Analysis on the Environmental Impact of Molten Salt Storage

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Abstract. This research provides detailed background knowledge and basic concepts of molten salt technology in today's world. In addition, the impact of this technology on the environment is speculated. Molten salt is a thermal energy store. In the process of converting thermal energy, molten salt remains liquid, 60% sodium nitrate and 40% potassium nitrate, and the advantage of remaining liquid is that it collects the sun's energy and converts it into thermal energy. In short, molten salt storage (MSS) converts energy into heat. Under the current circumstances, MSS is still very important to the world. It has a strong thermal conductivity, because the molten salt is liquid form, so the energy, such as heat can be freely spread in the water. The container of MSS is also very large, it is a huge cylindrical container, so it can hold a lot of molten salt and conduct a lot of energy at once. MSS is relatively affordable because it is made of iron, copper, and other materials, so the raw materials are not so expensive. Moreover, these materials do not produce any carbon dioxide when they are used, thus MSS has a positive impact on the environment. Besides, the world has already put MSS into use today, such as the industrial steam supply field.

Keywords: molten salt storage technology, large capacity, affordable prices, protective.

1. Introduction

Nowadays, global warming has become an urgent problem, and in order to avoid exacerbating the problem of global warming, several technologies have been proposed to deal with the environmental issues including potential Energy technology, chemical Energy, such as flow batteries, and thermal energy, represented by the molten salt storage (MSS), which has already been put into use in a large number of factories [1]. The reason why MSS has been put into use is simple for the high efficiency. MSS does not require a lot of human resources, and the whole process of energy conversion can be operated mechanically, thus helping factories to save labor costs. In this research, the reason for MSS widely used is analyzed and the possibility of it can continue to persevere and for how long is discussed. All of discussion will also center around the central question as can MSS solve the environmental problems? These are the questions that we need to explore, like global warming.

2. Types of Salt and Its Environmental Impact

2.1. Type of Salt

There are four different type of Salt: Sodium nitrate, Lithium Nitrate, Potassium Nitrate, Sodium Chloride. Sodium nitrate is one of the material of MSS, it does not create any harmful effect. Lithium Nitrate and Potassium Nitrate component are different, but their functions are same. They both produce oxygen when ist react with other chemical components. Finally for Sodium Chloride, it is different than other three chemical components, it will produce a little bit carbon dioxide when it reacted [2-7].

2.2. Detail about Salts and Its Environmental Impact

The first salt is sodium nitrate. The basic chemical formula for sodium nitrate is $NaNO_3$. Na stands for nano, and NO_3 stands for polyatomic ion. Polyatomic ion means a bunch of ions piled up on top of each other to create a chemical reaction. However, from an elemental point of view, sodium nitrate can never be a salt material for MSS because Sodium is strongly polluting and therefore will not be good for the environment. However, by heating it, the chemical properties of sodium nitrate will be

changed. After heating, a new chemical element oxygen appears. With this chemical formula alone, we can use sodium nitrate with confidence. Because sodium nitrate produces oxygen instead of carbon dioxide, it does not cause irreversible damage to the environment. Furthermore, Sodium nitrate plays an important role in MSS for oxygen is fused with heat to create a liquid state, which stores energy and provides a good conductivity. The second salt is lithium nitrate. Lithium nitrate, like sodium nitrate, has a negative impact on the environment on its own. Interestingly, lithium nitrate has a negative impact on the environment when it is burning. After combustion, lithium still produces a little bit of nitrogen oxide, but this doesn't mean that lithium nitrate will exacerbate the environmental problems. On the contrary, nitrogen oxide is more soluble in water, so when lithium nitrate is fused with sodium nitrate, it will also produce oxygen. Overall, lithium nitrate, like sodium nitrate, does not contribute to environmental problems. The third salt is potassium nitrate namely KNO_3. K stands for potassium, and when potassium is burned, it reacts with oxygen, that is, it reacts with NO_3, which also produces oxygen. Therefore, potassium nitrate does not have a negative effect. The last salt is sodium chloride namely NaCl. Sodium does not produce carbon dioxide like the previous three elements, and chloride has a higher melting point. So, when it heated, it reacts with sodium, dissolves in water, and produces oxygen. Therefore, when looking at the four types of salts mentioned above, they have very little impact on the environment, and therefore the chemical properties of these materials make Molten Salt Storage less likely to have a significant impact on the environment [2-7]. The types of salt solubility can be seen in fig.1.

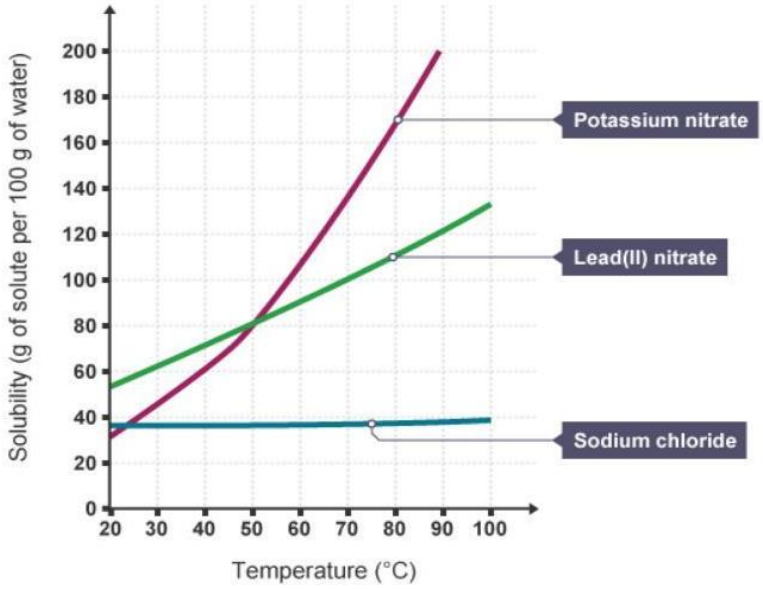

Figure 1. Types of salt solubility [8]

3. Way of Absorbing and Releasing Energy

3.1. The Environmental Impact of Processing

If people look at the raw material unilaterally, MSS doesn't have a negative impact on the environment. Thus, it is widely used in the factory. But that's not the reason why it's a good technology, for the process of absorbing and releasing energy should also be considered. The way of MSS absorbs energy is not complicated. Molten salt absorbs energy in two ways such as dual tank and thermoelectric mode. Firstly, the thermoelectric mode absorbs thermal energy by heating the salt and placing it in a storage tank, and then generates electricity to make the turbine rotate and boil the water to get energy from the salt. Discharging the energy is simple, and the energy is dissipated by generating electricity. Dual tanks are a bit more complicated, as one needs to prepare two tanks - a hot tank and a cold tank. To absorb energy, salt flows out of the side of the cold tank, is heated by a converter, and transferred to the hot tank, which stores the heat. To release energy, the salt flows out

of the side of the hot jar, heated by a converter and transferred to the cold jar to cool it down for a while before releasing it. This is how MSS works. But the point is that in both the energy absorption and energy release phases, energy is given off, not carbon dioxide or even oxygen at all. All that is transferred between the two tanks is heat energy, and that's it. As a practical example, in Julich, Germany, in 2020, the German Aerospace Center agreed to build a Molten Salt Storage facility. When people require the energy from the Molten Salt Storage facility, the German Aerospace Center has agreed to build a Molten Salt Storage facility. When people require the energy from the Molten Salt Storage, they will heat the salt to 565 Celsius at the beginning, then put this salt into the tank for cool for several days [8-10]. Germany achieves its goal through the thermoelectric mode, in which the Molten Salt is operated in a tank. Therefore, there is no gas leakage, which is a more environmentally friendly and conservative way to achieve the goal.

4. Evaluation of Environmental impact

In fact, if we want to know whether the environmental impact caused by molten salt storage is huge or not is easy, we can base on the Greenhouse gas emission. Nowadays, the cause of global warming is the excessive emission of Greenhouse gas, so we can compare the present Greenhouse gas emission with the emissions from Molten Salt Storage. Therefore, we can use the Greenhouse gas emission formula, also known as the GHG Emission formula [11].

$$\text{GHG Emission} = 0.001 * \text{Fuel Usage} * \text{High Heat Value} * \text{Emission factor} \quad (1)$$

According to the data provided by Jones et al, as of the end of the year, the greenhouse gas emission will be reduced to 0.001 by the end of the year. According to Jones et al, as of 2021, the world's greenhouse gas emission reaches a staggering 54.59 billion tons. We can calculate this based on the greenhouse gas emitted from the MSS facility, 0.001 * 700 * 565 * 24= 9492 million tons (data from MAN energy solutions). The common unit for GHG Emission is million per tons, so if we make the calculation, the amount of greenhouse gas released by Molten Salt Storage is 9.492 billion tons. Compared to 2019, the total amount of greenhouses gases emitted was 51.7 billion tons. The emission amount of MSS is much smaller than the total amount of greenhouse gas. Also, this gas only emitted when it is transferred. Therefore, it is reasonable to assume that MSS the environment and that the number of harmful gases it emits is insignificant [12].

From fig. 2, it can be easily seen that carbon emission will keep rising every year, so choosing MSS may be a good choice. Nowadays, the country is investing more and more in this technology [13].

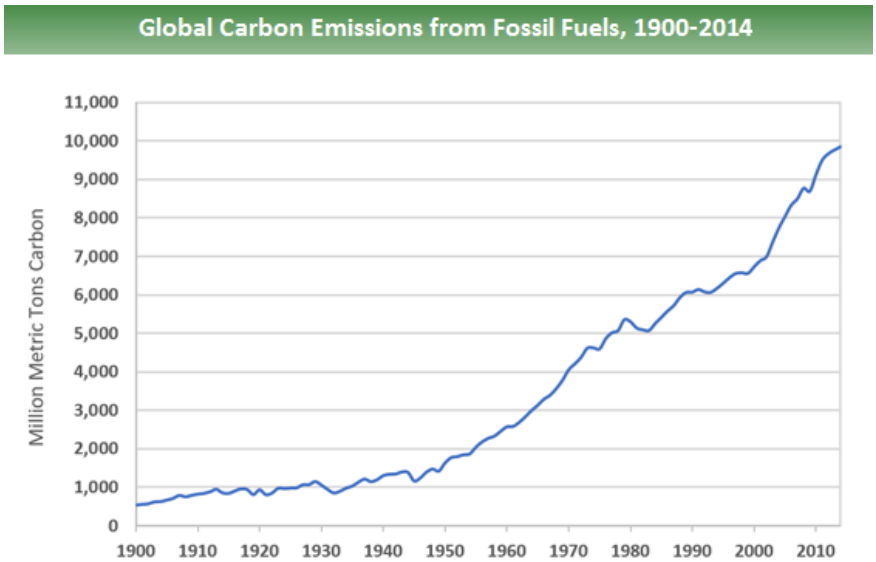

Figure 2. Trends in Global Emissions [12]

As shown in fig. 3 and fig. 4, the state's enthusiasm for MSS, and the investment is rising every year. Molten Salt Storage has basically reached to spread in the world, North America, Europe, and Asia are involved. There are also many organizations participate in the construction and use of Molten Salt Storage. Therefore, it is reasonable to assume that the country will not abandon MSS and continue to use it until 2027, as both icons show that the use of MSS is increasing, and it is predicted that the country's investment will reach 1,100,000,000 or more by 2027 [13-15].

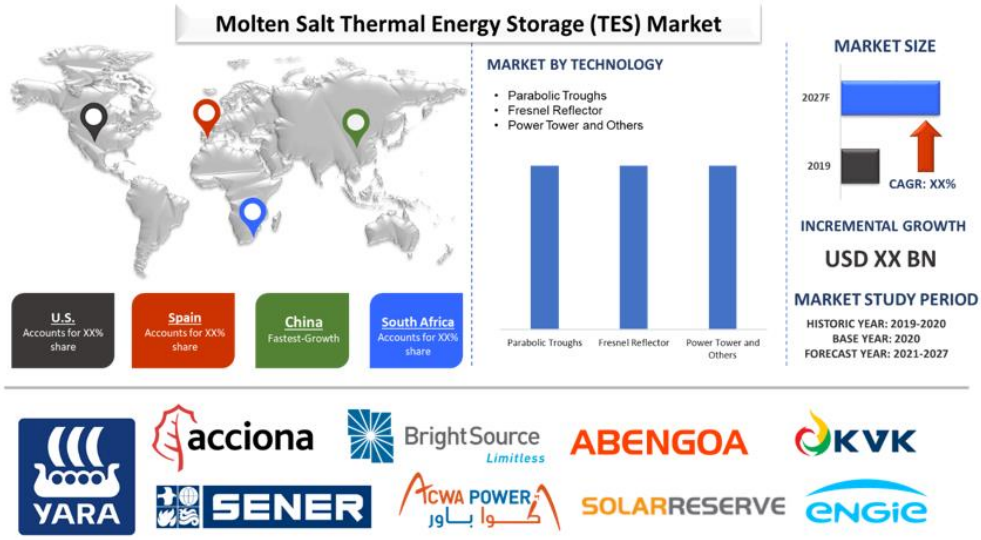

Figure 3. Molten Salt Thermal Energy Storage Market Size [13]

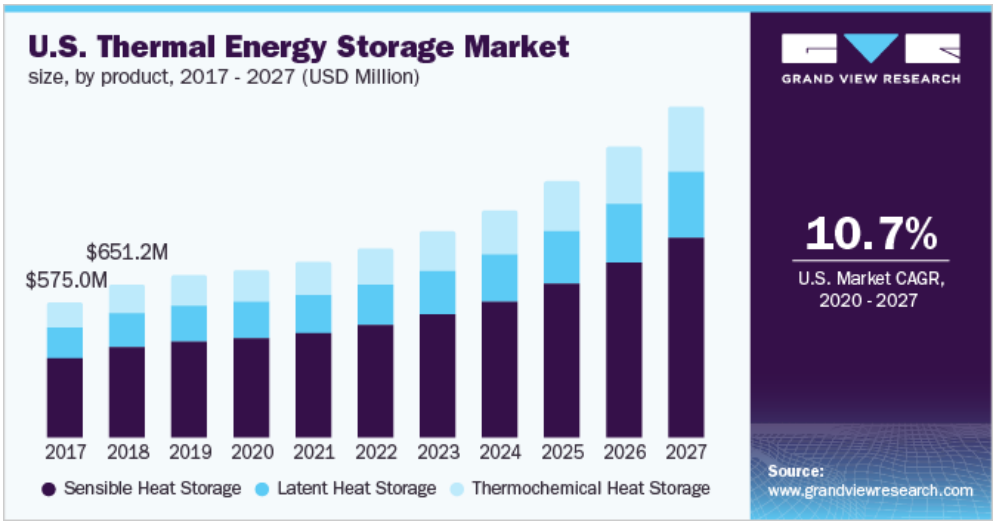

Figure 4. U.S. Therma Energy Storage Market [13]

MSS is not perfect for it also has some fatal flaws. These molten salts are highly corrosive, especially Sodium nitrate. It will erode the tanks; Although Molten Salt Storage's tanks are made of stainless steel, the stainless steel will slowly erode and rusted as it is heated over a long period of time. So, every time Molten Salt heats up, their chemical properties slowly erode the stainless steel until it can't withstand the heat of Molten Salt at lat. Therefore, in order to keep the molten salt storage in use, people can replace the MSS tank material with Bronze. In this way, no matter how long the erosion lasts, it will be very difficult for Bronze to rust, and Bronze, like stainless steel, can hold heat. Hence, Bronze is the perfect replacement of stainless steel [13-15].

5. Conclusion

In conclusion, the future of MSS is bright because it has a minimal negative impact on the environment, which is already a decisive factor. Its raw material of molten salts is all positive. When these salts had been heated, they do not produce any harmful gases, but it will create oxygen. Hence, it does not give burden to address the global warming. Also, after the calculation of GHG Emission, MSS only produce a small amount of carbon dioxide comparing to others. And these carbon gases only released when the Salts are transferred between cold and hot tanks. So, in the future, we can improve the channel between these two tanks to prevent the leak of carbon dioxide. Hence, I think Molten Salt Storage is a winner compared to other technologies. In addition, as the country invests more and more, Molten Salt Storage will inevitably continue to improve and further solve environmental problems. Predict in 2027, MSS may spread worldwide. Especially in the US energy storage market, investments are gradually increased.

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