Application and Practice of Industrial Robot Color Design Based on Kansei Engineering

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Abstract: In this era when the industry has developed to 4.0, many countries have made huge breakthroughs in the development of the industrial robot industry, and China is at the forefront in this field around the world. In order to enhance the competitiveness and influence of Chinese industrial robots in the international market, domestic industrial robot researchers must delve deeper into core technologies and study the kansei factors and needs of users. Only by incorporating the elements of user's kansei image into the color design of industrial robots can the designed industrial robot be more in line with the basic needs of users in terms of external image. Industrial robots integrate the theory of Kansei Engineering into the link of styling design, which transforms the user's perception of the product into specific design elements and reflects the design form through the product to form the semantic space of the product. If these kansei factors can be reflected in the design of industrial robots, it will increase the significant advantages of industrial robots in appearance. After a brief description of the development process of the industrial robot and related concepts of Kansei Engineering, this article studies the kansei elements of its color design by listing specific types of robots, hoping to provide reference to actual design.

1. Introduction

Industrial robots are a product of industrial manufacturing. This essence determines that industrial robots must meet the aesthetic needs of users through appearance performance in terms of function and emotion. In the present era, various scientific production technologies are in a state of continuous improvement, and users' basic needs for colors should be met. Industrial robots are really commonly applied in all walks of life. In order to adapt to the needs of different industries, designers of industrial robots should also take into account color design. If the theoretical knowledge of Kansei Engineering can be integrated into the robot design and its appearance can perfectly match its functions, the influence of China's industrial robots will continue to increase in the world. For changes in the external form of industrial robots, designers should also pay attention to changes in product shapes and materials. Color changes caused by materials are also extremely common. For this kind of changes, designers should carefully explore and try to transform from pursuing form and function to pursuing emotion and functions. In the continuous development of the times, designers must learn to constantly innovative industrial robot design concepts, accurately and cleverly apply Kansei Engineering theory and effectively extract the design elements of industrial robots, so as to promote the rapid development of the industrial robot industry of China.

2. The Related Concepts of Industrial Robots and Kansei Engineering

2.1 Related Concepts of Industrial Robots

Industrial robots are robots with a higher degree of freedom in the industrial field. They are usually used to perform work automatically and implement action functions according to their own impetus and control capabilities. The appearance of an industrial robot includes multiple parts, including the wrist, forearm, upper arm, base, etc. According to the theoretical knowledge of kinematics, the common configurations of industrial robots have many forms, as shown in Table 1. The most common one is the hinged operating arm. It is also known as the common joint type,

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which is similar in shape to the human arm, and the joints can rotate. Industrial robots do not exist alone in their work. They form a complete interaction system with humans and the environment, including two forms: robots-environment interaction system and human-computer interaction system. On the one hand, industrial robots are the core in the robot-environment interaction system. The industrial robot and other parts of the environment form functional units, including processing and manufacturing units and configuration units. On the other hand, the human-computer interaction system is based on users. They complete the connection and configuration of various parts through the control of the robot, including two forms: information display and instruction given device.

In addition, the human-computer interaction system also includes a special concept, namely the principle of robot teaching. Simply speaking, the robot can guide the user to complete the operation according to the actual needs of the user. Industrial robots have the functions of automatic memory and storage, including the motion parameters and position changes of the industrial robot itself. After the teaching is completed, the users only need to send an accurate instruction to the industrial robot to complete the teaching operation. In the design process of industrial robots, contemporary users pay more attention to the appearance of industrial robots. Color matching is one of the main factors that affect the external shape of the robot. The surface treatment of industrial robots can also reflect the level of craftsmanship through color matching. As far as the color design of industrial robots is concerned, there is great room for designers. They can make a clear design plan for the specific needs of users, and determine the final plan after communication between the two parties.

Table 1 Common Kinematic Configurations of Industrial Robots

Kinematic configuration	Features	Application
Cartesian operating arm	This kind of robots are highly precise and controllable, but they move relatively slow and occupy a large space.	They can engage in handling objects, inspection, welding operations, palletizing, EOD, etc.
Hinged operating arm (joint type)	Robots of such type follow the movement principle similar to that of human arms, and their joints can rotate freely.	They can be arranged to undertake the rapid inspection and development of automobile assembly, error detection, sheet metal parts, artwork, glass products, plastic products and other products
SCARA operating arm	With selective flexibility, this kind of robots can take advantage of flexibility in the movement of XY 2D, and they have strong rigidity when moving along the Z axis.	They can engage in the assembly of electronic parts and the handling of automobiles, plastics, pharmaceuticals, foodstuffs, etc.
Cylindrical operating arm	The power output of arms of such type are relatively sufficient. The linear part can be hydraulically driven, and for some cavity machines, they can directly enter the interior. But they also have certain space limitations. For example, they are easy to touch other objects and the linear drive part is not very closed.	-
Spherical operating arm	The working range near the center bracket is large, covering a large working space, but the controllability is not strong.	-
Closed-loop structure	The rigidity of the structure is very reliable, but the motion range of the joints is reduced, resulting in a reduction in the coverage of the robots' workspace	This kind of arms can be used for micro-manipulation robots, motion simulators and parallel machine tools. They can also be used in the fields of biology and medicine to realize microsurgery. In addition, they can be used in telescope adjustment devices in the astronomy field.

2.2 Related Concepts of Kansei Engineering

2.2.1 Kansei Cognition

In practice, human beings usually come into direct contact with external things in the context of information obtained by the senses. These things may affect the psychological response of human beings, and form various influences in the human brain, so that they have various forms of preliminary cognition of different things. Kansei cognition has a wide range, mainly including three aspects: sensation, perception and presentation. These three aspects are interrelated and interdependent, which is inseparable from the neural structure of the human body. When a person contacts something, his initial cognition is a kind of feeling. This kind of sensation is a product that is coordinated with activities in the process of sensory and brain composition, and reflects the individual attributes of things, and then he distinguishes various types through senses. After completing the sensory process, the human brain gradually forms an objective overall cognitive image, namely, the so-called perception. Perception does not simply superimpose the sensations of the human brain, but highly summarizes the initial human cognition on a holistic basis, which lays the foundation for the formation of presentations. The presentation of human cognition of a thing can be divided into two types: memory presentation and imaginary presentation. The former is the reproduction of human past memories, while the latter is the association and prediction of the image of the thing. The consciousness of the human brain is relatively complex. On the basis of preliminary cognition, it will consciously merge the fragmented cognition, and gradually form a direct and indirect conversion, making the unique attributes and characteristics of things completer and more specific. Human kansei cognition is formed on this basis.

2.2.2 Kansei Intention

While users make kansei cognition of a product, most of them will express their own intentions. A user generally grants his personal wishes based on the information provided by the product, and then he has a subjective affection and attitude towards the product, that is, like or dislike. This is a state where the subjective factors of the user are intertwined with the external image of the product. It can also be understood as the influence of the information and imagination brought about by the product under the influence of human special psychological and emotional activities. It is an information processing intelligent activity made by the human brain as the core. According to different sensory stimuli, the kansei intentions obtained by human beings are also different, such as visual imagery and auditory imagery. In reality, people's visual imagery is higher than auditory imagery. In short, the image of a person has strong complexity and are closely related to the complex psychological activities of humans. Many factors can affect it, and emotions of different people also have commonality. Through the features displayed by the product, the information obtained by different users may be similar or inconsistent. This is the so-called kansei intention.

2.2.3 Kansei Engineering

Kansei Engineering is highly comprehensive, integrating theoretical knowledge from multiple disciplines such as engineering and design. Since the essence of Kansei Engineering is to study the need of users for appearance through the research technology of engineering, the early Kansei Engineering is called “Emotional Engineering”. It was only in 1986 that Japanese automotive research experts put forward the term “Kansei Engineering”. This expert is Professor Kenichi Yamamoto of a Japan Automobile Company, and he found that the modern industrial model is changing. As a product manufacturer, producers must pay attention to the perceptual needs of users in order to win a more favorable market survival value. Therefore, Professor Kenichi Yamamoto named this product research work based on user perception as “Kansei Engineering”. Since the 1990s, some countries have incorporated the research concept of Kansei Engineering in the fields of automobiles and home appliances, and are committed to developing new products that are useful to modern people. China introduced the research and application of Kansei Engineering at the beginning of this century, which shows that Chinese researchers still have a large space for development in the application and research of this subject.

3. Application of Kansei Engineering in the Color Design of Industrial Robots

Under the influence of the globalized economic market, users' individual needs for products are becoming more and more obvious. The “pursuit of form and function” in the past can no longer satisfy the design concept of contemporary industrial robot products. Users today pay more attention to the external form of industrial robots, and their desire to buy products is complementary to their initial impression and functions of target product. They are often in a good initial impression to initiate the desire to understand the product's function. It can be seen that it is very important to apply the Kansei Engineering in the color design of industrial robots. Under the influence of barrier-free manufacturing nowadays, users' sensibility is the starting point of the color design of industrial robots, that is, “consumer image -- product sensibility -- design details”. The relationship between product color design and user sensibility can be established on this basis. Scholars in the industry have discovered through research that Kansei Engineering includes the following three types:

3.1 Qualitative Inferential Kansei Engineering

A tree diagram or other types of icons are established on the basis of hierarchical inference methods. Seeking the details of the color design of industrial robots does not rely on computers to analyze requirements, but uses a goal-oriented method to design industrial robot materials. Designers start from the 0-level kansei, and then decomposes the valuable sub-levels, such as the 1-level kansei...the N-level kansei, until the color design of the product reaches the ideal.

3.2 Forward-and-Inverse-Combined Kansei Engineering

In order to realize the full conversion between the color design and the kansei intention of the industrial robot, designers fully combine the perceptual elements with the morphological elements, and then combines them with the computer. Therefore, it is also called computer-aided kansei engineering. Its content is divided into forward quantitative and reverse quantitative: the former focuses on users' kansei demand for industrial robots, while the latter focuses on designers' kansei evaluation of users.

3.3 Mathematic Model Kansei Engineering

Designers take the users' specific sensibility as the target variable of the industrial robot design and establish a model that can realize the users' kansei demand. This is the so-called mathematic model. For example, A Japanese company once applied this model to the research of color printer color designs. Taking “the color of the human skin looks better when printed with photos” as a quantitative research, a kansei engineering research with the characteristics of mathematical models was established. It can be proved that the mathematic model kansei engineering can be applied to the color design of industrial robots.

4. Specific Practice of Kansei Engineering in the Color Design of Industrial Robots

Flexible multi-joint single-arm robot have multiple joints and multiple degrees of freedom. They are a kind of industrial robots with high flexibility and technology, which can perform more flexible actions to meet the requirements of industrial operations such as product packaging, inspection, polishing and precision assembly. Therefore, they are most widely used. According to the design process and structural characteristics of this type of robots, the author uses the relevant methods of product modeling design and color perceptual analysis to carry out detailed design from the aspects of form, color and material, and finally complete the detailed modeling.

4.1 Design and Conception Process

In the modeling design of industrial robots, the perceptual factors are the direct practice of the theoretical knowledge of Kansei Engineering, and product image modeling design has become an important competitiveness of enterprises. Designers can start from the design elements of industrial robots, and then follow the diagrams to avoid errors in the design process. As shown in Figure 1, in order to make the robot have more circular elements, designers can design a capsule-like contour in

the preliminary design, and then look for breakthroughs in length. Then, designers can change the line reconstruction of the industrial robot arms (as shown in Figure 2) to change the traditional rigid state of the arms, so as to reflect the mechanical and aesthetic characteristics from the form.

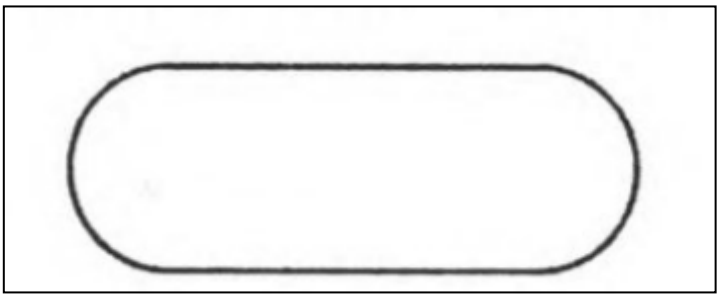

Fig.1 Conception Process of Industrial Robot Design 1 (for Reference)

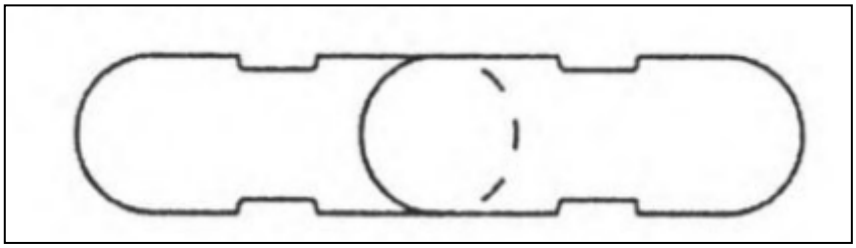

Fig.2 Conception Process of Industrial Robot Design 2 (for Reference)

4.2 Application of 3d Modeling

Designers can employ Rhinoceros 5.0 (3D modeling software) to design specific outline schemes for industrial robots, and then use the computer for virtual modeling to draw the basic shape of industrial robots in the 3D space. The design focus can be “from-point-to-line”, to “from-line-to-surface” and then to “from-surface-to-body”, and then adjust the design ratio of each part of the industrial robot within the limited size range, with the purpose to make the designed robot meet the actual production requirements. In the application of 3D modeling, designers can perfect the design details of industrial robots to make their appearance design more complete. After the 3D modeling and drawing are completed, the designers can use Keyshot to complete the color rendering of the industrial robot products (as shown in Figure 3). Getting a more realistic 3D image means that the designers has completed the basic work of combining industrial robot color design with kansei engineering.

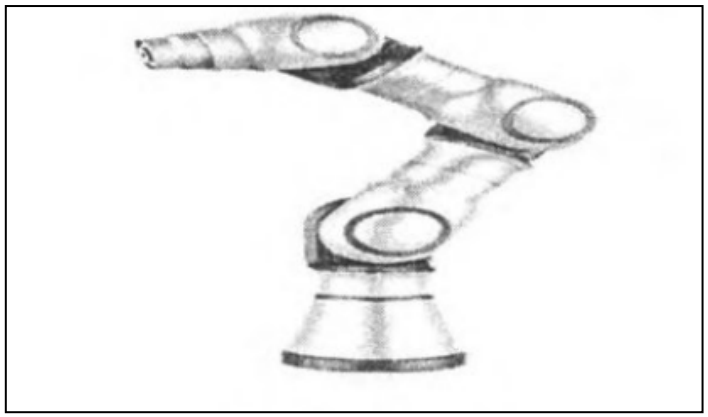

Fig.3 The Final 3d Modeling Renderings of Industrial Robot Kansei Engineering Design

4.3 Analysis of Color Design

Under the concept of perceptual engineering, the color design of industrial robots is mostly white, red and “engineering yellow” based on the emotional intentions of users. “Engineering yellow” represents “stable, rigorous and scientific”, which gives people a sense of security. White symbolizes seriousness. In the medical field or other fields that require precision instrument

operation, the application of white in the design industrial robots can drive the staff to respond to work with a calm attitude. Red has an effect of warning. For some dangerous jobs, red can be used to mark something, which means “do not approach”. Different industrial robot manufacturers have unique color schemes, but the robots they design do not wear very special colors. At present, white, red, and “engineering yellow” are generally used in the color design of industrial robots, which can show a sense of serious science and show a better industrial artistic effect. In 3D modeling, these three colors have strong expressive power and are suitable for color design of industrial robots.

5. Conclusion

Kansei Engineering is a commonly used method in industrial product design, which can provide guidance for product design. But for the design of different products, the application of Kansei Engineering is also obviously different. In the color design of industrial robots, the research of kansei image is closely related to its application field. In consideration of the needs of users, the manufacturing industry of industrial robots should use the theoretical knowledge of Kansei Engineering dialectically in the specific manufacturing process with the development of modern manufacturing technology. In addition, it is necessary to choose an appropriate design method and attach importance to the external color matching of industrial robots, so as to give customers a novel and wonderful experience.

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