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Application of TRIZ Theory in Noise Improvement of Vertical Refrigerated Display Cabinet

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Abstract: This paper takes the air-cooled vertical refrigerated display cabinet as the research object, analyzes and improves the noise problem of the vertical refrigerated display cabinet by using TRIZ theory. Firstly, the noise problem of vertical refrigerated display cabinet is clearly defined and the main noise sources are determined;secondly, the product noise problem is transformed into TRIZ problem model, and the problem model is determined to be a technical contradiction; secondly, the idealization level of each component is analyzed to determine the useful and harmful functions; finally, the invention is determined by using archishure general engineering parameters and contradiction matrix Principle and find a specific solution, effectively reduce the noise of vertical refrigerated display cabinet.

1. Introduction

With the rapid development of China's economy, the popularity of vertical refrigerated display cabinets is getting higher and higher. Due to different refrigeration methods, vertical refrigerated display cabinets are divided into direct cooling type and air-cooled type. The direct cooling type has the advantages of low power consumption, low noise and low price. However, the speed of refrigerated food is slow and the temperature uniformity is poor, so it needs manual defrosting. Air cooled refrigeration has the advantages of high speed, no need of (automatic) defrosting, good temperature uniformity, but high price, high power consumption and high noise. As people's quality of life is getting higher and higher, the requirements for the consumption environment are naturally higher and higher. The noise problem of vertical refrigerated display cabinet has been paid more and more attention by dealers and customers. Innovation is mentioned 58 times in the report of the 19th National Congress of the Communist Party of China, which emphasizes that innovation is the strategic support of modern economy. The traditional innovation methods include trial and error method, brainstorming method and reverse thinking method. Its innovation efficiency is low and it is easy to cause huge waste of human and material resources. In 1956, Altshuller put forward the "Theory of Inventive Problems Solving", namely TRIZ theory, which not only improves the ability to solve technical problems, shortens the R & D cycle of products, but also makes the direction of enterprise technological innovation predictable, thus reducing the risk of enterprise technological innovation. At present, TRIZ not only plays an important role in the field of engineering technology,

but also has been applied in natural science, social science, management science, biological science and other fields. In this paper, the noise problem of vertical refrigerated display cabinet is analyzed and improved by using TRIZ solution principle shown in Figure 1.

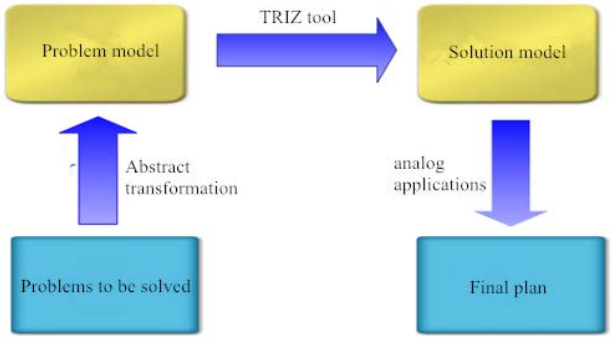

Figure. 1 Principle of TRIZ

2. Define the System Name

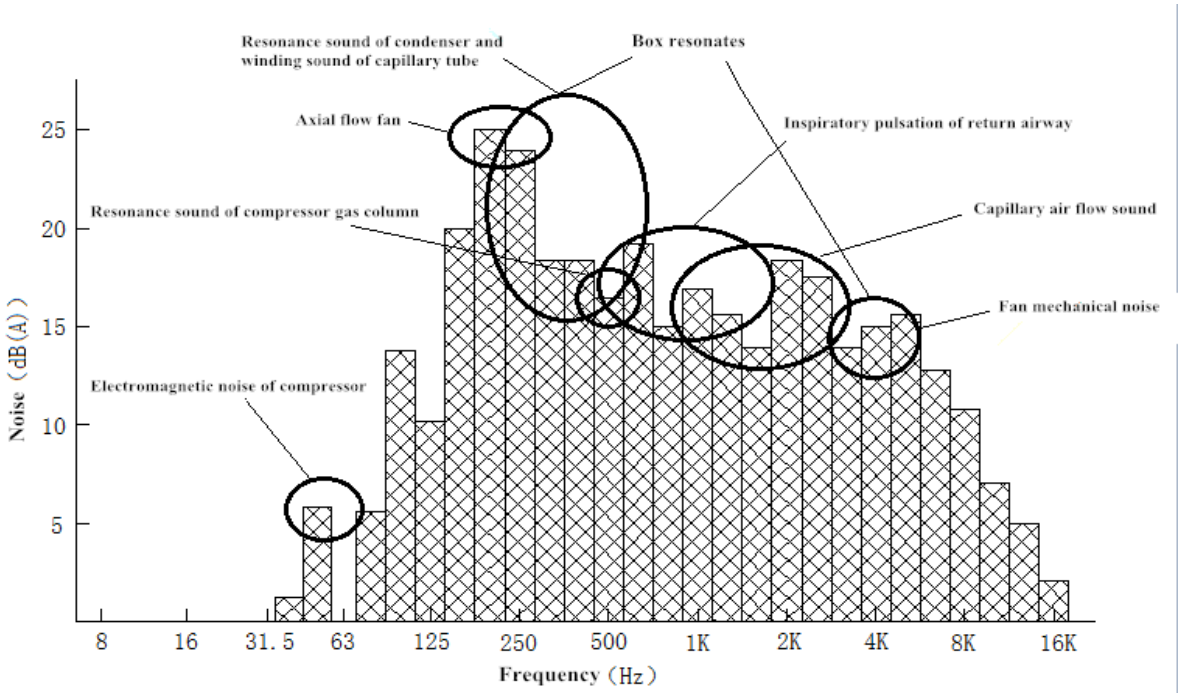

Figure. 2 Noise and frequency distribution of vertical refrigerated display cabinet

To solve the noise problem of vertical refrigerated display cabinet, it is necessary to have a clear definition of the problem to be solved. Air cooled vertical refrigerated display cabinet is a kind of heat insulation cabinet with the functions of refrigeration and display, which is mainly used for the storage and sale of beverages. The compressor works to compress the refrigerant into high-temperature and high-pressure gas, and then flows through the condenser to release heat to the outside and change into low-temperature and high-pressure liquid. Then it enters the evaporator and becomes low-temperature and low-pressure gas to absorb the heat in the box and realize the refrigeration in the box. According to the description of the whole working process of the vertical

refrigerated display cabinet, we can simply define the system name as "the parts of the vertical refrigerated display cabinet cooperate to realize refrigeration". The noise generated in the whole working process mainly includes mechanical noise generated by compressor operation, pneumatic noise generated by condensation fan operation, pneumatic noise generated by evaporation fan operation, and fluid noise generated by refrigerant flow in pipeline. The noise frequency distribution is shown in Fig. 2.

3. Ransforming into TRIZ Problem Model

In order to use TRIZ as a tool to solve problems, it is necessary to transform specific problems into corresponding models. According to the above discussion on the working principle and noise problems of the vertical refrigerated display cabinet, the TRIZ theory is further used to describe the vertical refrigerated display cabinet. Its working principle is described as follows: power driven compressor, power driven condensing motor, power driven evaporation motor, condensing motor driving condensing fan blade, evaporation motor driving evaporation fan blade, U-shaped bracket fixing condensation motor, straight plate bracket fixing evaporation motor, compressor bottom plate fixing compressor, compressor bottom plate fixing U-shaped bracket, top cover fixing straight plate bracket, compressor driving Moving refrigerant.

The main noise problems of vertical refrigerated display cabinet are as follows: mechanical noise generated by compressor operation, mechanical noise generated by condensation motor operation, mechanical noise generated by evaporation motor operation, pneumatic noise generated by condensation fan blade rotation, pneumatic noise generated by evaporation fan blade rotation, condensation motor colliding with U-shaped bracket, evaporation motor colliding with straight plate support, compressor impacting compressor bottom plate, U-shaped The bracket collides with the bottom plate of the compressor, the straight plate bracket impacts the top cover, and the refrigerant collides with the refrigeration pipeline. The problem model described in this paper belongs to technical contradiction. The tool to solve the technical contradiction is contradiction matrix. The solution uses 40 invention principles.

4. Functional Analysis

Functional analysis is a tool to analyze problems, and it is a tool to identify the functions, characteristics and costs of system and super system components. Some of the noise components described in this paper are the main noise sources of the vertical refrigerated display cabinet, and some are the non main noise sources of the vertical refrigerated display cabinet. According to the contribution of each component noise to the overall noise of the vertical refrigerated display cabinet, the functional properties of each component are analyzed and determined, and the ideality of each component is obtained by using the idealization level formula of formula (1). The ideality of each component is shown in table 1.

$$Ideality = \frac{\sum UF}{\sum HF} \tag{1}$$

Table 1 Component function analysis

Component	Useful functions	Harmful effects	Cost	Idealization level
Compressor	8	5	10	0.53
Condensing motor	4	2	2	1
Evaporation motor	5	2	2	1.25
Condensing fan blade	3	2	1	1
Evaporation fan blade	3	1	1	1.5
U-bracket	2	2	1	0.67
Straight plate support	2	2	1	0.67
Compressor bottom plate	4	1	2	1.33
Top cover	5	1	3	1.25
cryogen	1	3	1	0.25

In the formula: $Ideality$ is the ideal level; $\sum UF$ is the sum of useful functions; $\sum HF$ is the sum of harmful functions.

The useful functions include all the valuable results of the system, while the harmful functions include transition cost, energy consumption, pollution and danger.References.

From table 1, we can get the ideal level size of each functional component, from small to large: (1) refrigerant; (2) compressor; (3) U-shaped support; (4) straight plate support; (5) condensing motor; (6) condensing fan blade; (7) evaporation motor; (8) top cover; (9) compressor bottom plate; (10) evaporation fan blade.

5. Applying the Principle of Invention to Determine the Solution

According to the function analysis of each component and considering the transformation cost of the enterprise, we analyze the TRIZ problem of the evaporation fan blade, and the evaporation fan blade is shown in Figure 3. If the ordinary evaporation fan blade is used as the power source of the air cooling system, the product cost is low, but the aerodynamic noise of the fan blade rotation is large, and the aluminum alloy fan blade rotation has certain risk. If the solution is to use an airfoil blade made of PP material as the power source of the air cooling system, as shown in Figure 4, the aerodynamic noise generated by the fan blade rotation can be greatly reduced, and the safety is higher than that of the aluminum alloy fan blade, but the airfoil blade structure is complex and the cost is slightly higher.

As our goal is to improve the noise of the vertical refrigerated display cabinet, we choose to replace the aluminum alloy fan blade with the airfoil noise reduction fan blade, so the airfoil fan blade becomes the technical contradiction of our choice. The objective of our optimization is to reduce the noise in the working process of the vertical refrigerated display cabinet. Therefore, reducing the noise is a parameter to be improved in the technical contradiction. Because it is necessary to install airfoil blades to reduce the aerodynamic noise, the cost of the product is increased, so the cost of the product is a deteriorating parameter.

The improved and deteriorated parameters are converted into general engineering parameters of archishure, and the closest general engineering parameters among 39 general engineering parameters are found. Since the "noise reduction" measure is to replace the airfoil blades, it is closest to the 12 "shape" of the general engineering parameters. Similarly, "increased product cost" is closest to 24 "material loss" of general engineering parameters, so the corresponding table of specific parameters and typical parameters shown in Table 2 is obtained.

Figure. 3 Common evaporation fan blade

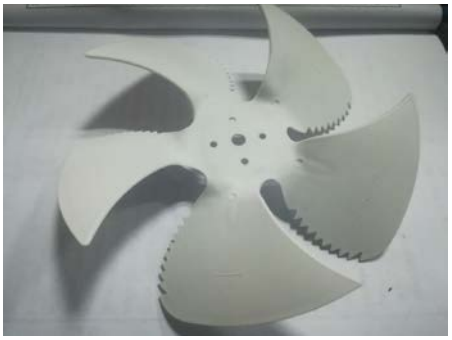

Figure. 4 Airfoil evaporation fan blade

Table 2 Corresponding table of specific parameters and typical parameters

	Specific parameters	Typical parameters (general engineering parameters)
Improving parameters	Noise reduction	Shape
Deterioration parameters	Increase product cost	Material loss

The improvement parameter "shape" and deterioration parameter "material loss" are determined in the altshuler contradiction matrix, as shown in Table 3. The improvement parameter "shape" is in line 12, and the deterioration parameter "material loss" is in column 23. The numbers displayed in the cross corresponding units are 35, 29, 3 and 5. Each number corresponds to the number of 40 invention principles, as shown in Table 4.

By using the invention principle determined by the above steps, the specific solution is found. By replacing the airfoil noise reduction fan blade, the aerodynamic noise of the fan is effectively reduced, and the overall noise of the vertical refrigerated display cabinet is obviously reduced.

Table 3 Contradiction matrix (local)

Improved parameters Deteriorating parameters		23	24	25	26
		Material loss	Information loss	Loss of time	Amount of matter
9	speed	10, 13, 28, 38	13, 26	-	10, 19, 29, 38
10	Power	8, 35, 40, 5	-	10, 37, 36	14, 29, 18, 36
11	Stress and pressure	10, 36, 3, 37	-	37, 36, 4	10, 14, 36
12	shape	35, 29, 3, 5	-	14, 10, 34, 17	36, 22
13	stability	2, 14, 30, 4	-	35, 27	15, 32, 35
14	strength	35, 28, 31, 4	-	29, 3, 28, 1	29, 10, 27

Table 4 40 invention principles

1	segmentation	11	cushion in advance	21	rushing through	31	porous materials
2	extraction/taking out	12	equipotentiality	22	convert a harm into a benefit	32	change the color
3	local conditions	13	inversion	23	feedback	33	homogeneity
4	asymmetry	14	spheroidality	24	mediator	34	rejecting and regenerating parts
5	consolidation	15	dynamicity	25	self-service	35	transform the physical／chemical state
6	universallity	16	partial or excessive actions	26	copying	36	phase transformation
7	nesting	17	shift to new dimension	27	disposable objects	37	thermal expansion
8	anti-weight	18	mechanical vibration	28	replacement of mechanical system	38	strengthen oxidation
9	prior counteraction	19	periodic action	29	pneumatics or hydraulic construction	39	inert environment
10	prior action	20	continuity of useful action	30	flexible “shells” or thin films	40	composite materials

6. Conclusion

In this paper, the noise problem of vertical refrigerated display cabinet is analyzed with TRIZ theory. According to TRIZ theory, the evaporation fan blade in the air cooling system of vertical refrigerated display cabinet is determined as a group of technical contradictions analyzed in this paper, and the closest general engineering parameters are found out among 39 general engineering parameters. Then, according to the two general engineering parameters found, the corresponding numbers of 40 invention principles are determined in the contradiction matrix, and finally the solution of replacing the airfoil noise reduction fan blade is determined, which can better reduce the whole machine noise of the vertical refrigerated display cabinet.

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