

## Research Article

### Application of New Technology in Design of Food Machinery

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**Abstract:** The purpose of this study is to explore the new technologies of food machinery design and apply them in food machinery design, thereby promoting the outer and inner quality of food machinery. It specifically researches the application of high technology and modern product design technology in design of food machinery. The article elaborates that the high technology includes the nanometer technology, virtual manufacturing technology and intelligent technology; the modern product design technology includes the optimal design and concurrent design. And then it is introduced that researching the application of new technology in design of food machinery has great significance, based on which the conclusion has been reached.

**Keywords:** Concurrent design, food machinery, intelligent technology, nanometer technology, optimal design

#### INTRODUCTION

Food machinery is the mechanical device and equipment what is used in the process of processing the raw materials of food into finished products. The species of food machinery are very complex, of which the classification, according to the difference of the sort and industry of food, could be divided into the grain and oil processing equipment, fresh-keeping and processing equipment of fruit and vegetable, livestock and poultry products processing equipment, aquatic products processing equipment, convenient food processing equipment, beverage processing equipment and comprehensive utilization equipment of waste in food processing, etc.; according to the difference of unit operation of food processing, could be divided into the food conveying machinery, food cleaning and sorting machinery, food crushing machinery, food separation machinery, food blending machinery, food concentrate machinery, food drying machinery, food sterilization machinery, food curing machinery, food freezing machinery and food packaging machinery, etc. In recent years, with the development of food processing industry, it has all differentiated into many new types of processing machinery in each branch. For example, in food separation machinery, it develops many new separation machineries such as supercritical extraction, nanofiltration, microwave-assisted extraction and ultrasound-assisted extraction; in food crushing machinery, it newly launches ultrafine crushing equipment such as airflow crushing, vibration crushing and ball milling crushing. At the same time, the cross of different industries produces some new industries again. For example, the vegetable protein drink in grain processing, fruit and vegetable juice drink in fruit and vegetable processing, liquid milk in livestock and

poultry processing and other industrial development, form the beverage processing industry of which technology is advanced and product is convenient and nutritious. It is clearly that the food machinery products have a wide range of diversity and complexity in structure (Wang, 2009).

Food machinery in our country has three stages of development. The first is the first 50 years of the 20<sup>th</sup> century when the food processing was completed mainly by manual operation and basically belonged to the traditional mode of production of workshop-style. There were only a small amount of mechanization production modes and they were all in the eastern coastal area. The application of small amount of equipments was also imported from other countries. The food processing at this stage was also mainly the industrial production of taking the flour production processing as the principal thing. Similarly, the equipments used by flour factory were also introduced from abroad (Jiang, 2015). It can be said that almost no food production factory had been decent for that first 50 years of the 20<sup>th</sup> century. The second is the 50~70s of the 20<sup>th</sup> century when the mechanization of food processing and food industry had got great development. The food processing factory especially this kind of food manufacturing and processing factory of grain and grain and oil was built throughout the country. Mechanization of the primary mode of production was basically realized in most of the grain processing factory. At the same time, the food processing factories were also in the state of half manual operation and half mechanization production mode. While machining was used only in some key processing program, the traditional manual operation mode was continued to use. In this stage, our country passed nearly 30 years to energetically develop the food

mechanization industry and the food machining of this period could already meet the development demand of food processing industry in our country basically, which also made a great contribution to the continual development of food processing industry. The domestic food machining in our country had preliminarily formed. Again, since the 1980s of the 20<sup>th</sup> century, namely after reform and openness, the food processing industry has also got rapid development, which also benefits from the implementation of the policy of reform and openness in China and the foreign capital has also been introduced along with reform and openness, appearing many food processing enterprises of foreign businessmen sole proprietorship and joint venture. These sole proprietorships and joint ventures run by foreign businessmen introduce a large number of advanced food processing technologies and advanced food machineries. As a result, China's various aspects of requirements for food processing have been greatly improved, such as quantity, variety and quality requirements, which greatly promote the development speed and course of food machinery industry in our country. At the same time, our country also keeps pace with the times to digest and absorb the advanced food machinery processing technologies introduced from abroad, which makes our country's machinery industrialization level of food processing get greatly promotion. Since the 1990s of the 20<sup>th</sup> century, a new round of technology reform project followed, realizing the upgrading of food processing and mechanical processing. Through the two-time technology reform, it can be said that the food mechanization basically realized the modernization of machinery. During this period independent food mechanization industry has formed (Zhang, 2013).

At present, our country's food industry has been the essential industry of the pillar of national economy at the present stage and food machinery fully arms the food industry. Since the 21<sup>st</sup> century, people's living standard has improved and the requirement for food quality also gradually improves, which also provides a broad development space for the industrialization industry of food machinery (Zhang, 2013).

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).

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	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

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 the new technologies of food machinery design and apply them in food machinery design, thereby promoting the outer and inner quality of food machinery, strengthening additional value and whole shape effect of product, satisfying the demand of market competition and creating higher economic efficiency.

## MATERIALS AND METHODS

**Application of high technology in design of food machinery:** With the development of society and the

progress of science and technology, high technology is widely used in design of food machinery. The application of high technology in design of food machinery plays an important role in enhancing production efficiency and economic benefit, reducing energy consumption and production cost, increasing yield and improving market competitiveness. At present, the high technology widely used in food machinery mainly includes the virtual manufacturing technology, intelligent technology and nanometer technology, etc., thus it constantly has new food machinery products that have high technical content and are more humanized put on the market. Compared with the traditional food processing technology, the high technology has greater economic benefits, social benefits, environmental benefits and other development advantages.

**Nanometer technology:** The emergence of nanometer technology provides a new platform for the development of food machinery design. People could design and manufacture a variety of food machineries according to their own needs.

**New nanometer modified rubber:** Rubber and plastic are the raw materials widely used in food machinery, but the usual rubber is by adding carbon black to improve its strength, abrasion resistance and aging resistance, so its product is black and is not suitable for use on food machinery. The advent of nanometer materials solves this problem. The various indexes of new nanometer modified rubber have all greatly improved. Especially the anti-aging performance is improved 3 times, service life for more than 30 years and the color is gorgeous and color preserving effect is excellent.

**Powerful magnetic refrigeration medium:** The general development trend of magnetic refrigeration is from low to high temperature, constituting magnetic nanocluster, using the refrigerating method of spin system magnetic entropy change and developing into magnetic refrigerator of taking Cd as magnetic refrigeration medium. Compared with the usual refrigerating method of compressed gas, it has high efficiency, low power dissipation, low noise, small volume, no pollution and other advantages, which opens a new route for the food freezing and cold storage equipment (Xiao, 2004).

**High quality surface coating:** Nanometer ceramics has good wear resistance, high strength and strong toughness, which could be used in manufacturing the sealing ring and bearings of food machinery, in order to improve the wear resistance and corrosion resistance. As a German research institute, it with nanometer silicon substrate ceramics developed the special

transparent coating of no pollution and wear-resistance, which has the functions of pollution prevention, dust prevention, scratch resistance, abrasion resistance and fire prevention and which could be used in surface coating of the components and parts on food machinery that directly contact with food (Xiao, 2004).

**Good absorbing ability:** Nanometer SiC and Si<sub>3</sub>N<sub>4</sub> have strong absorption for infrared in wider range of wavelengths, which could be used as infrared wave-absorbing and wave-transmitting materials. If made functional thin film and fiber, they could be used in the infrared drying and infrared sterilization equipments of food machinery (Xiao, 2004).

**Virtual manufacturing technology:** The virtual manufacturing technology is developed based on CAD/CAM/CAE technology. On the one hand, CAD/CAM/CAE technology provides relatively mature technologies including modeling technology, analysis and optimization technology, manufacturing process emulation technology, analysis and evaluation technology, design analysis and evaluation technology and product information integration, transformation and sharing technology for the realization of the virtual manufacturing technology. Especially the modeling technology plays an extremely important role in the virtual manufacturing technology. On the other hand, the virtual manufacturing technology is beyond CAD/CAM/CAE technology. While CAD/CAM/CAE technology mainly considers the product itself information integration and modeling, the virtual manufacturing technology also considers some problems of machining process such as modeling (Wang, 2009).

One important feature of virtual manufacturing technology is attaching importance to management by objectives in the process of design and manufacturing, to make every step established on the basis of practicality and feasibility and to prevent the randomness, blindness, assumption and the reluctance of dealing with difficult problem. Food machinery design is generally divided into four stages including feasibility study, step design, detail design and design improvements respectively and each stage can be divided into several steps again. According to above analysis, using the virtual manufacturing technology to research and develop the manufacturability, produce-ability and cooperation of some food machinery and adopting the computer simulation and virtual reality means, to work on the computer cooperatively by team and to achieve product design, technology planning, processing and manufacturing, performance analysis and quality inspection under the dynamic operating conditions and the essence process of product manufacturing such as the management and control at all levels of process in enterprise, have very important

significance for enhancing the decision-making and control capacity of manufacturing process at all levels, reducing the blindness of product development, shortening the development cycle, reducing the manufacturing cost, improving the adaptive capacity of machine, increasing the operational reliability of machine and prolonging the service life of machine (Wang, 2009).

The virtual manufacturing is a new manufacturing technology, which is based on the modeling technology, computer simulation technology and virtual reality technology.

**Modeling technology:** The virtual manufacturing system is the mapping of real manufacturing system under the virtual environment and is real manufacturing system's modeling, formalization and the abstract description and expression of computerization. The modeling of virtual manufacturing system includes the information system structure of production model, product model and process model.

**Computer simulation technology:** The computer simulation technology could automatically synthesize three-dimensional model by computer, namely could demonstrate actual situation, according to the need to modify in front of the user. Computer synthesis speed is fast and the modification work is rapid and convenient. If user's some requirements cannot reach, computer will give real-time feedback to designers, exempting later repeated modification. The simulation technology performed by computer can shorten the design period of production line of food machinery (Tian and Liu, 2008).

**Virtual reality technology:** The virtual reality technology a comprehensive technology is generated because of the combination of human imagination and electronics etc, which is in order to improve interactive mode between people and computers and enhance the operability of computer. It synthetically takes advantage of computer graphics system, interface equipment such as all kinds of display and control and multimedia computer simulation technology to generate



Fig. 1: Multipoint interactive virtual simulation screen initiated by the Chinese academy of sciences



Fig. 2: Immersing virtual reality

a kind of specific and interactive three-dimensional environment called virtual environment on the computer. The virtual reality system includes three basic elements of the operator, machine and man-machine interface. Users can naturally interact with this environment through all kinds of sensing system, making person produce the immersive feel of be personally on the scene, which not only improves the degree of harmony between human and computer, but also becomes a powerful simulation tool (Wang, 2009), as shown in Fig. 1 and 2.

**Intelligent technology:** Intelligent technology is the technology introduced lately and often used in the design of food machinery. This technology is mainly used to solve the complex system problem that is difficult to solve and control in traditional method. Generally the food processing system of intelligent control that takes the intelligent technology as core all possesses the ability of intelligent learning. It has to be said that intelligent technology is a big leap in food processing industry and also is one of high and new technologies in the industrial circle of the 21<sup>st</sup> century (Jiang *et al.*, 2013).

After years of operation and development, food machinery industry is making the transition from traditional simple model to automation model. The control element system of intelligent technology has been widely used in the control system of food machinery and the programmable controller, a variety of new-type sensors and microcomputer technology are applied to all parts of food machinery production process, especially in some large food processing production line. Intelligent electronic control element effectively links each one-piece of food machinery together, which not only improves the production efficiency sufficiently, but also gives further play to the potential of machine.

At the same time, the computer technology in the intelligent technology makes operation process of food machinery processing more simple and convenient. Adopting computer to control process and processing stage and equipped with all kinds of parameter metering devices, make the processing, measuring and testing to complete in one machine. For example, in order to control the batching accuracy, the food dust production system is generally equipped with the continuous measuring device such as the flow machine and speedometer connected with the computer and the

beginning and end of every working procedure are controlled by computer, strictly to control all kinds of batching concentration and flow, so the error precision can be controlled within thousandth of accuracy. Equipment operation is more convenient, labor-saving and more professional and continuous and the automatic degree is greatly improved. Using the intelligent technology to control food machinery makes food machinery detect and adjust automatically, which remarkably enhances the production efficiency of food machinery, improves the working conditions, enhances the product quality, reduces the processing cost and increases the product competitiveness (Xiao, 2004).

**Application of modern product design technology in design of food machinery:** Market competition is increasingly intense, of which the focus is focused on product quality, cost, reliability, energy consumption, etc. According to the reality of food machinery industry in China, the application of modern product design technology in food machinery design is the only way to survive and develop for enterprises.

**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, researching on the application of new technology in design of food machinery 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 explore the new technologies of food machinery design and apply them in food machinery design, to innovate food machinery products and to make the products provided by us be always the brand of innovation (Jiang, 2014).

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, 2014). To solve these problems thoroughly, it should constantly explore the new technologies of food machinery design and apply them in food machinery design. Vigorously develop new technologies, 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 development of society have a higher request to the food industry, which also promoted the new technologies related to food machinery to have further development and wide application, which makes food



machinery products embody the new characteristics including new technology practicability, manufacturing technology advancement, energy conservation, production line mechanization and automation, beautiful product appearance and excellent inner quality. At the same time, the new technologies adopted constantly make the product standardization, serialization, universalization improved gradually and make the food machinery production capacity constantly increase and the efficiency continually improve, which not only raises the labor productivity, but also improves the working conditions, reduces the cost and enhances the market competitiveness of food machinery products.

Under the unremitting research of researchers, the new technologies have had a revolutionary change in the food industry, which also provides a wider development space for the development of food machinery. And the role of new technology in food machinery design is also more important.

At present, the food industry has become an indispensable part in our country's economic development, which is leading the development of manufacturing industry and meanwhile also provides the stage for the development of relevant light industry and heavy industry.

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