

## Research Article

### Study on Design Method of New Age Food Machinery

Xiaowei Jiang

Institute of Machinery and Vehicle Engineering, Changchun University, Changchun 130022, China

**Abstract:** The study purpose is to investigate an effective design method for food machinery, thereby raising the external appearance quality and pleasant of food machinery, strengthening additional value and whole shape effect of product, satisfying the demand of market competition and creating higher economic efficiency. The study elaborates on the green design, optimal design, concurrent design and bionics design, including the shape bionics, structure bionics, interface bionics and texture bionics, to introduce the great significance of researching food machinery, based on which the conclusion has been reached.

**Keywords:** Bionics design, concurrent design, food machinery, green design, optimal design

#### INTRODUCTION

The development of the food machinery industry in China began in the 1970s, formed in the 80s. In the late 80s and early 90s it entered the stage of rapid development, initially forming an independent industrial system of complete category and supporting variety. Since the 80s, the average growth rate per annum of output value is about 24%. At present in our country the scientific research and teaching institutions specialized in food machinery are more than 500 and the food machinery enterprises are more than 1900, with an annual output value 13.5 billion Yuan (Chen, 2005).

In recent years, in China, the food machinery industry although has obtained certain achievements, relative to the development and requirement of food industry the development of food machinery is still inadequate (Jiang, 2013). Currently the self-sufficiency in food machinery equipment in our country only reaches needed 60~70%, every year still importing a number of food and packing machinery. Large food factory in particular, Sino-foreign joint venture, is still using the whole production line imported from abroad.

The ability of processing agricultural products is very poor in our country. In the main agricultural products, the one which is processed into food accounts for only 2~30% of total output, while developed countries could reach 15~70%, as shown in Table 1 (Liu *et al.*, 2002).

In the world, the countries that are advanced in food machinery technology such as the United States, Germany, Italy, France, Japan, Denmark, the Netherlands, Switzerland and Sweden are taken as delegate. In this countries the processing rate of food raw materials is generally over 70%, some as high as 92%. Their food industry output value proportion in the

gross industrial output value is very high, generally over 10%, the highest close to 18%, is 2~3 times of the agricultural output (Chen, 2005).

The developed countries have a great variety of food and packaging machineries, as much as more than 3000, which could meet the needs of the food and packaging industry. The degree of specialization, serialization and automation of equipment is very high (Liang, 2003). It combines machine, light, liquid and gas technology, using computer control, automatic detection and automatic adjustment. The application of a large number of new technologies greatly improves the production efficiency, improves the working conditions, improves the product quality, reduces the processing cost and enhances the product competitiveness (Zhan, 1999).

In order to retain nutrients in the food as much as possible and to avoid damage under high temperature and the oxidation, in the food industry it should adopt low temperature and low pressure process as far as possible. So low pressure processing technology has been widely used in developed countries, such as vacuum conveyor, vacuum filtration, vacuum degassing, vacuum cooling, vacuum evaporation, vacuum crystallization, vacuum granulation, vacuum concentration, vacuum puffing, vacuum molding, vacuum packaging, etc. and freeze concentration and freeze drying technology and equipment has also been widely used.

The main purpose of the study is to investigate an effective design method for food machinery, thereby raising the external appearance quality and pleasant of food machinery, strengthening additional value and whole shape effect of product, satisfying the demand of market competition and creating higher economic efficiency.

Table 1: Main food resource production and processing situation in our country

Product name	Annual output (myriad T)	Status in the world	Processing proportion (%)	Processing proportion of developed country (%)
Grain	49000	1	2	30
Fruit	5453.0	1	10	40~70
Vegetables	33000	1	10	30~40
Meat	6200	1	4	30~50
Aquatic product	3906	1	30	75
Eggs	2125.4	1	0.25	15-20



Fig. 1: Food machinery of concrete shape bionics

## MATERIALS AND METHODS

**Bionics design:** Advocating the bionics design of food machinery not only could create the food machinery of complete function, compact structure and reasonable material, making it be more competitive, but also could give food machinery shape with the symbol of life, making the design return to nature, enhancing the unity of human and nature and creating a high degree of harmony between human society and nature. On the one hand, through the bionics it embodies the product characteristics and natural emotion, closes the distance between people and products, considers human psychological feeling and physiological comfort and reflects the harmony between the products, people and environment; on the other hand, the food machinery products designed by using the bionic method could show the functional factors of product positioning more clearly, increase the spirit interaction between people and products, more fit consumers' purchasing psychology and get the consumers' recognition (Wang, 2013).

German famous designer Luigi Colani once said: "the basis of design should be from the truth that the life in the nature takes on and what I do is nothing but to

imitate the variety of reality which the nature reveals to us." It tells us that the nature contains the nature's mystery of endless precious deposits of design. The bionics in industrial design mainly embodies the following respects.

**Shape bionics:** Depending on the realistic degree of reappearing things, characteristics and features it could be divided into the concrete shape, abstract shape and image shape three kinds.

**Concrete shape bionics:** Concrete shape is that penetrating the eyes construction with the physiological nature reaction to feel the existent shape after cordially mapping the shape of outside world into the retina excitor. The bionics design of concrete shape has a good sense of taste, appetency and naturalness and people are willing to accept. If food machinery moderately adopts natural shape, it would bring intimacy and taste for the food industry workers (Fu, 2002), as shown in Fig. 1.

**Abstract shape bionics:** Abstract shape is from natural objects prototype, through generalization and abstraction, from the whole, reflecting the unique form and the generality of characteristic just accords



Fig. 2: Food machinery of abstract shape bionics

substantive characteristics of object. The simplicity with the requirement of modern industrial products for the simplicity of appearance shape, geometry and product semantics. Therefore, it is widely used in modern product design. It would make food machinery appearance be more concise and beautiful for food machinery designers to moderately use abstract bionics, as shown in Fig. 2.

**Image shape bionics:** Image shape bionics design is the advanced stage of bionics design. It is the key to find the specific relation between prototype and object, for the relevant natural objects attributes, using the manner of metaphor and symbol to reflect the characteristics of product. Image shape bionics is the inspiration of designer for nature and put this kind of inspiration through product to elucidate, thus reaching the realm of objects and me blending. It is the key to find out the internal relations between natural objects and products through the analogy with product and natural objects. If this trade-off relationship is proper, it would make the design be unity of form and spirit, preferably reflecting the peculiarity of product. The shape bionics is often used in modern automotive modeling design, such as SEC coupe of Mercedes Benz, Twingo of Renault and perfectly round Mazda 121, all looking like some kind of animal. Viper of Dodge likes a snake of preparing to give you critical strike and Ferrari 275GTB looks like a cod fish. Food machinery equipment could also refer to some concept of automobile design, making its appearance show a certain style (Qiu, 2005).

**Structure bionics:** With in-depth development of bionics, people not only imitate biology from the appearance and function, but also get a lot of inspiration from biological peculiar structure. Structure bionics design is through researching the structural organization form of the whole or part of biology to find the potential similarities with the product and then to imitate, in order

to create a new image or to solve new problems. The non-smooth mould-board of bionic scales designed by Congqian and other designers does not produce adhesion in the soil cutting test. Compared with the smooth mould-board, it could reduce bulldozing resistance about 15% on average. Food machinery developers should also find more inspirations from nature, by imitating the particular structure of some aspect of biology so as to improve the efficiency of food machinery (Wang, 2013).

**Interface bionics:** In modern industrial product design, it is very rare simply from a certain aspect of the shape, function, structure or material to simulate; it is more usual to conduct the bionics design synthesizing the multiple aspects of shape, function, structure and material and also from the perspective of existential philosophy (namely harmony and commensalism) of the nature world to conduct the bionics design (Jiang, 2014b). This kind of bionics design that is not only from the individual forms of nature, but also from the overall survival concept of nature, coincides with the functional design and emotional design of interface design, so it is simmered down to interface bionics design. The developers of food machinery could get enlightenment from the interface bionics, making the interface of food machinery more humanized.

**Texture bionics:** Simulating a natural attribute of biological surface texture and conveying the aesthetic experience and visual effect such as the surface organization structure, shape and texture of the molding material, are called the texture bionics. The stripes on zebra's body are the derived protective coloration in order to adapt to the living environment; it is a very successful example of bionics that humans use the zebra stripe to the military. Due to the continuous development of material surface treatment technology and the birth of bionic material, it provides a colorful strange area for texture bionics. Existing research shows that the body surface of the animal which lives in sticky and wet soil presents the non-smooth characteristic of geometry, which has the effect of reducing viscosity, resistance and attrition. Non-smooth surfaces could change the plough cut of abrasive to the surface into a roll, so playing a part in reducing resistance and attrition. If applying the structure and composition texture to the surface layer of mechanical components of touching soil, it would improve the abrasion resistance of mechanical components of touching soil. Food machinery design should also adopt the texture of reducing resistance and attrition to design the one of higher efficiency and longer service life (Wang, 2013).

**Green design:** Currently, in order to conform to the trend of the age and strengthen the design concept of ecological environment consciousness, it is the common practices in the field of food machinery industry to apply the green design to the food machinery.



Fig. 3: Green design of food machinery material



Fig. 4: Green design of food machinery structure

**Green design of food machinery material:** When conducting the green design for food machinery materials, it should choose the materials of low consumption, low pollution, low cost, easy processing, easy processing, easy recycle, anti-corrosion, non-toxic and easy removal and cleaning. Because the food produced by the food machinery is to let consumers directly eat and the food quality is related to people's health, it should make sure the selected food machinery material is safe when designing (Fu, 2013), as shown in Fig. 3.

**Green design of food machinery structure:** When designing the structure of food machinery, it equally should adhere to the concept of green design to assemble, manufacture and disassemble easily. Under the condition of ensuring the product quality improved continuously, it should reduce the number of parts as much as possible; in the assembly and manufacturing process, it should as much as possible achieve the clean production and reduce environmental pollution to prolong the service life of equipment. At the same time, to achieve the improvement of the production process, after the product reaches service life, its part components could be refurbished and reused or safely put away. Detachability design not only could reduce the cost of dealing with waste, but also reuse the part components, as shown in Fig. 4.

### **Green design of hydraulic system and power system in food machinery:**

Applying the green design to the hydraulic system and power system of food machinery has a very important function. The hydraulic system is the main transmission system of food machinery, but there are many problems exist in this system, such as noise pollution and oil pollution and other issues. These problems will affect the quality of food and also become the obstacle factors of influencing the food industry development. Using water and vegetable oil instead of mineral oil could solve the problem of oil pollution and adopting the voice control system could solve the problem of noise pollution. Therefore, it should speed up the research on ecological hydraulic system, such as water pressure, vegetable oil and others and put into use as soon as possible, improving the existing problems. In the power system of food machinery, through the consumption of primary energy oil to produce food, equally there will also be the potential risk such as the oil pollution, noise pollution and thermal emission pollution. Using electricity instead of oil as the power is the embodiment of the green design in the power system of food machinery. It should accelerate the development to the vegetable oil, solar energy, natural gas and hydrogen energy so as to make them be applied in the food machinery (Fu, 2013).

**Optimal design:** Optimal design technology is the optimal design scheme that using the optimal numerical computation method and computer technique to get the engineering problems. First of all, it must describe the practical problems with mathematics, forming a set of mathematical model composed of mathematical expressions and then select the optimal numerical computation method and computer program, operate and solve on the computer, getting a set of optimal design parameters which are exactly the optimal solution of design. Adopting the optimal design technology to design food machinery, not only could reduce the weight of equipment, material consumption and manufacturing cost, but also could improve the quality of equipment and working performance, such as the connecting rod mechanism used in food machinery a lot (slider-crank mechanism and crank rocker mechanism, etc.). The traditional design method is to use graphical method or analytic method, of which the calculation precision and design efficiency are low. Although the classical differential or variation adopted to find the optimal solution could solve simple question, it is relatively difficult. To general problems of mechanical design, the classical differential method is powerless. In addition, the gear reducer is widely used in food production line and the distribution of its transmission ratio directly affects the size and weight of each part of the gear reducer and lubrication condition of gear. If gear uses oil lubrication, it is more reasonable to use the lightest weight of gear as the objective function in the

optimal design. To optimize the cutting tools of chopper of the block material and meat grinder, it should make the cutting tool parameters meet the requirements that it could clamp material that the power consumption of cutting should be small and that cutting torque should be uniform. As now the structure of food machinery is more and more complex, the mathematical model got according to actual problems is also more and more complex. The traditional optimization algorithm is difficult to solve them, so the modern optimization algorithm has been successfully applied in some mechanical optimization problems, such as genetic algorithm, neural network algorithm and others. Therefore, the optimization design could be applied in the mechanism design of food machinery, structure design of parts and the design of the system, etc. On the premise of meeting the functional requirements, it will make the technology economy of the designed food machinery better (Wei, 2005).

**Concurrent design:** Traditional food machinery design is a serial design process. Each downstream working stage could begin until the upstream stage finishes. In early stage of design, it could not fully understand the requirements of the subsequent process, as it lacks of regular information exchange between upstream and downstream design phase, designers, technicians in areas of food hygiene and food technology and users. If it has feedback, that is also after the event, which makes the development cycle of new product long, cost high and product quality hard to ensure. At present, the market competition heats; product batch is more and more small; variety is more and more; life cycles of product market are getting shorter and shorter, which forces enterprises to adopt more effective methods to shorten the design cycle, improve product quality, reduce product cost and improve the quality of after-sales service. Under this requirement, the concurrent design emerges as the times require. In the design phase, the concurrent design is a comprehensive consideration of the influence of the technology project, manufacturing, assembly, testing and maintenance in product life cycle and it parallels and integrates each link through the product database management system, shortening product development time, reducing product cost and improving the quality of product. This approach requires food machinery designers, food technology designers and inspection personnel to work together and at the very start of the design, from the concept formation to product scrap disposal, all the factors including components selection and the effect to the food quality, food technology, environmental impact, cost, schedule etc., should be put into consideration in the whole life cycle of products. Concurrent design is the important reflection on concurrent project in product design and development activities, based on the information integration realizing

functional integration of various activities in the process of product development and is on the basis of the advanced network technology, information technology and various design tools, realizing the synergy work of multi-expert system. With the development of concurrent engineering theory and network technology, concurrent design is bound to become one of the important methods of food machinery design (Wei, 2005).

## RESULTS AND DISCUSSION

At present, research on the food machinery design methods has great significance. The processing objects of food machinery are all kinds of agricultural and sideline products which are the main body of agricultural and sideline products in processing machinery, which has a close relation with agriculture. Therefore the development of food machinery is, in fact, the practical action of the central-government to address the issue of agriculture, is a significant step to realize agricultural modernization and industrialization with the support of industry. As a food machinery designer, we should constantly work on new design methods to make new food machinery products and make the products which are provided by us be the brand of innovation.

From an overall perspective, there're still many design problems in food machinery design nationwide. In the process of the development of food machinery industry, there're less products are self-innovative and more are imitative, it usually is only simple development and manufacture which is following the technique abroad and increase the gap with developed countries gradually. Lack of innovative spirit is the real reason (Jiang, 2014a). To solve those problems thoroughly, constantly research on innovative design methods is required. Vigorously develop new design methods, apply basic and soft-science research and overcome some significant scientific projects which are essential, strategic, comprehensive, motivating and derivative. Meanwhile, speed up and strengthen significant scientific and technological achievements and technology which have guidance effect to industrial technology such as the transformation and promotion of bio-technology, supercritical fluid extraction technology, the new sterilization technology, membrane separation technology, photoelectric liquid gas meter automation technology, to promote the healthy development of the food machinery industry in our country (Liu *et al.*, 2002).

## CONCLUSION

The above is the design methods of food machinery which is presented by the author, aiming at our country current development condition of food machinery, combining the industrial design principle and esthetics

rule which should be followed by the modeling design of food machinery. The author makes an exploration on the green design, optimal design, concurrent design and bionics design, hoping that the exploration would have a help towards accelerating the development of our food machinery product and hoping that the design of food machinery should cause an extensive value and a related development work also should be energetically carried out.

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