Research on Adaptive Design of Agricultural Machinery Equipment Based on Resource Integration-Sprayer Case

Jiecheng Zhu, Huabin Wang
201730510504@mail.scut.edu.cn, hbwang@scut.edu.cn

School of Design South China University of Technology Guangzhou, China

Abstract—The problem studied in this paper is how to maximize the integration of resources, save costs, reduce the price of agricultural machinery, and reduce the burden of farmers to purchase machinery. Taking the design of Guanglian 3WZ650 agricultural sprayer as an example, the research and development cost of agricultural machinery equipment is reduced through the adaptive design based on resource integration. It is concluded that adaptive design based on resource integration can effectively reduce the production and development cost of agricultural machinery, save resources, help manufacturers reduce costs, and also help reduce farmers' purchase burden, effectively promote the mechanization of agricultural production, and improve agricultural production efficiency.

Keywords-Agricultural machinery; Design; Resource integration; Adaptive design

1 INTRODUCTION

In recent years, the annual central document of China is closely concerned with the development of agriculture, agricultural production has been taken seriously by the country. With the development of agricultural modernization in China, traditional artificial agricultural production mode has been gradually replaced by modern agricultural machinery assisted production, and the use of farm machinery has greatly improved production efficiency and labor cost. With the development of science and technology, computer technology [1], unmanned driving technology [2] and other advanced technologies have been applied to the design and production of agricultural machinery. At the same time, with the increasing awareness of environmental protection, people begin to pay attention to energy conservation, environmental protection and cost control in agricultural machinery production [3]. For example, the wireless communication module has been applied to emission detection of agricultural machinery [4]. Farmers naturally pay more attention to the cost of agricultural production because of the related interests. In addition to the cost of running and maintaining agricultural machinery in production, the price of purchasing agricultural machinery is also a cost factor that farmers are very concerned about. The price of agricultural machinery is related to the cost of producing them. It is necessary to reduce the cost of research and development of agricultural machinery manufacturers to produce agricultural machinery equipment. In the stage of agricultural machinery design, the rational

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integration of resources and the use of existing resources for adaptive design will be of great significance to the reduction of agricultural machinery production cost.

2 THE COST CONTROL

Cost control in the production cycle of agricultural machinery products includes [5] seven aspects: design and development, process flow, material procurement, manufacturing, quality control, inventory management, and information technology. The impact on cost and the means to control it are different for each segment. The costs here can be divided into R&D costs(research and development costs) and production costs according to the production cycle and the final impact of the costs on the product, as shown in Figure 1.

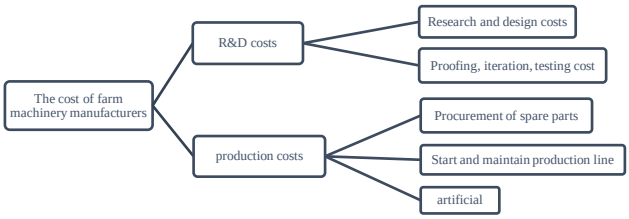


Figure 1. Classification of the costs of agricultural machinery manufacturers.

R&D cost refers to the cost spent by the manufacturer to test and perfect the product during the period from the beginning of R&D to production, which can include the cost of prototype production and testing during the iteration of the program. Although the results of the prototypes and tests may be different from or irrelevant to the final product, or even extremely different from the final product, it is the continuous experimentation and data collection at this stage that ensures that the final product design is relatively mature.

Production costs, on the other hand, are the costs of producing a product after it has been designed to the point where it can be put on the market for sale. It can be subdivided into fixed production costs required for each product, such as the purchase cost of components required for each product, which is required for each product produced; and costs with a certain service life after a one-time expenditure, such as the molds and processing machines required to open a production line, which have a certain number of uses after acquisition. Since this type of cost has a variable service life, its average service life can be obtained by means of research or manufacturers' warranties, etc., and then the ratio of the average consumption per product produced to its average life can be measured, thus quantifying such cost estimates into the former category.

Production costs may sometimes overlap with R&D costs. For example, the tooling used in formal production may be reserved from proofing during the R&D stage, so the cost of this tooling can be attributed to both R&D and production costs.

The design and development phase is the one that has the greatest impact on costs, both in terms of R&D costs and production costs. This is because the design of a product determines the processes needed to produce it and the materials to be purchased, and will continue to affect all

subsequent stages. Good design can avoid the need for higher-cost processes and technologies without affecting quality; while some companies do not pay attention to the design phase of cost control, and blindly compress costs in the process or material procurement part, resulting in a lower yield of the product, adding a serious burden to the aftermarket, but also affect the brand reputation, which is undoubtedly the bottom of the barrel.

3 RESOURCE INTEGRATION

Ye, Yiming [6] et al. modified the design of an old machining center machine tool based on its left parts, making full use of the components of the original machine tool, thus replacing the purchase of a new machine with more than 500,000 yuan that required waiting for a one-year supply period with a solution of about 200,000 yuan and two months of repair time cost, saving about 300,000 yuan for the enterprise. Their core idea is to maximize the use of existing resources through resource integration, thus avoiding the scrapping of old equipment. The author believes that the same idea can be applied in the design of agricultural machinery, so as to get a new design concept, that is, to carry out good cost control in the design and development stage, you can carry out resource integration in the design stage of the product, according to the existing resources for adaptive design. From the point of view of feasibility and cost, the maximum adaptable to the existing known conditions and availability of procurement components, making full use of the available resources, thus reducing unnecessary mold development and cumbersome new parts production procedures, to achieve the effect of saving resources and reducing costs.

Bocconcelli Roberta et al. analyzed the relationship between interaction and integration of digital resources in the online environment from a marketing perspective [7] and defined it. Although the integration of resources in a physical product like agricultural machines is different from digital resources, there are still some conclusions that can be applied to the integration of resources in agricultural machines. In this paper, the resources in the design of agricultural machinery are divided into existing resources and market resources, as shown in Figure 2.

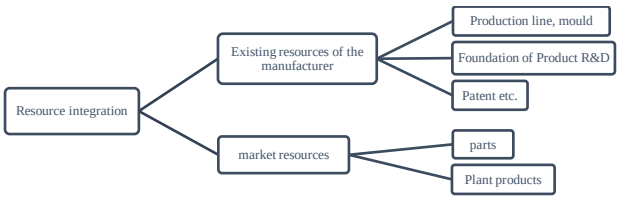


Figure 2. Classofication of resources

Existing resources include the existing production resources of agricultural machinery manufacturers, such as existing production lines and molds, patents, and the existing product development base. In order to maximize the use of these resources on the basis of ensuring the function of the product, retaining the original functional structure, and keeping the parts that do not need to be updated, can greatly reduce the cost of opening the mold of the product and the design and development cost of new parts, and also maximize the use of old molds to achieve the purpose of saving resources and reducing costs.

Market resources are parts that can be procured in the market. Although not all parts have a uniform standard, if the design of the parts without a uniform standard will play arbitrarily, it will inevitably greatly increase the cost of custom parts in the subsequent material procurement process. If the design stage can take into account this problem, select existing parts in the market that are similar to what the design needs first, and then deign on the basis of existing parts around its dimensional characteristics, then the cost of the part is certainly lower than the custom parts, but also, the existing parts will be more mature than the redesigned parts of the production process, even at the same cost of quality control will be better.

4 ADAPTIVE DESIGN

The adaptive design of the product is mostly adapted to the working environment [8] and working requirements [9] of the product, while the adaptive design based on resource integration is to adapt the design to the integrated resources in the design process, so that the resources can be maximized used in the design.

According to the different types of resources, the corresponding adaptation is also different. For existing resources, such as the original functional structure, while retaining and using the original structure, the shape design of the relevant parts can be optimized according to the original shape, or even retain the partial shape and use the original mold to reduce the cost of re-molding; as for market resources n, after selecting the parts to be used, we need to measure or contact the parts manufacturer to obtain the specific dimensional data and machining accuracy of the parts, and then take these parameters into consideration when designing and producing the drawings, so that the selected parts can maximumly fit in the assembly while ensuring the cost of the machining process.

Different degrees of adaptation will also affect the final adaptive design. There are degrees of adaptive design: just reserving a hole for a headlight and designing the opening to fit the headlight according to its shape are both adaptive designs. But the difference in design precision and processing difficulty between the two is great, and the refinement of the design and the overall fluidity of the product shape are also different. Therefore, although there are many manufacturers know how to reduce costs by integrating resources, but the level of their product modeling is uneven. Thus, achieving good design results also need to adapt to the depth of resources, rather than adapt only to the surface.

But sometimes, despite the deep adaptation design, the final product is still not as good as it should be. This is often due to the inconsistency between the local adaptation and the overall design styling. Getting a great adaptive design should't just focus on design adapting to the resources, but also need to adapt the resources to the design in the process of resource integration and selection, choose the parts resources that fit the overall design style, so that when the selected resources are adapted to the design, the harmony of the overall design style will not be affected by the adaptation of the local resources.

5 GUANGLIAN 3WZ650 AGRICULTURAL SPRAYER CASE

Figure 3. Guanglian 3WZ650 agricultural sprayer

As shown in Figure 3, Guanglian 3WZ650 agricultural sprayer is fully adaptive designed based on resource integration.

In terms of resource integration, for the market resources, Guanglian 3WZ650 agricultural sprayer uses the lamps and mirrors and other parts procured from the market; for the existing resources, the structure of the previous generation products, such as the chassis, machine position, operation area components and other structures and spaces are also retained in the adaptive design under the premise of ensuring the functions.

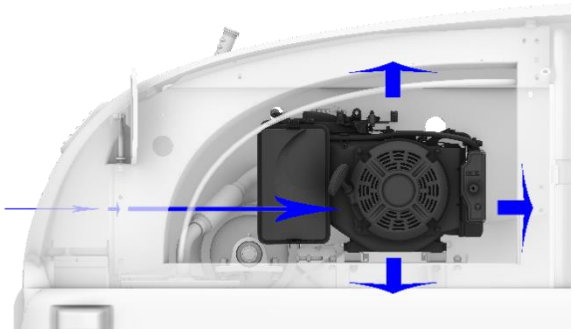
There are different adaptive designs for different resources: in the adaptive design for market resources, the layout of the parts such as lights are adjusted according to their shape and volume to ensure the feasibility and reasonableness of their positions in the assembly: the round headlight positions are rounded openings accordingly; the side lights, due to their large internal volume and considering the assembly needs, will top the chassis if they are positioned lower, leading to structural problems, so their positions are raised to avoid conflicts with the chassis, as shown in Figure 4.

Figure 4. The dotted line shows the chassis plane

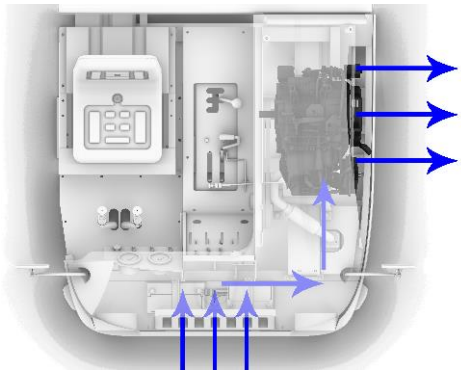
In the adaptive design for existing resources, trade-offs were made according to the parts layout of the previous generation of products: since the previous generation of products had a mature production line, the original structure and space layout of the chassis, machine position, and operation area components were selectively retained in the design under the premise of ensuring functionality, so that the new product could be produced in the old production line by handing over parts of the structure, which not only extended the life cycle of the original mold and

improved its utilization efficiency, but also reduced the production and testing costs of the new mold.

The design of the fuselage shape and structure also follows the coordination and adaptation of different factors: the color of the shell is matched with reference to the influence of color on the shape [10], because the red color will make the overall shape give people an upward, floating perception, so the overall shape is not designed entirely in red, but the lower edge is divided into another part near the chassis, using a subdued gray and black to balance the floating perception that is brought by the large area of red. The design of the fuselage contour takes into account the internal mechanical structure and design requirements [11], while referring to aerodynamics and using a streamlined appearance to reduce air resistance [12]. While ensuring aesthetic appearance, both fit and protect the internal components. For example, the ventilation holes in front of the front cowling, and the openings in the side body form air convection channels that just cover the engine inside the fuselage, as shown in Figure 5, thus achieving the function of effectively dissipating heat for the engine and avoiding overheating leading to fuselage failure.



(a)Schematic diagram of sideview structure



(b)Schematic diagram of topview structure

Figure 5. Schematic diagrams, Black for the engine, the arrows show the direction of air flow

In terms of the degree of adaptation, the product has also been designed for deep adaptation to ensure the overall design unity. For example, the headlight and sidelight, as shown in Figure 6, are integrated into the shape of the round headlight because it is embedded between the red and gray-black housing, because the lower gray-black housing plane is higher than the upper red housing plane, and the headlight surface is exactly between the two planes, so when dealing with the interface with the headlight surface, the lower housing around the headlight part added a half circle of concave gradient, and the upper housing around the headlight added a half circle of convex gradient. In the lower housing, the sidelight cutout is also dimpled and graded to fit the sidelight profile. The addition of these depth-adaptive details makes the overall body shape smooth and natural with a unified style.

Figure 6. (a)Headlight (b)Sidelight (c)Assembly details of lights

In the adaptive design of this product, not only the design to fit the resources is considered, but also the integration of resources is made to fit the overall design style. In the integration of resources, the existing parts are chosen to save cost, also the influence of the shape of the parts on the overall style of the product is considered, so as to ensure that the overall shape of the final product is harmonious and beautiful. Thus, the final product may have a simple, smooth and beautiful shape.

6 CONCLUSION

In the development and production process of agricultural machinery, adaptive design based on resource integration can effectively reduce its production and development costs, save resources, help manufacturers reduce costs, and also help reduce the burden of farmers to purchase machines, effectively promote the mechanization of agricultural production and improve agricultural production efficiency. At the same time, the depth of adaptive design can also effectively improve that the agricultural machinery only focus on the function, thoughtless of the modeling. to achieve a balance between functionality and aesthetics, in order to make China's agricultural machinery to reach the high-end level, into the forefront of the world.

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