

Research on Innovative Design of Shared Refrigerator

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Abstract

The conceptual design of shared refrigerator is mainly from the humanization to solve the problem that different smells that made by different foods stored together, and it can effectively avoid the unreasonable use of the refrigerator space. In this refrigerator design, the practical problems encountered in the using process are fully considered and analyzed, and the humanized design concept is widely used. This article, focusing on people's needs in their daily lives, taking full account of the relationship between structure and function of the refrigerator, is mainly about the innovative design and research of shared refrigerator in terms of function, structure, materials, process and man-machine relationship, etc. This article puts forwards a new refrigerator–design-concept to make people feel the beauty, happiness and convenience of life brought by the design.

Keywords: *shared; refrigerator; innovation; research.*

1. Introduction

With the development of science and technology, and the improvement of living standards, people's requirements on the design have been increased. More attention has been paid to the study of humanization design. The practicability and suitability of the products have increasingly become an important indicator of product evaluation, and humanization design has become the center of product-design-thinking. Shared refrigerator is based on this concept and it is designed for people living in public space. Under the condition that people have different lifestyles when using refrigerators, it provides different individuals with separate space. Modular structure design allows many people to share the refrigerator resources, which can maximize the equal treatment of each member and improve everyone's using method and environment.

Shared refrigerator is mainly based on the design concept and trends of modern refrigerator, focusing on the need of users, considering the emotional experience of individuals by modular design. The structure of the refrigerator not only meets the characteristics of existing products, such as environmental protection, energy saving, low cost, and high capacity, but also focuses on considering the using process and behavior of multiple users. Applying a modular method to the design of refrigerator structure can satisfy the purpose of the common use of multiple people. The layout of the storage space is designed reasonably and the shape of the product is in line with tastes of modern life, which creates a harmonious and comfortable living space for people.

The innovative design of shared refrigerator embodies in the following aspects.

Wu Nai-qun is the corresponding author.

2. Function and Structure

2.1. Function Principle

The refrigeration compressor of single system refrigerator constantly sucks the refrigerant vapor in the evaporator, and compresses it into high-pressure, high-temperature steam to the condenser. Refrigerant vapor is condensed into liquid because it gives off heat in the condenser. Liquid refrigerant passes through the filter drier to remove the impurities and moisture of the refrigerant. The refrigerant is changed from high pressure to low pressure in the capillary tube of throttling element, and small amounts of liquefied refrigerant appear. When the refrigerant leaving the capillary throttling element, becomes a gas-liquid two phase mixed state, and then enters the evaporator. The refrigerant in the evaporator boils and evaporates, changing from the liquid into a gaseous state by absorbing heat from the cooled object. Then low-pressure, high-temperature refrigerant vapor is sucked and compressed by the compressor into the next cycle^[1]. The working principle of the refrigerator is as shown in Figure 1.

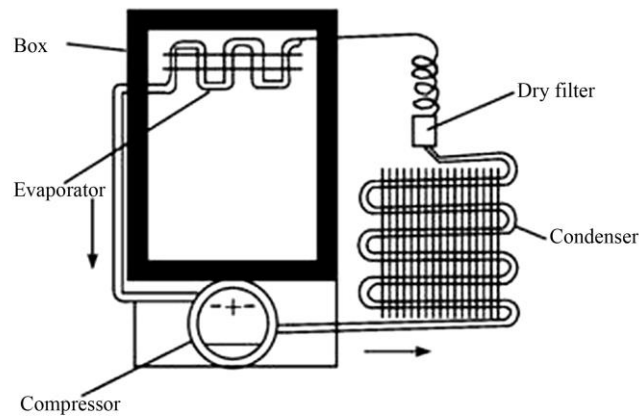


Figure 1. Working Principle of the Refrigerator

In the refrigeration system, evaporator, condenser, compressor and throttle valve are the essential four pieces. The evaporator is cold delivery device. Among these the refrigerant realizes the cooling effect by absorbing the heat. The compressor is the core that plays a role of sucking into the compressing and transporting refrigerant vapor. Condenser is the heat-release device that transfers the heat absorbed in the evaporator together with the heat transformed from the work of compressor to the cooling medium away, which achieves refrigeration.

Parameter comparison of different types of air compressors which is the most important component commonly used in the refrigerator is as shown in Table 1.

Table 1. Performance Parameters of Different Air Compressor

Model	Input Power (W)	Refrigerating capacity (W)	Current (A)	Refrigerant	Power (V)
QD25	80	68	0.65	R12	220V-50Hz
QD55	125	132	1	R12	220V-50Hz
QD75	162	176	1.2	R12	220V-50Hz
QD180	380	440	2.8	R12	220V-50Hz
QD210	435	510	3.1	R12	220V-50Hz

In table1, refrigerant R12 refers to Freon 12.

Freon is a colorless, odorless, transparent, and almost nontoxic refrigerant.

Chemical properties:

1. Toxicity: low toxicity or nontoxic, such as R12 is low toxicity which can be considered as almost nontoxic compound. The more of the number of chlorine atoms, the more of the toxicity; the more of the number of fluorine atom, the less of the toxicity.
2. Flammability: the reduction of hydrogen atoms number in molecules results in the decrease of flammability and the increase of chemical stability.
3. Stability: the increase of hydrogen, chlorine and fluorine atoms number enhances the chemical stability of the working fluid. Chlorine atoms increases, increasing the longevity of the working fluid in the atmosphere, the ability to destroy the ozone layer strengthened^[2].

The commonly used Freon parameters are as shown in Table 2.

Table 2. Parameters of Commonly used Freon

Model	Chemical name	Boiling point (°C)	Freezing point (°C)	Critical temperature (°C)	Critical pressure (MPa)
R11	CCl ₃ F	23.82	-111	198.0	4.41
R12	CCl ₂ F ₂	-29.78	-158	112.0	4.11
R13	CClF ₃	-81.40	-181	28.9	3.87
R21	CCl ₂ F	8.92	-135	178.5	5.17
R22	CHClF ₂	-40.75	-160	96.0	4.97

R12 is the widely-used medium temperature refrigerant that is suitable for small and medium-sized refrigeration systems, such as refrigerators, freezers, *etc.*

The shared refrigerator focuses on the food that needs to keep frozen and refrigerated for storage and preservation. Through the full consideration for the needs of individual and the modular structure combined design, the shared refrigerator provides independent space that can be freely used in a unified structure, which meets the different requirements of different individuals and truly realizes the refrigeration function of a personalized shared refrigerator.

2.2. Structure

Structure design is the main point of the design, and only when the structure design is reasonable will the exterior designs be more modern. Therefore, structure design not only reflects various parts of the design, but also is the key to fully realize the product function.

Modular design method is applied in the structure design of the product. To take a four-person-dormitory as the target environment, this design is based on the arrangement and combination of regular planar graphs, and also considers the modern sense and the fashion of the visual appearance of every independent space, so that the three-dimensional structure plays a supporting role in the function. The position of the compressor is placed in the bottom of the refrigerator, which considers the stability and facilitates the heat dissipation. The panel is a touch screen that can save space and is convenient to operate. The design of Panel combines technology and fashion, increasing the quality of products better. The beverage bottle separators are made of a relatively lightweight structure, and the structure above and below can just fix the beverage bottle, as shown in Figure 2.

The design of the handle is simple but not easy. It is consistent with the style of the refrigerator door, as shown in Figure 3.

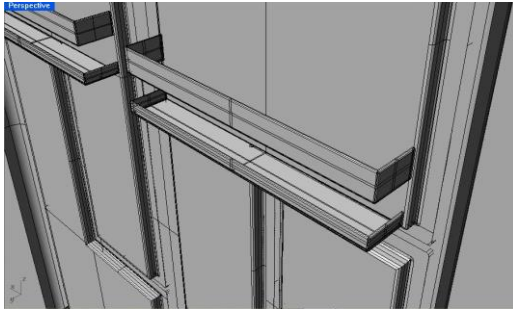


Figure 2. Beverage Bottle Barrier Design

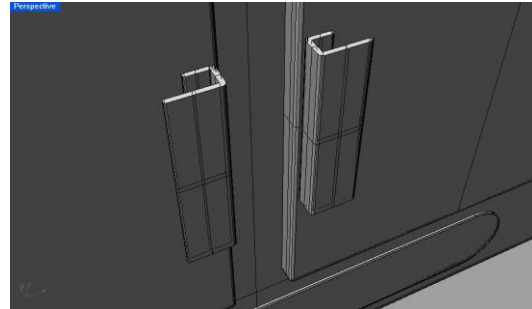


Figure 3. Design of Unique Handle

Separate storage structure is the focus of design, enabling each person to have an independent space, as shown in Figure 4.

The compressor is located in the lowest level of shared refrigerator, which reflects the consideration of the reasonable space setting, the best working effect, and the organic combination with the whole product, as shown in Figure 5.

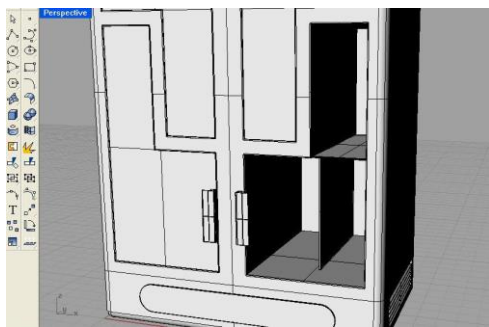


Figure 4. Independent Space Design

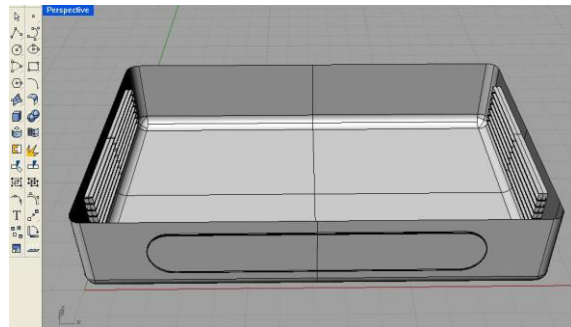


Figure 5. Position of the Compressor

3. Material and Technology

3.1. Material

The change of refrigerator structure is few while the selection of material has a large impact on its performance and cost. Usually in the design there are a variety of materials that can meet the requirements. It requires structural designers to have a clear understanding of the performance and cost of candidate materials. To use high-end materials in high-end products and low-end materials in low-end products, the materials selected needs to be as cheap and high quality as possible, which should meet the quality requirements of the product and to avoid the excess of quality. In the actual design process, experienced structural designers often choose materials based on their experience or the recommendation of mold manufacturers in order to save the time and reduce the risk of design^[3]. ABS is commonly and widely used in producing refrigerators due to its good mechanical properties, and it can be used for some components whose using requirements are general while appearance requirements are high, such as the inner liner of refrigerator, the upper plate, the positioning plate and so on. Designers also need to use

different types of materials according to the special requirements (high temperature, flame retardant).

1.The shell material of shared refrigerator is mainly engineering plastics ABS. ABS is a copolymer of styrene, butadiene and propylene sunny. The reason choosing ABS is that it has high strength, light weight, large surface strength, smooth and easy-cleaning surface, dimensional stability and good creep resistance. ABS plastic can be plated, which not only can make the surface of plastics products have metallic luster and beauty, and significantly improve the wear resistance and surface strength, but also enable the products to be resistant to moisture and solvent erosion, which can improve the service life and the commodity value of the products^[4].

①Mechanical properties of ABS plastic

Plastic ABS has excellent mechanical properties and impact strength. It can be used at very low temperatures. Plastic ABS has excellent abrasion resistance, good dimensional stability and oil resistance which can be used for bearings under medium load and low speed. The technical parameters of ABS plastic is as shown in Table 3.

Table 3. Technical Parameters of ABS Plastic

Density (g/cm ³)	Proportion (N/cm ³)	Melting point (°C)	Decomposition temperature (°C)	Forming shrinkage rate	Forming temperature (°C)	Drying temperature (°C)	Drying time (H)
1.10	1.05	170	260	119	200-240	80-90	2

②Thermal Properties of ABS plastic

The heat distortion temperature of ABS plastic is 93 ~ 118°C, and the temperature of products can also be increased by about 10 °C after annealing treatment. ABS can be used within a temperature range of -40 ~ 100 °C, but at -40 °C it still can show some toughness.

③Electrical properties of ABS plastic

The electrical insulation of ABS is good. ABS is almost not influenced by temperature, humidity and frequency, and can be used in most environments.

2.The material of the inner structure of refrigerator is mainly GPPS.

GPPS is a kind of colorless, odorless, tasteless, shiny and transparent particles, which is a general purpose polystyrene. GPPS has light weight, low price, low water absorption, great coloration, dimensional stability, good electrical performance^[5]. Its products are transparent and easy to process. The performance parameters are shown in Table 4.

Table 4. Technical Parameters of GPPS Plastic

Glass transition temperature (°C)	Density of amorphous (g/cm ³)	Crystal density (g/cm ³)	Melting temperature (°C)	Resistivity (Ω *m)	Coefficient of thermal conductivity (W/m*k)
80-90	1.04-1.06	1.11-1.12	240	1020-1022	0.116

GPPS can be dissolved in aromatic hydrocarbons, chlorinated hydrocarbons, aliphatic ketones and esters but only swelling in acetone. It is resistant to some mineral oils, organic acids, alkali, salt, and lower alcohol. Its water absorption is low, so it can still maintain its mechanical properties and dimensional stability in the wet environment. Electric performance of GPPS is excellent. Its volume resistance and surface resistance are very high, and it is neither affected by the changes of temperature and humidity, nor

the impact of corona discharge. In addition to it, the radiation resistant performance of GPPS is also very good.

The main drawback of GPPS is brittle and easy to crack, low impact strength, poor heat resistance. GPPS cannot be used in boiling water. It can only be used at low temperature and low load.

3.2 Crafts

The outer surface of shared refrigerator is relatively simple. The molding process of it is injection molding as shown in Figure 6. The first step of injection molding is adding the granular or powdery raw materials to the hopper of the injection molding machine, then the material is heated and melted into fluid. Driven by the screw or the piston of the injection machine, the liquid material is injected into the mold cavity through the nozzle and mold casting system, and eventually hardened and shaped in the mold cavity^[6-8].

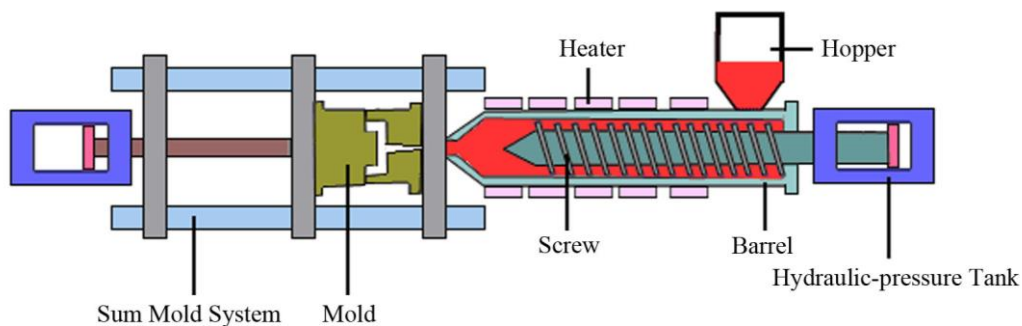


Figure 6. Injection Molding

The shared refrigerator needs to go through several injection molding because it consists of several parts. The injection mold has parting surface. The shape of the parting surface is divided into a flat surface, and the position of the parting surface is selected at the maximum outline of the plastic part. Plastic parts need to remain in the side of the movable die, which is conducive to the smooth release of plastic parts. The dimensional accuracy and surface quality of plastic parts are ensured by the choice of parting surface which is not only conducive to mold processing and exhaust, but also in line with the design principle^[9].

4. Colour Design

When people see the product, color is the first thing that draws their attentions, then the shape of the product and other factors. The charm of color is vital which affects people's feeling of spirit. Only when color conforms to people's life style and aesthetic taste, people would feel comfortable. Each color has its own characteristics, Such as the color of high Chroma and high brightness often give a high sense of gorgeous while the color of low Chroma and low brightness often give a simple sense.

The color appearance of products, not only has aesthetic and decorative characters, but also has symbolic meanings. As the core of visual aesthetics, color has profound impact on people's visual perception and emotional state. The feeling of people on color is the most intense and direct, and the impression is the most profound. Color of products comes from the human visual perception and physical stimulation, and a wealth of experience association and physical association, thereby people have complex psychological reaction to color. Different colors give people a different psychological feeling^[10]. The relationship between color and feeling is as shown in Table 5.

Table 5. Relationship between Color and Psychology

Colour	Psychological feelings
<i>Red</i>	Enthusiasm, Happy, Sexy, Authority, Confidence
<i>Yellow</i>	High brightness, Warning
<i>Green</i>	Fresh, Peace, Growth, Life, Safety
<i>Blue</i>	Calm, Broad, Eternal, Distant, Quiet, Refreshing, Sad
<i>Purple</i>	Elegant, Noble, History, Abstract, Wisdom, Indifference
<i>Black</i>	Noble, Steady, Technology, Heavy, Hard, Male, Industrial information
<i>White</i>	Pure, Noble, Clean, Cold
<i>Grey</i>	Soft, Elegant, Popular

The design of share refrigerator choose blue as the main color which represents calm and elegant. The share refrigerator' s different colours are shown as Figure 7.



Figure 7. Different Colors of Share Refrigerator

5. Man-Machine Relationship

During daily life, every one connects with the objects around all the time. When people use these objects, an interactive relationship occurs between people and objects, which is called man-machine relationship. The “machine” in the man-machine relationship not only refers to the machine people often say, but also refers to a variety of tools, instruments, equipment, facilities, furniture, transport and labor protection appliances. When people are in a particular environment, this time, the man-machine relationship is the relationship between man and the environment^[9]. The man-machine relationship when people stand operating the machine is shown in Figure 8.

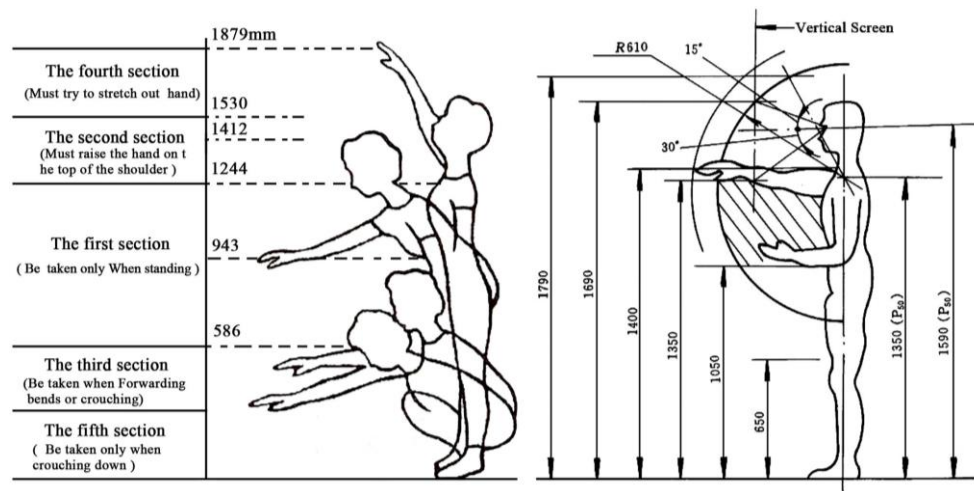


Figure 8. Man-Machine Relationship Picture of People Stand in Operating

From the physical and psychological point of view, people have a certain height, proportion and psychological characteristics, so design should follow people's physical, psychological dimension. In terms of psychological factors, people and objects always have a relationship in a certain space-time. Specific time and space will make people have different emotional effect. Appropriate scale space will give people a sense of security. If the scale of space exceeds the perceived security field, people will feel lonely and insecure due to lack of reliance. Ergonomics requires that product design should meet the physical and psychological requirements of people and enable people to control the machine comfortably and effectively.

5. Conclusion

The main emphasis of shared refrigerators is the innovation on the function, shape and structure of the product. Designing a new type of refrigerator with diverse functions can provide a reasonable and convenient product for people's daily life, and bring people convenience and joy when people use it. In this design, not only the material selection, part mating, processing and other technical issue need to be solved, but also the product appearance, color matching, ergonomic theory and other industrial design problems. This new shared refrigerator can provide consumers a new, comfortable lifestyle because of the research the work above.

Acknowledgements

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