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Plastic Packaging Reduction in Automobile Manufacturing Industry

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Abstract: With the acceleration of modernization, automobile enterprises are developing and changing while growing. The competition in China's automobile market is intensifying, and the packaged finished goods, such as bag packaging products and Plastic Packaging (PP), are hot in the development of enterprises. Plastic is good because it is not easy to damage; but waste plastics are not easy to damage. Almost all plastic waste cannot be degraded in a short time, and plastic has been eroding the whole biological group on the earth through the food chain circulation system since its birth, and its harm is self-evident. Based on this, this paper discusses and analyzes the reduction of PP in the automobile manufacturing industry; this paper briefly analyzes the harm and causes of excessive PP, and puts forward the methods of using tank truck transportation, recyclable folding buckets instead of disposable PP buckets, and adding lining in PP buckets to make PP bucket recycled; Finally, the static stress of PP barrel (PPB) is tested by calculating the side pressure of PPB. With the increase of material depth, the static stress and drop impact stress increase, and the impact stress is much greater than the static stress; with the increase of drop height, the impact stress increases, and the circumferential stress is greater than the vertical stress; it shows that the PPB is easy to be damaged only when it is subjected to great impact when falling. This method can be used for PP reduction.

1. Introduction

China's economy is developing rapidly, and the production technology of chemical products is also making continuous progress. The energy and raw materials needed are increasing every year. All aspects of industry, agriculture, national defense, scientific research, and people's life are inseparable from these chemical products. For the transportation of these chemical wastes, we continue to design PP transportation and comply with the green cycle design. Therefore, this paper studies and analyzes the reduction of PP.

Many scholars at home and abroad have studied the reduction of PP in automobile manufacturing industry. Nassereddine A aims to explore the production system of plastic manufacturing in Lebanon and clarify the implementation of lean system and its related obstacles.

According to the literature, the lean practice map is drawn. A sample of 20 factories was investigated and analyzed to explore the current situation of lean implementation in these organizations. The results show that there are some obstacles and challenges in the implementation of lean practice in Lebanese plastic manufacturing enterprises [1]. Basalp D research found that wood plastic composites (WPC) are produced from the waste of a large number of recycled plastics and wood after consumption, to reduce the environmental impact of plastics, protect natural resources and support the circular economy of sustainable production and consumption. Pure WPC (v-wpc) and r-wpc compounds were prepared from wood flour (WF) and maleic anhydride graft compatibilizer to evaluate the effects of recycled polymer type and compatibilizers on mechanical properties. It is found that the tensile strength of r-wpc produced by recycled PP (r-pp) is higher than that of r-wpc produced by mixed polyolefin and recycled PE [2].

This paper mainly discusses the research on the reduction of automobile PP, the optimization of packaging size, and the application of container recycling logistics. This paper analyzes the methods of using tank car transportation, replacing disposable PPB with a recyclable folding barrel, and adding an inner lining in PPB to make PPB recycled. Starting from the side pressure of bulk materials on the plastic bucket, the static stress of materials in the packaging bag is studied; through the drop impact test, the acceleration change of the bulk material in the plastic woven bag during the impact process is measured by using savertm3x90 environmental recorder, and the impact stress change of the material during the drop process is analyzed [3, 4].

2. Reduction of PP in Automobile Manufacturing Industry

2.1. Hazards and Cause Analysis of Excessive PP

The prominent feature of excessive PP is the excessive consumption of packaging. The transfer of packaging cost increases the economic burden and psychological pressure of consumers. The increasing domestic waste also increases the burden of urban waste recycling and treatment. The disadvantages of packaging are mainly reflected in the following aspects:

First, excessive packaging wastes resources and pollutes the environment. A large number of renewable and long regeneration cycle natural materials are used in packaging. Producers overemphasize the environmental protection characteristics of using natural materials. Excessive packaging has not only caused a large number of resource waves, but also caused secondary pollution to the environment. Excessive packaging produces a large amount of domestic waste, which adds an additional burden to the city. More importantly, some packaging wastes are difficult to degrade, and the increase of degradable solid wastes year by year brings immeasurable harm to the environment [5].

Second, excessive packaging damages the economic interests of consumers and enterprises. The added value of packaging accounts for too much of the value of the product and even exceeds the value of the product itself. This practice of seizing the host and emphasizing the appearance regardless of its quality not only damages the interests of consumers, but also damages the economic interests of enterprises. For example, excessive packaging makes it difficult for consumers to have an intuitive understanding of products. People often think that luxury packaged goods must be of good quality; in addition, it is also a common phenomenon to tie in other goods with excessive packaging.

Third, induce social luxury. Blindly increasing the amount of packaging materials and complicating the production process have created some "sky high" commodities and provided a breeding ground for the spread of bad social phenomena of corruption and luxury. In terms of the interests of the whole society, packaged goods with excessive materials, excessive functions and complex processes violate the purpose of establishing an energy-saving society and are not

conducive to the development of a circular economy.

2.2. Condition of Automobile Packaging

Due to the complexity of automobile spare parts, it has its problems and deficiencies in transportation, storage, and loading and unloading. For many automobile factories, in terms of storage, due to the different specifications, sizes, and types of spare parts, the packaging volume, specifications and sizes are diversified, the storage space requirements are different, and a lot of warehouse space is wasted. Moreover, the warehouse management also has certain difficulties, which consumes a lot of human and material resources [6, 7].

For the selection of packaging materials, most of the existing automobile spare parts packaging adopts disposable packaging materials, such as carton packaging and wooden frame packaging, and the lining packaging materials also adopt disposable packaging materials such as pearl cotton, PE bag, bubble film and black collodion. To improve the timeliness of delivery, it is generally necessary to pack the spare parts immediately upon arrival. Therefore, a large number of packaging materials are stored, and the diversification of their specifications and types also increases the storage of packaging materials. In the process of packaging operation, due to the diversified specifications of packaging materials, the operation intensity is high and the efficiency is low. At present, spare parts are mainly aimed at the majority of customers, and our spare parts need to go through various automobile 4S stores to face end customers.

2.3. Reduction of PP

Figure 1 shows the environmental treatment process of waste plastic bags. The waste is mainly divided into two occasions, namely, residential area and public area (both sides of the road). The residents are mainly responsible for the garbage classification in the residential area, while the domestic garbage in public areas such as both sides of the road, in addition to the citizens spontaneously throwing the garbage into the trash can, the sanitation workers will assume the main role of garbage classification. Plastic bag waste in this public area will still be classified as dry waste without additional classification [8].

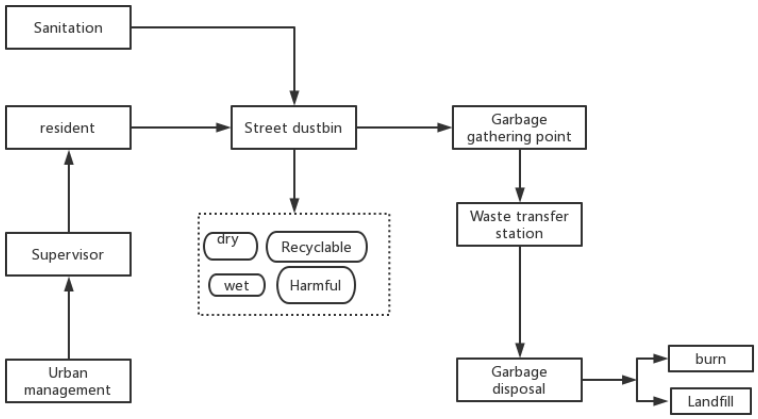

Figure 1: Environmental treatment process of waste plastic bags

From the perspective of environmental protection, in addition to ensuring that the daily production activities of the factory comply with relevant laws and regulations, it will also be committed to reducing emissions and increasing efficiency - of course, these emission reductions

and increasing efficiency also include the emission reduction of plastics. Through careful observation of the manufacturing process, we found that a large number of chemicals are packaged in plastic, such as electrophoretic materials in the paint workshop, engine oil, emulsion and chip oil in the engine plant, brake fluid in the final assembly filling center, etc. If there is a way to optimize the PP of chemicals, it can significantly reduce the use and waste of plastics.

We will introduce two methods of preparing the spare tank in the electrophoresis workshop [9].

2.3.1. Electrophoresis Preparation Tank

The electrophoresis tank is modeled according to the actual size. The electrophoresis tank is 4m wide and 4m high. The upper opening is 31m long and the lower bottom is 24m long. Since the coating process of the car body enters the electrophoresis tank from the air, and then enters the air from the electrophoresis tank, to more accurately simulate the whole process and increase the moving space of the car body, the car body in white is fixedly connected by a mobile sled and moves along the guide rail during the coating process of the electrophoresis tank. The whole electrophoresis coating process is divided into three stages: the groove entry section, the horizontal section, and the groove exit section, the three stages are numerically calculated. The three coating calculation processes adopt different grid methods, the overlapping grid method is adopted in the launching stage and grooving stage, and the elastic deformation and local regenerative dynamic grid method is adopted in the horizontal stage. The three stages are analyzed, respectively, to obtain the variation law of the external flow field and aerodynamic characteristics of the vehicle body in each stage.

Electrophoretic process is the key process of vehicle anti-corrosion. The latest trend in the industry is to reduce the material cost of vehicle production through the latest second-generation high swimming power electrophoretic paint materials, and can meet the supporting needs of new energy-saving and environmental protection processes such as phosphating pretreatment such as silane and zirconium series and water-based non intermediate coating. The resin system of the second generation of high permeance electrophoretic paint is quite different from that of ordinary electrophoretic paint, and its parameter control range and solvent system are also different. Therefore, in the process of switching from the production line of ordinary electrophoretic paint to the second generation of high permeance electrophoretic paint, the whole tank is usually used to abandon the old model point electrophoretic paint, and the new model electrophoretic paint is reconfigured to realize the switching between the new and old electrophoretic paint [10].

2.3.2. Transport by Tank Car Instead of Disposable PPB

Boxes, barrels, bottles, cans, and bags that can hold dangerous goods are called packages and containers of dangerous goods. Their manufacturing materials and use methods shall comply with the provisions of relevant standards and adapt to the special properties of dangerous goods; the performance of the specific packaging used on dangerous goods and whether it can ensure that it will not be damaged under the external action or due to the packaging itself during transportation must be verified by certain experiments and tested according to relevant standards. The qualified packaging must be used in the actual waste transportation.

The PP of electrophoretic materials can be stored in the preparation tank on site, and then the electrophoretic materials can be transported into the preparation tank by tank truck, and the PP can be cancelled directly; traditional electrophoretic materials use disposable PP, which not only wastes PP materials, but also produces a large number of plastic hazardous wastes. Both economic and environmental benefits are relatively poor. Since there are tanks in the workshop, tank cars can be used instead of PP.

The operation process is as follows: use the tank car to transport the electrophoretic materials, and transport the chemical materials in the tank car to the electrophoretic preparation tank through the pipeline. Then, according to the production demand, the electrophoretic materials in the standby tank are transported to the main tank through pipeline. It not only saves PP and reduces plastic hazardous waste, but also saves the storage area of packaging barrels and the labor hours of shovelers. While achieving economic benefits, it also reduces the discharge and disposal of hazardous wastes. Many tank car accidents are also closely related to liquid sloshing. In the design stage of tanks, engineers installed longitudinal wave plates for tanks carrying liquid to suppress the longitudinal shaking of the liquid, while a few installed transverse wave plates to suppress the transverse shaking of liquid.

2.3.3. Use Recyclable Folding Barrels Instead of Disposable PPBs

In view of the situation that there is no tank preparation equipment on site and the amount of use is also large, how can we cancel the PP? The answer is to use folding barrels. Metal folding barrels can ensure long-term recycling. Finally, disposable PP can also be directly cancelled.

First, put the cardboard in the folding bucket for support and fixation, and put the oil inside the inner lining bag, to ensure stability in the process of transportation and feeding. After feeding, the residual oil in the lining bag can be fully utilized, and a small amount of lining bag can be disposed as hazardous waste.

Folding drum packaging is divided into commercial packaging and transportation packaging, and its transportation packaging includes delivery packaging and collective packaging; the meaning of commercial packaging of automobile folding bucket is almost similar to that of transportation packaging of logistics packaging, which is to ensure product safety and facilitate storage and transportation. Therefore, automobile folding barrel packaging is also logistics packaging. Due to the various specifications and types of automobile spare parts, and the terminal's demand for various spare parts is extremely unstable, the packaging standardization must consider how to assemble different spare parts, and the assembled specification and size series must correspond to the internal size of the transportation equipment, that is, the series size must match the size of the transportation equipment to maximize the space utilization [11]. For the standardized package size series of folding barrels, the commercial package size of spare parts plays an important role.

2.3.4. Add Lining in the PPB to Recycle the PPB

Environmental protection laws and regulations are becoming increasingly stringent. Since 2017, packaging contaminated with chemicals must be disposed of as hazardous waste, and direct recycling is not allowed. To save the cost of PP materials and the disposal cost of hazardous wastes. For some scattered PP, such as emulsion in engine factory, brake fluid in final assembly workshop, etc. We require the supplier to add a lining before supply, and the barrel mouth needs to use a special structures to prevent chemicals from pouring back into the barrel.

The strength and toughness of the lining bag shall be confirmed by several rounds of tests, and the process quality verification shall be carried out after the chemicals are lined to ensure that the quality of the chemicals is not affected by the lining. After feeding, the residual chemicals in the lining bag can be fully utilized, and a small amount of lining bag can be disposed as hazardous waste.

The combined use of these three plastic reduction methods can give priority to reducing the PP volume of the automobile industry by more than 95%, greatly reducing the raw material cost and hazardous waste disposal cost of plastics, bringing benefits to the company and making great contributions to social environmental protection [12].

3. Calculation of Side Pressure of PPB

The stress analysis of the granular layer with the thickness of be in the cylindrical container is carried out. Firstly, the cross-sectional area of the granular layer is defined as s, the perimeter is l, and the distance from the upper surface of the granular body is e then the pressure difference between the upper and lower particles of the granular layer on the granular layer is vertically upward, and the size is SBQ; The gravity of the granular layer itself is vertically downward, and the size is ρ Gsbe, where ρ Is the density of plastic particles, and there is friction between the particle layer and the side wall of the container μσ Lbe. The force balance of the particle layer can be listed as follows:

$$\rho gSbe = Sbq + \mu\sigma_{ii}Lbe \tag{1}$$

According to the initial conditions e = 0 and q = 0, C = 0, the relationship between the pressure and depth of granular particles in the container is as follows:

$$q = \frac{\rho gs}{\mu LJ}(1 - e^{\frac{\mu Le}{s}}) \tag{2}$$

When e is small, the pressure is about equal to ρ, Ge, which is similar to the relationship between the pressure and depth of water in a cylindrical container; when the depth e approaches γ, when, the pressure tends to be saturated, and the expression of circumferential and vertical static stress of packaging bag with size $\frac{\rho gs}{\gamma LJ}$ is as follows:

$$\begin{cases} \sigma_\theta = \dfrac{\rho Gh^2}{2\mu k}(1 - d^{-\frac{2\mu p}{h}e}) \\ \sigma_e = \dfrac{\rho gh}{2k}e - \dfrac{\rho gh^2}{4\mu pk}(1 - d^{-\frac{2\mu p}{h}e}) \end{cases} \tag{3}$$

Where h represents the radius of the cylindrical plastic barrel (m) and K represents the thickness of the plastic barrel (m).

4. Experimental Test and Analysis

In this paper, the PPB used for sodium hydroxide in the actual packaging is selected. After the two samples are loaded, the packaging is standing on the ground, which is approximately cylindrical. The weight of No. 1 sample bag is 25kg, the measured perimeter is 1000mm, and the calculated cylindrical radius is 159mm; the weight of No. 2 sample bag is 50kg, the measured perimeter is 1100mm, and the calculated cylindrical radius is 175mm; the wall thickness of the barrel is 0.5mm. Lay the plastic lined base cloth on sodium hydroxide, and place metal blocks and weight on the base cloth, with a total weight of N; when the sample bag weight is 25kg and 50kg respectively, the static stress value of materials at different depths on the plastic barrel wall is obtained according to formula (3), as shown in Table 1 and table 2.

It can be seen from the above table that, under the condition of the same quality of the materials in the packaging bag, the static stress of the plastic barrel bearing materials in the packaging bag increases with the increase of depth, the static stress at the bottom is the largest, and the circumferential static stress is greater than the vertical static stress at the same position; At the same depth, the greater the mass of materials in the packaging bag, the greater the static stress, and the difference is increasingly obvious from top to bottom.

Table 1: Static stress values at different depths of material when the sample bag weight is 25kg

position	e/m	Circumferential stress σθ/MPa	vertical stress σe /MPa
upper part	0.05	0.10	4.3×10^{-3}
central section	0.24	0.45	0.10
bottom	0.48	0.80	0.36

Table 2: Static stress values at different depths of material when the sample bag weight is 50kg

position	e/m	Circumferential stress σθ/MPa	vertical stress σe /MPa
upper part	0.05	0.13	2.8×10^{-3}
central section	0.32	0.62	0.16
bottom	0.59	1.08	0.58

Next, we test the falling damage of the plastic bucket during transportation. Put the material into the plastic woven bag. After loading, put the savertm3x90 environmental recorder on the upper part of the material and sew it with the sewing machine. Then stand up the plastic woven bag and put it on the worktable of the drop test machine for drop test. The drop heights of the test are 0.8m, 1.2m, and 1.6m, respectively. Repeat the above steps, put the savertm3x90 environmental recorder in the middle and bottom of the material, respectively, and do two groups of tests, respectively. The impact stress of the materials in the packaging bag is shown in Figure 2.

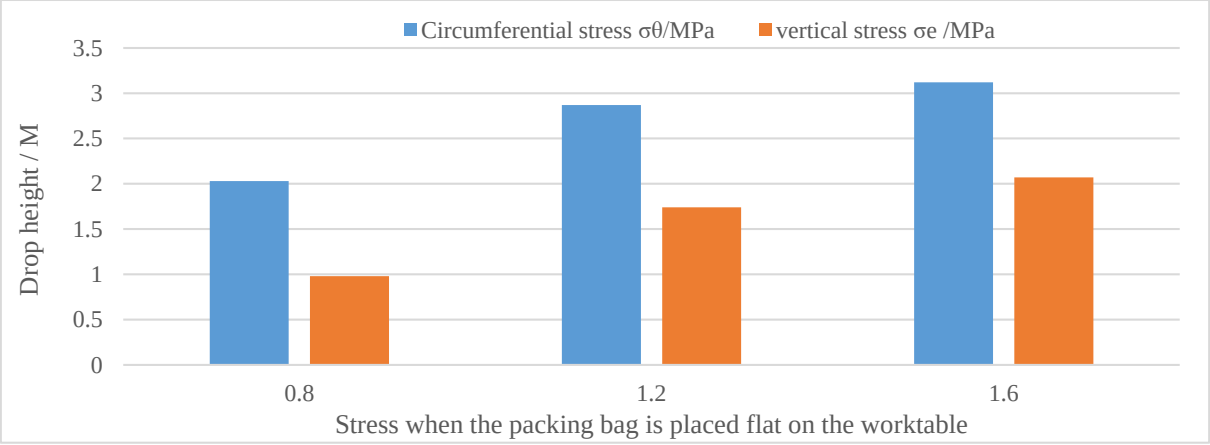

Figure 2: Impact stress of materials in packaging bag

It can be seen from the Figure 2 that when the packaging bag is placed flat on the workbench, the position of the savertm3x90 environmental recorder remains unchanged. With the increase of drop height, the acceleration value increases accordingly, and the impact stress value of the inner materials increases, and the circumferential stress is significantly higher than the vertical stress. It can be seen that the greater the drop height, the greater the impact acceleration of the packaging bag, and the greater the impact stress of the inner materials.

Through the above analysis, the following four conclusions are obtained: when the PPB is placed on the ground and the quality is the same, the static stress of materials at different depths is different, and the static stress increases with the increase of material depth; at the same depth, the greater the mass of the inner material, the greater the static stress; When the PPB drops from different heights, the impact stress of the material at the same depth increases with the increase of the drop height; When falling from the same height, the impact stress increases with the increase of the depth of the inner material; And the circumferential stress of materials at the same drop height and depth is greater than the vertical stress.

5. Conclusions

This paper discusses the reduction of PP in automobile manufacturing industry and studies the change of drop impact stress of PPB with different depth and drop height. However, due to the limitation of time and by academic level, this paper has some defects to be improved. The following contents can be further studied in the future work: the static stress formula of packaging bags obtained in this paper still needs to be verified by a large number of tests on packaging bags of different materials and different materials inside. PPB is a flexible material, and the shape of the packaging bag will change after falling impact. Considering this factor, the dynamic mechanical properties of plastic woven bag during falling impact need to be further analyzed and studied; the optimization of PP in the workshop also needs to be considered from more aspects, such as packaging structure, variety of packaging materials, environmental protection, appearance and image, etc.

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