymers and shown that they have a considerable ability of radioactivity resistance which can be considered to be used to produce the cockpit shield. Some ways to produce those polymers are also shown in that paper [10].

4.2 Feasibility Analysis

By observing the data from that research [10], it can be concluded that those polymers possess a lot of properties that can make them suitable for making the cockpit shield. For example, those polymers are extremely light while having a high hardness, more importantly, they also have a very strong radiation resistance ability that is even better than those traditional radiation resistance materials like leads. Furthermore, due to the high plasticity of polymers, it's quite easy to use them to produce objects. Thus, polymers are certainly a theoretically perfect materials for producing the cockpit shield.

However, some flaws still exist, producing those polymers is still very sophisticated for a lot of entities for that plenty of advanced technologies are required [10], and producing them also requires a considerable cost. Moreover, installing those shields on those related vehicles is also a hard job, but this may be solved by publishing some mandatory regulations.

To sum up, although this method is very hard to apply, it can effectively prevent accidents related to the radioactive goods transportation. It's a DGTs safety enhancement method with a great potential, it should be widely focused and gradually increase its feasibility.

4.3 Further Suggestions

The further suggestion on this method is very simple, which is to conduct more experiments on finding new economical and uncomplicated ways to produce those polymers, making it more practical. Simultaneously, enhances the regulatory measures and co-prevent the radioactive goods' transportation incidents with it.

5. Conclusion

So far, three theoretically available methods for enhancing DGTs safety have been completely analyzed. The pros and cons of those methods and further suggestions on how to strengthen those methods and how to further enhance the safety of each certain type of goods have been brought. By conducting those strengthened methods, there is a great possibility that a large percentage of DGTs-related incidents can be prevented, which also means lots of people's lives have been secured and many parts of our environment can be protected.

Also, it's very still important to focus on other possible solutions and methods for enhancing the DGTs safety to a greater extent. Moreover, DGs are not just limited to the three types that this paper introduced, measures on other types of DGs, such as toxic substances, biohazard substances, etc. are also required to be found and taken. In addition, methods that are not in a science perspective, for example, enhancing regulations, strengthening supervision, fortifying training and administration, etc. should also be used as a combination with those measures in a science perspective. By doing this, DGTs' safety can be guaranteed at a next level.

All in all, DGTs' safety is an essential issue in our modern human society that can't be ignored. More research should be dedicated to it and this research holds the belief that this issue can eventually be well-managed one day in the

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future.

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