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Dismantling Report of Disposable Lighters

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Abstract

We will use SolidWorks to draw the model of the disposable lighter and inquire about the process and material of the relevant parts, and discuss its design concept, the material strength and functionality of each component, and cooperate with COMSOL to analyze the difference between theoretical and practical application to parts, reconsider what design tweaks or processing the component could have done to extend its life. Finally, we analyze the advantages and disadvantages of disposable lighters and our evaluation of this product, and also propose some feasible improvement plans for the shortcomings. That is, this project will describe the material, process, size, and function of each component of the lighter, and then explain the ignition and transmission principle of the lighter, and then discuss the use of the disposable lighter in different weather and operating environments, as well as the advantages and disadvantages of the processing process. Disadvantages, put forward feasible improvement methods for the shortcomings, and think about the design scheme that can make the disposable lighter more complete.

Keywords

Disposable lighter, mechanical design, Solidworks, Comsol

Introduction

As a common tool in life, there are many different styles and brands of lighters on the market. In fact, these are not necessarily related to the amount of fuel, but the wrong method of use and the lack of understanding of the lighter. due to internal principles. Therefore, this study selected the most common and cheap disposable lighters in life (Flint Lighter Qianhui Magpie TC6 T45270) as the research object.

1. Anatomy results of the Lighter Internals components

1.1 Introduction of the components' material

Table 1. Parts List

Numbering	Name	Size(mm)	Material	Processing	Function
1	Case	21*9*67	ASplastic	injection molding	Store liquid
2	The wind-shield	14*10*15	white copper	stamping, electroplating	Protection from strong winds, accumulated gas concentrations, and air convection
3	The button	21*8*8.5	ABSplastic	casting, rolling	Buckle the brass tube and drive the gas valve to release the gas
4	The fire ring	8.5*10*2	ABSplastic	casting, rolling	Manually adjustable firepower
5-1	Spring (large)	2*2*24	Stainless steel	Stamping, quenching, annealing, electroplating	Hold against the flint so that it is in full contact with the drum
5-2	spring (middle)	1*1*5	Stainless steel	Stamping, quenching, annealing, electroplating	Return the brass tube to its original position
5-3	spring (small)	2.5*2.5*7	Stainless steel	Stamping, quenching, annealing, electroplating	It can keep the gas output stable and help increase the flame intensity
6	The cotton gasket	4*4*2	absorbent cotton	Die cutting and drilling	Avoid direct contact between the large spring and the bottle body
7	The fire adjustment tube	5*5*10.5	POM	Injection molding, rolling	Connect with the fire ring by thread, adjust the size of the air outlet
8	The support tube	5.5*8*29	POM	Injection molding, drilling, turning	Support steel wheels, place flint and steel, strengthen structures
9	The back sealing plug	3*3.5*5	POM	Injection molding, drilling, turning	Uniform force applied to cotton pads
10	The filter element	3*3*57	glass fiber (absorbent cotton)	Drawing, drawing, curing polymerization	Filter the impurities inside the bottle to maintain the stability of the firepower
11	Capillary brass tube	2.5*2.5*14.5	brass	Compression drawing, graded expansion	As the only outlet for the gas to escape
12	Flint	3*3*5	Cerium iron alloy	melting iron, refining	Drum friction produces sparks
13-1	Rubber ring(large)	3*3*1	rubber	Vulcanization, compression molding	Relieve the impact rebound effect, avoid the local stress of the material is too large or the impact force is too large to damage other components
13-2	Rubber ring(middle)	2.5*2.5*1	rubber	Vulcanization, compression molding	
13-3	Rubber ring(small)	2*2*1	rubber	Vulcanization, compression molding	
14	Rubber plug	2*2*3.5	rubber	Vulcanization, compression molding	Keep air tightness
15	Steel wheel	13*13*13	Steel, synthetic diamond	Pinning, gear hobbing, heat treatment, welding	The power source of friction fire
16	Upper sleeve	5*5*6.5	Low-carbon steel	High pressure tube method, electroplating, casting	The channel through which the gas flows can prevent the butane from directly contacting the fire control tube
17	Lower sleeve	4*4*7.5	Low-carbon steel	High pressure tube method, electroplating, casting	Cover the filter element and increase the strength of the filter element
18	The bottom plug	4*4*2	Low-carbon steel	High pressure tube method, electroplating, casting	Fixing the position of the cotton spacer

1.2 Introduction to Transmission Principle

1.2.1 Firepower adjustment

The fire adjustment tube (part 7) and the capillary brass tube (part 11) sandwich the small spring (part 5-3). Under normal circumstances, the No. 5-3 parts are under pressure. The fire ring (part 4 part) adjusts the tightness of the thread between part 7 and the bottle body (part 1), and the capillary brass tube (part 11 part) is in a fixed position, thus changing the 5-3 displacement, thereby changing the overlap between the No. 11 part and the fire control tube (part 7), and controlling the size of the opening on the No. 11 part itself. Therefore, when the lower gas channel is opened, the upper gas channel, that is, the size of the orifice on the No. 11 part, can determine the size of the gas output to achieve the effect of firepower regulation (Figure 1).

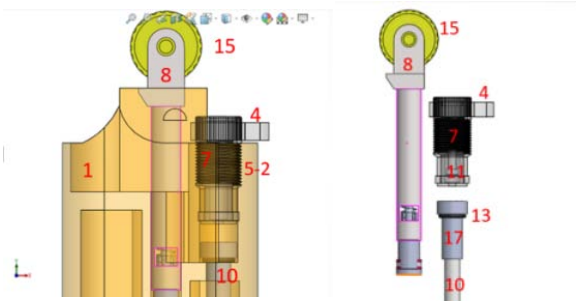

Figure 1. Fire power adjustment transmission diagram (right) including the internal structure of the bottle body (left).

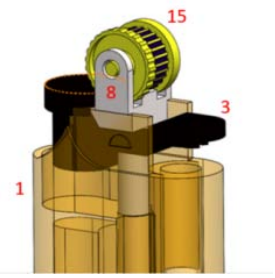

Figure 2. Schematic diagram of spark generated by flint friction.

1.2.2 Flint friction creates sparks

When the steel wheel (part 15) is subjected to external force, the artificial diamond in the middle of the No. 15 part and the flint (part 12) below it are resisted by the support tube (part 8) and the large spring (part 5-1) rubbing sparks (Fig. 2).

1.2.3 Opening gas passage

The entire structure above the right lower sleeve (part 17) forms a nested structure through some concave and convex parts between the structures, and is connected to the top. The button (part 3) is pressed through the support tube (part 8) and the bottle body. The contact point of (part part) acts as a fulcrum to form a lever motion. Due to the small radius of the small spring (part 5-3), the stiffness coefficient is high, and it is affected by the labor-saving lever, which can form a large force, enough to pull The one-piece upper structure on the right operates upwards, while the lower sleeve (part 17) itself is hollow with a central hole that becomes the lower channel for gas escape (Fig. 3).

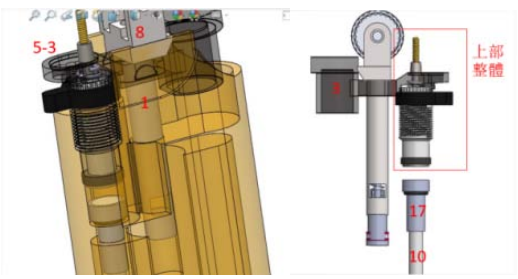

Figure 3. Schematic diagram of the gas channel (left) with the internal structure of the bottle body (right).

Figure 4. Schematic diagram of fire power maintenance (left) with buttons (middle) fire power adjustment part (right) with windscreen.

1.2.4 Maintenance and extinguishing of firepower

After the passage is formed, the liquid butane is gasified into a gaseous state due to the high pressure inside compared to the outside atmospheric pressure and can be released from the gas passage starting from the filter element (part 10) to reach the windshield (part 2), Due to the large enclosed area here, the butane gas accumulates to form a high density, and the sparks sprayed by the friction between the flint and the steel wheel make the high-density butane react with the sparks and burn; if the button is released at this time (part 3), due to the action of the spring, the position of each part is restored, and the gas channel is closed, so that the air hole dominated by the upper brass tube (part 11) will be hidden in the fire regulating tube (part 7), and the lower part of the gas will be hidden. The channel is closed, and even though the upper channel on the fire control tube is still open, no gas escapes, so there is no flame (Fig.4).

1.3 Advantages of this product

The shape of the parts of the product is required to be complex, but the casting mode can allow the parts to be mass-produced and reduce costs; and most of them are smaller and thinner parts, and the materials used are mostly plastic, steel, etc., and the price is low, so its manufacturing cost is low, and it can be directly discarded after use; the rubber ring has a low cost but can effectively buffer large instantaneous and local stress. The parts of the disposable lighter are thin and require repeated cyclic braking, which is prone to fatigue or even rupture. The rubber ring can significantly alleviate this problem at a lower cost; butane is gaseous at room temperature and pressure and is more volatile. It is stored in a large amount inside the lighter in a liquid state, so that the lighter can be used for a long time and its practicability is enhanced (Baidu Encyclopedia, Rubber Seal [DB/OL]. 2022-05-08.)

1.4 Disadvantages and improvements of this product

1.4.1 Environmental impact

Disadvantages: In terms of quantity and quality (mass) of the constituent parts of disposable lighters, traditional plastics and rubbers account for a large proportion, but these polymer compounds or sulfides are not easy to be decomposed and have high biological toxicity.

Improvement: Can be replaced with biodegradable synthetic extracts such as chitin and cellulose from crab shells and wood fiber.

1.4.2 Affected by weather factors

Disadvantages: A series of traditional lighters, including disposable lighters, use exposed flames, which not only has a low energy conversion ratio and low firepower, but also is easily disturbed by external wind and rain. Once extinguished accidentally, it may continue to produce toxic gases.

Improvement: By adding a windproof cap, butane and air can be quickly mixed by Bernoulli effect in a closed chamber, and then ejected from a small grid at high speed by Venturi effect, so that the firepower is large and windproof.

1.4.3 Ignition failure

Disadvantages: In actual operation, we also found that the contact method of flint and lighter often causes ignition failure, and one of the main reasons for this is that the rotation speed is not enough, that is, the force is not enough or the air is relatively humid.

Improvement: The solution we provide is to add a closed chamber at the friction joint to ensure effective friction and ensure that it can generate sparks normally in rainy or wet conditions. In addition, a labor-saving lever structure is installed to ensure that each time can generate enough torque to ensure enough rotation speed to generate sparks. In order to make it more convenient to use, a plane can be used to increase the area of the input end of the lever to form a but-

ton-type structure (Xia Guifang, Wang Zhiqun, Liu Hongcheng, Chen Dongming, & Yu Hongbin, 2013).

2. Stress Analysis of Material

2.1 Basic assumptions

We perform stress analysis on the part that the hand touches, namely the button. Since the actual pressing situation will be very different from the theory, we make some assumptions about the material and failure: (1) The force exerted by the hand is a distributed force, which will be simplified into a concentrated force in subsequent operations. (2) The key between the button and the support tube is in the form of a pin. Although the key of the lighter is not a pin structure, the main support reaction force is the same as the case where it is assumed to be a pin. (3) It is assumed that the key material is uniform and consistent.

2.2 Simulation Stress Analysis of Material

Through simple approximate actual calculation, we have roughly grasped the stress state of the button when the lighter is working, but in order to understand more specific and accurate results and avoid the insufficiency of design considerations, we chose to use Comsol software to do simulation analysis for its steady-state process.

The simulation process of this topic is as follows: First, use Solidworks to construct the spatial geometry of the button and store it as a part file (SLDPRT). Select the steady state simulation of solid mechanics in it; set the filling material; set the boundary conditions (fixed, free) according to the actual combination with other parts; select the input boundary load (input amount); select the appropriate mesh (precision); Configure the solution distributor (input the relevant formula or select an existing fit model); set the solution amount, this topic is the stress distribution; simulate the calculation and export the report.

The brighter part on the graph indicates the greater the stress. The results show that when the lighter is working, the stress distribution of the keys is relatively even, which is basically consistent with our estimated calculation. However, it is worth noting that the color at the contact with the shell below it is lighter, that is, the stress is larger, which may be caused by the smaller area of the hollow structure, which needs to be paid attention to in the design. This part is not considered in our previous calculations, so it shows that the rational use of modern advanced technology has its advantages and necessity (Hunan Jingzhuan Automation Technology Co., Ltd., 2021).

3. Results and discussion

As for the results of stress analysis, we found that the support will bear a large stress, so we choose a linear polymer with high density and high crystallinity such as POM material, which has excellent abrasion resistance and pressure resistance as support tube material. For the design of the internal structure of the lighter, we have sorted out the following points: (1) Gas diffusion, butane is a gaseous state at normal temperature and pressure, so the butane inside the lighter is compressed and maintained in the bottle before a certain pressure can be obtained. In a liquid state, the shell needs to be able to withstand this pressure difference, so a divider is added to increase the strength of the bottle body against the pressure difference. At the same time, when the gas channel is opened, it is necessary to consider that the instantaneous air pressure at the maximum firepower, that is, the maximum gas flow, will not cause the springs and bonding structures to exceed the maximum load, or the contact elements caused by the absorption of heat during the butane phase transition so it can suffer cold shrinkage, resulting in greater fatigue. These thermal expansions and contractions can cause cracks. (2) Combustion conditions. When maintaining combustion, it is necessary to keep the gas passages open and stable, so the parts of the two gas passages need to have rigidity that can maintain a steady state. The button should not be fatigued and damaged due to frequent use. At the windshield, it is necessary to ensure that the butane gas will not spread easily and form a higher concentration, and it is also necessary to ensure the entry of an appropriate amount of air. It plays a role in supporting combustion; and it is necessary to maintain the stability of the air flow and avoid the large swing of the flame. (3) Flame control. In the third point, there are already some requirements related to partial flame control. In addition, the fire power adjustment mechanism driven by the fire ring needs to maintain a steady state, that is, the thread or wedge surface needs to maintain a large friction, but cannot if it is too large, it will lead to inconvenience for the user to adjust the fire power (Foshan Shunde Zhiwang Machinery Equipment Co., Ltd., 2021).

4. Conclusion

Although disposable lighters are cheap and common, the production process and internal working principle of their components are not simple. It is inevitable that they can become one of the important components of today's lighter

market. Its ingenious design ideas lead to its low price, convenient use, and certain reliability, which is worth our study; but its shortcomings are also more obvious, and the direction of improvement is also clear. Overall, disposable lighters are a very successful product in modern society.

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