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OPTIMIZED NEW PRODUCT DEVELOPMENT PROCESS

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Abstract

New product development is an important key to sustainable business management. Although mass production brings good quality and cheap products, the overproduction afterwards often becomes a difficult problem for enterprises to manage sustainably. Therefore, companies must be committed to developing new products in order to continue to create demand for sustainable business. As new product development becomes more and more important, related tools for product development are gradually being developed. However, most of these product development tools focus on how to improve product stability and reliability (axiomatic design, TRIZ, and Taguchi method) , manufacturing and comprehensive quality control (TQM and 6σ) , and comprehensive management thinking (DSS and PLM) . Although the above technology has made progress in concept and technology, it is still insufficient for the overall product development and integration work. This research focuses on the new product development process, discusses how product development responds to technical constraints and consumer market needs, and proposes optimal product design procedure. This new product development process covers design strategy analysis to mass production of products. This process integrates management methods and processes such as market design engineering, manufacturing, and marketing.

Keywords: New product development, new product development process, sustainable business

Introduction

New product development has always been an issue that must be faced in the sustainable operation of enterprises. With the development of technology,

product functions and content are becoming more and more complex and the product life cycle is becoming shorter and shorter, making new product design and development work more and more important. For new product developments in volume production scale, development costs include initial market development and design costs, as well as subsequent mold, tools, testing, production equipment inputs, and more (Ulrich and Eppinger 2016; Trott 2012) . Once the development fails, the inventory and related equipment generated may become idle and lost. Although the success rate of new product development is low, the company is mostly conservative and cautious about new product development, but companies still need to continue to develop new products to maintain survival and profitability. For companies, there are major incentives for new product development including (Assink 2006; Li et al. 2007; Cooper et al. 2005; Saravia et al. 2008) :

1. Although the success rate is very low, the reward for success is very impressive: 60% of new product development plans were discontinued before listing, and 40% of successful listings were unable to profit from exiting the market. Although the success of new product development is difficult, once the new product development is successful, the profit is usually several times or even more than 100 times. Therefore, new product development has become the key to enterprises' competition, survival and creative advantage.
2. Design strategy is critical to quality and cost: Usually the cost of the product design phase is about 5%, but 80% of the product costs are established in the design phase.
3. Only innovation can survive: Products have their life cycle and must be developed continuously, otherwise they will be eliminated by the market.

The development of related technologies and tools for product development is becoming more and more mature. There include: single purpose design (reverse engineering, concurrent engineering, DFA, DFM, DFC, DFT and QFD) ; stable design (axiomatic design Taguchi method and TRIZ) ; comprehensive thinking design (DFSS, PLM, design thinking and lean thinking) ; Manufacturing and quality stability design (TQM and 6σ) (Krajewski et al. 2015; Heizer et al. 2017; Stevenson 2018; Fitzsimmons et al. 2019) . However, for the complete process of new product development, including: preliminary specification design, verify whether the cost performance has market competitiveness, confirm the feasibility of development, complete the prototype test, and complete the mass production marketing plan. These still need to be strengthened.

Features that new products require include: achievability (appropriate quality and price) ; meet the needs of consumers; both competitive and customized. For the research of new product development process management and the application of current practice, the development tools are similar, but the tools still have their emphasis. The R&D tools are mainly for the stable implementation of all stages of R&D work: engineering, testing, trial production, mass production, marketing, after-sales service and environmental recycling. The common limitation of each tool lies in the fact that most of the components that rely on the design of subjective

judgments from the design concept to the concrete presentation of the prototype are mostly.

This study explores products with different drive characteristics (market-driven, technology-driven) from the perspective of product development processes. Discussion and analysis in the process of product development: how to respond to technical constraints and diversified needs of consumers; review the lack of current R&D tools; myths and engineers' myths about product design. Based on the results of the analysis, this study will propose: product development strategies that can be adopted, application techniques and tools, tasks and practices at each stage of the development process, and build an optimal new product with marketability and feasibility development process to make product development work more efficient and efficient.

The new product development tools

In different technologies and competitive environments, companies have different considerations for developing new products, and thus develop various analytical tools. Table 1 shows the core technologies and practices for different product development tools and the limitations of this tool.

Table 1. Conceptual Guidance Tool

tool	core strategy	tool limitations	purpose description	reference
reverse engineering	imitate, speed	the latter part of the project to the completion of R&D	imitation fast listing	Roxana et al. (2013)
concurrent engineering	speed, cost	design, engineering to the completion of R&D	quick listing	Loch and Terwiesch (2000)
axiomatic design	customer, function, prototype, process	independent axiomatic and information axiomatic. a generalized rational design is available but the operation is still slightly rough.	beyond the limitations of experience and tools	Arcidiacono et al. (2017)
QFD	customization, cost	subtractive thinking, unable to handle the needs that customers cannot express	customized design strategy: optimization of technology and customer needs	Akao and Mazur (2003)
TRIZ	design parameter, prototype	engineering parameter selection, complete prototype	provide principles and design guidance for structural and detailing	Belski and Belski (2015)
DFSS	integrate QFD and competitive thinking	comparing the relative factors of competitors	customized design with competitive thinking	Pande et al. (2000)
PLM	manage thinking after product design	lack of design strategy thinking in the previous paragraph, focusing on the retrospective design of the latter paragraph.	quality assurance and control in the latter stage	Corallo et al. (2013)
6σ	ensure quality management thinking	control defective products at 3. 4ppm level	measurement guarantee quality	Pande et al. (2000)
TQM	comprehensive quality assurance management thinking	concept and practice from top to bottom	total quality	Anvari et al. (2012)
collaborative design	the overall benefits are optimized	design front to quality management of mass production	reduce wear and stability	Kamrani (2008)
lean thinking	reduce waste (quality, flexibility, customization)	design front to quality management of mass production	reduce waste, stabilize quality and comprehensive effects	Womack and Jones (2003)

design thinking	customization and optimization are the guiding objectives; the latter paragraph is based on this concept to modify the design, manufacturing, and service processes.	prospective customization, design, engineering to mass production and service	prospect customization priority and prototype realization thinking。	Brown (2010)
reliability engineering	quality, cost	quality from the later stage of the project to the completion of research and development	stable quality	Zio (2009)
DFM DFT DFC DFQ	quality, cost	design, engineering, quantity management	technical implementation	Bargelis (2007)
DFA DfDA	quality, cost, speed	design, engineering, quantity management	technical implementation	Bargelis (2007)

The new product development tools listed above have their own uses and solve the problems encountered in different new product development types. However, summarizing the current new product development management processes and tools, this study still find some limitations, as described below.

1. Management limitations: based on the principle of stability, lack of innovation and customization, usually suitable for the extension of existing products.
2. Marketing limitations: The separation and positioning of products are often abstract and difficult to present. The effect of product differentiation is more difficult to predict.
3. Design limitations: Detail design and customer strategy parameters are primarily dependent on the subjective experience of the design engineer. Relevant research and development tools such as axiomatic design, TRIZ or design thinking can only be used as an aid or reference.

For the optimization of new product development, the optimal design mainly emphasizes the combination of resources that meet the needs of consumers and the competitive market. That is, consumers will choose products with relatively high CP values. Therefore, product design must focus on:

1. For products with a small number of innovative competitors and alternative technical conditions, the CP value comes from the customer's perception of the value of the product, the importance of solving the problem, and the cost that must be paid.
2. For products with technological choices, due to limited technical capabilities, innovation competition comes from design strategies. CP values emphasize customer comparisons and individual needs for products and design costs (prices paid by customers and learning costs) .
3. Products that are highly competitive and mature in the market mainly emphasize comparative interests, so reducing costs, improving quality, and service are key.

The CP value is usually increased by lowering the price and improving the quality and service. In general, in the process of product design, the way to adjust the CP value can be divided

into the following six categories: 1. cost (price) 2. popular (appearance) 3. brand (advertising) 4. quality (process) 5. function (design) 6. service (aging) . The method of adjusting the CP value includes: (1) improving performance, the price is constant or the difference is not large; (2) the price is lowered, the performance is unchanged or the difference is not large; (3) the performance is improved by the inductive factor, and the perceived CP value is improved. (4) reduce learning costs and increase the perceived CP value.

Optimize New Product Development Processes

This research focuses on the new product development process, starting with product positioning, through specification design, quality design, and marketing strategy. The new product development process is divided into four major stages (optimal specification, optimal prototype, optimal production, and optimal marketing) and seven major procedures (product position, specification design, configuration design, engineering technology, reliability, production quality, and marketing strategy) . In the optimal specification phase, the main tasks include feasibility analysis, product positioning, and product specification design. In the optimal prototype stage, the main work includes detailed design of the product, engineering design of the mold and fixture, and product testing. In the optimal production stage, the main work includes product mass production design and process quality control. In the optimal marketing phase, the main tasks include marketing strategy setting and market competition response. Figure 1 illustrates the optimization of the new product development process. Table 2 describes the contents of the stage of product development process.

Systematic Thinking And Tools For New Product Development

The factors to be considered in the development of new products are very complicated. In addition to the factors of the enterprise itself, it is also necessary to consider the competition and opportunity factors of the market. This research focuses on the control of key stages and processes in new product development, and integrates new product development trends to develop specific and feasible development processes. The common types of new product development can be divided into two categories: market-driven spindle and technology-driven spindle. The following are the product development strategies and tools used in each stage of product development for these two types.

Market-driven development of new products

New product development based on market-driven, can be divided into four stages, usually products starting from original technology. At this time, when thinking about product sales practices, the products that are launched usually have a shortage of supply (A. Production orientation) . This phenomenon of short supply will attract investment in mass production and cause oversupply such as competition or market saturation. Enterprises must rely on sales to clear inventory to maintain economic production scale (B. Sales orientation) . After oversupply, companies often need to avoid vicious price cuts through market segmenta-

tion, customization, differentiation and innovation (C. Marketing Orientation) . When products enter a mature and saturated stage, companies must innovate marketing techniques to attract customers to re-consume (D. Innovative orientation) . Table 3 shows the strategies and tools that are appropriate for new product development in each stage.

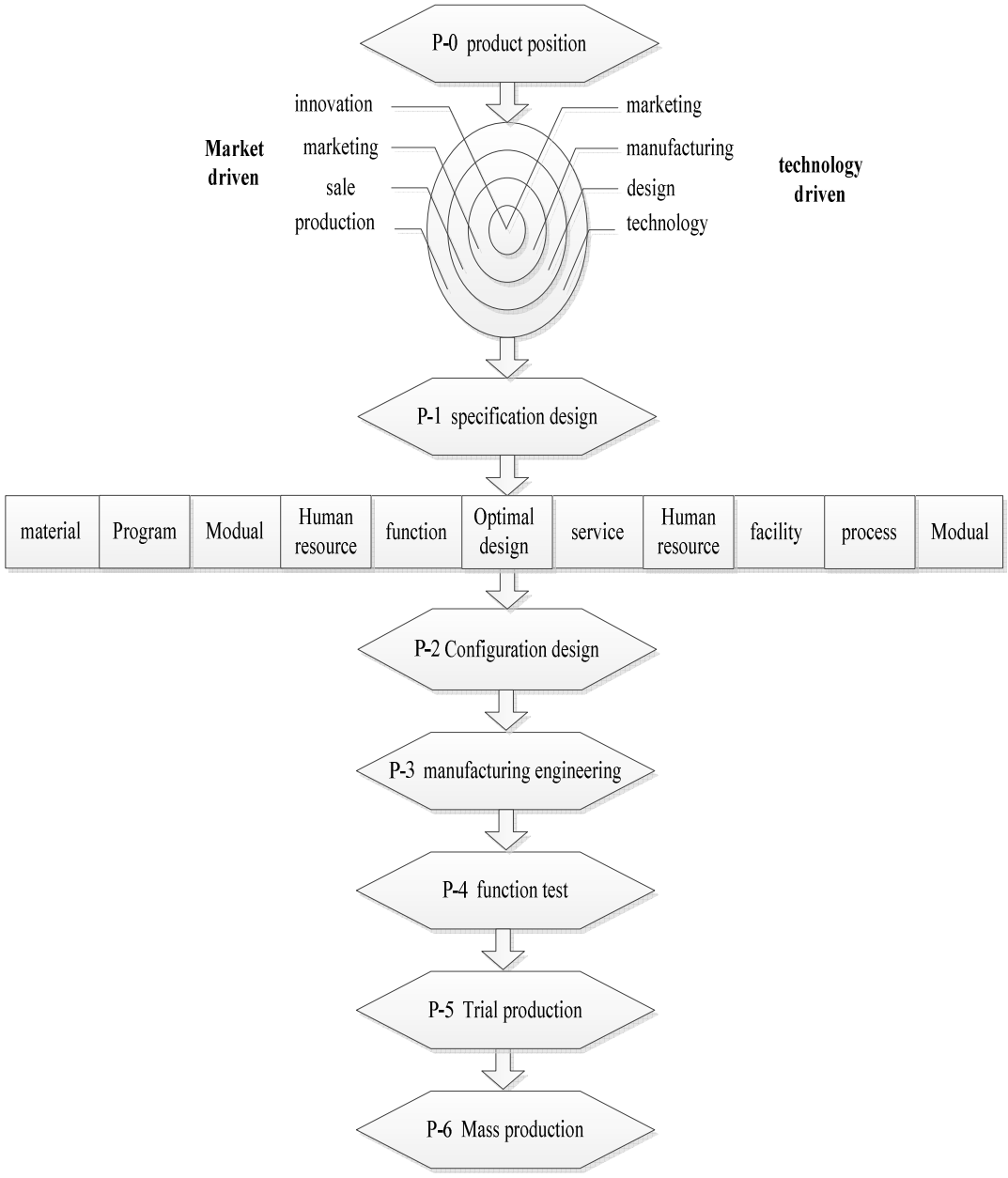

Figure 1. The Optimization Of The New Product Development Process

Table 2. Stage Of Product Development Process

stages	procedure	work stage	work mission	work content	output
optimal specification	p-0	product position	target product positioning; feasibility analysis of technology, price and market	1. analysis of enterprise market strategy 2. confirm the feasible preliminary specifications	1. feasibility analysis 2. preliminary specifications 3. prototype-0
	p-1	specification design	product design strategy	1. design parameter simulation 2. confirm the optimal design strategy	1. design parameter trade-off calculation 2. market competition analysis (CP value) 3. prototype-1
optimal prototype	p-2	configuration design	product detailing	1. parameter expansion 2. design and build samples	1. complete the detailed design 2. sample confirmation. 3. prototype- 2
	p-3	engineering technology	engineering design; tool design; component optimization	1. design of mold and fixture 2. making a preliminary prototype	1. tool completion confirmation 2. prototype-3 (operable prototype) .
	p-4	reliability	product function testing and improvement	1. functional and reliability testing 2. component specification correction confirmation.	1. reliability analysis. 2. prototype-4 (functional prototype)
optimal production	p-5	production quality	mass production test; stable production quality	1. mass production technology development and confirmation. 2. raw material data filing. 3. manufacturing engineering data documentation.	1. BOM, SOP, SIP, and DCN 2. technical confirmation of process and tools 3. process and equipment validation 4. prototype-5 (mass production confirmation)
optimal marketing	p-6	marketing strategy	mass production market competition and response strategy	1. data file confirmation 2. complete personnel, equipment and materials	1. ECN and MRP confirmation 2. matching product and marketing strategy 3. prototype-6 (p-5 and marketing combination)

Table 3. Market-Driven New Product Development Stages, Strategies And Tools

stage	production orientation	sales orientation	marketing orientation	innovative orientation
strategy	predominance technology intensive patent	speed imitation time base competition low price	modularization customization differentiation niche market	sensible marketing instant advertising brand endorsement
tool	technology hiding DFT DFC technical stock leading strategy DFM DFA	reverse engineering pricing strategy promotional techniques DFC zero inventory	QFD DFC modularization customization differentiation	event marketing cross-industry alliance polygonization

However, market-driven new products do not fully follow the evolution of the above stages. In addition to the complete four stages of product development, new products can be developed at each stage, such as modifying the appearance, institutional composition, changing the process to reduce costs or improving quality, and also targeting products to focus on marketing and services. Figure 2 illustrates the process and specific practices of A. Production Orientation, B. Sales Orientation, C. Marketing Orientation, and D. Innovation Orientation as New Product Development Drivers.

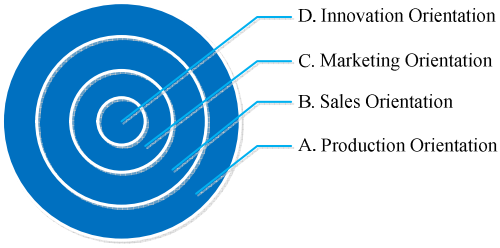

Figure 2. Market-Driven Four Stages Of New Product Development

1. Production orientation is the beginning: new products developed by new technologies

The new product starting from the production-oriented stage will go through the complete new product development process at all stages of P0 to P6 in Figure 1. The development of new products captures the benefits of each phase through the four-stage process of ABCD. However, the corresponding strategies of different stages must also be adjusted during the development process. This new product development type will allow a complete view of the design and production process. Such a company with a complete process of developing new products usually has a large scale and has good research and development capabilities. The competitive environment faced by new products will dominate from the monopoly to the oligopolistic and finally close to perfect competition. The development process of new products often goes from patents or technology-exclusive products, experience of technology imitation, patent expiration and other factors, and gradually moves toward marketing as a means of competition. As new products mature and become more popular, the market will gradually become saturated. Enterprises will be able to obtain complete market benefits through design innovation, process innovation, and marketing innovation.

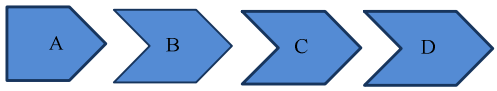

Figure 3. Stages Of Production Orientation NPD

2. Sales orientation is the beginning: a competitive new product that stabilizes the market

Sales-oriented product development will go through the two processes of manufacturing and marketing of P5 and P6 in Figure 1, and obtain the benefits of each stage through the three stages of BCD. In each stage, product development is mainly based on imitation, but it is still necessary to adjust the strategy to balance production scale, expand sales or clear inventory. When product technology matures and is accepted by the market, it will attract more followers to compete. Then there will be competition for product price reduction. At this time, product positioning and segmentation should be carried out, emphasizing dif-

ferentiated marketing, or emphasizing emotional appeals such as brand and appearance, and carrying out creative marketing.

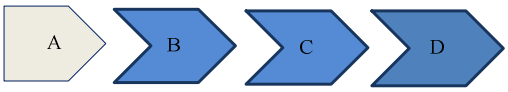

Figure 4. Stages Of Sales Orientation NPD

3. Marketing orientation is the beginning: growth and repositioning to design new products

Marketing-oriented new product development will go through the complete product development process at all stages of P0 to P6 in Figure 1, and gain the benefits of each stage through the CD process. In each stage, the product technology is mature, and the differences between individual products are not large, and the development is usually carried out in a way that imitates the product. When the products are accepted by the market, they will attract followers to compete. In order to avoid price competition, product development will emphasize market segmentation and customer design. When the products are accepted by the market, they will attract followers to compete. In order to avoid price competition, product development will emphasize market segmentation, customer design, product differentiation and the search for niche markets.

Figure 5. Stages Of Marketing Orientation NPD

4. Innovation orientation is the beginning: product innovation marketing strategy in mature saturated market.

Innovation-oriented new product development will go through the two processes of manufacturing and marketing of P5 and P6 in Figure 1, and gain the benefits through the D process. At this point the product has become saturated and the product must be innovative to attract new consumption. This innovative marketing emphasizes branding, advertising, integration channels or promotions to expand the market and create new demand.

Figure 6. Stages Of Innovation Orientation NPD

Technology-driven development of new products

Technology-driven new product development process emphasizes achievable engineering thinking design and mass production oriented prototype design. For the prototype guidance that emphasizes practice as the spindle, it should be driven by technology as the main axis, which is more suitable for the actual execution of the new product development process. The preemptive and competitive advantages that new products may have can be divided into four states, A: technological innovation, B: design fits, C: process optimization, and D: marketing creativity. As shown in Figure 7, ABCD can present new product developments either continuously or independently and continuously or cyclically. Table 4 shows the strategies and tools that apply to technology-driven new product development at all stages.

Table 4. Strategies And Tools For Technology-Driven New Product Development

stage	Technological innovation	Design fit	Process optimization	Marketing creativity
strategy	Technological revolution Prospective study Dominant key	Optimum design Material agency Manufacturing Engineering	Quality strategy Cost strategy Process Optimization	Deepening service customized Innovative value package Sensible marketing Exterior
tool	brainstorming research and Development	TRIZ QFD Module design DFM DFC DFA	Reliability engineering DFC DFA DFM	Promotion strategy Event marketing Foreign business alliance

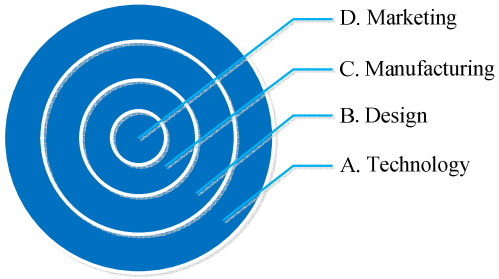

Figure 7. Technology-Driven Four Stages Of New Product Development

1. Starting with technological innovation: complete new product development process

The new products of technological innovation will go through the complete new product development process in all stages of P0 to P6 in Figure 1, that is, through the four stages of ABCD process to obtain the benefits of each stage. Products will be monopolized to oligopolistic, and finally close to a fully competitive state. During the development of ABCD, products that are monopolized by patents or technologies will experience factors such as technology imitation and patent expiration, and gradually move toward marketing as the main competitive means. In the development process, companies also need to adjust strategies at different stages. Such companies with R&D capabilities to fully develop new products usually have a large scale. As new products mature and become popular, or because market competition will cause product market saturation. Enterprises can obtain appropriate benefits through B: design fits, C: process optimization, and D: marketing creativity.

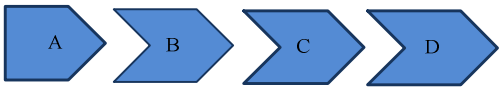

Figure 8 Stages Of Technological Innovation NPD

2. Starting with design fits: the product market is relatively mature and will compete with design differentiation

The development of new products based on design adaptation will go through the development process of each stage of P1 to P6 in Figure 1. The products mainly obtain the benefits of each stage through the process of running through the main BC and part of the AD. Products must adjust different strategies at different stages. The front section is based on technical originality and design ingenuity, while the latter section is based on process optimization and marketing. Overall, design, production and sales still need to retain its flexibility. When the product technology is mature and accepted by the market, it will at-

tract followers to join the competition. Products will face competition from price cuts, similar technologies and similar products. At this point, the product can usually be adjusted through positioning, differentiated design and marketing methods.

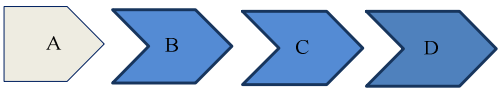

Figure 9. Stages Of Design Fits NPD

3. Starting with process optimization: stable supply of mature products and process optimization

Process optimization new product development emphasizes process optimization as the core competition and will experience the various stages of P3 to P6 in Figure 1. Through the CD two processes, the company's acquisition phase benefits mainly through cost reduction, quality improvement and stable production supply. But companies must also build better competitive conditions to assist in product promotion during the marketing phase. When the products are accepted by the market, the product strategies that the company can adopt include: reducing costs, improving quality, establishing preemptive advantages, and establishing barriers to entry for anti-blocking followers.

Figure 10. Stages Of Process Optimization NPD

4. Starting with marketing creativity: product innovation marketing strategy in mature saturated markets

Marketing creativity new product development will go through the new product development process from P5 to P6 in Figure 1. In general, the product will only go through a process of D, and the benefits of each stage are saturated and mature. Although innovative marketing can be extended to the market, products must also adjust the possible opportunities at each stage to create new demand. After the product is positioned, it should be differentiated into marketing, and then assist the emotional appeal of brand and appearance to carry out creative marketing.

Figure 11. Stages Of Marketing Creativity NPD

Conclusion

Product development has always been an important issue for enterprise survival and competition. Although many systematic and effective technologies and tools have been developed, the chances of successful new product development are still low. Based on the process concept of new product development, this study explores the relevant characteristics, problems and countermeasures of new product development.

This research is aimed at the optimization of the new product development process. There includes four major stages: optimal specification, optimal prototype, optimal production, and optimal marketing, and seven major procedures: product position, specification design, configuration design, engineering technology, reliability, production quality, and marketing strategy. In addi-

tion, this research also divides the main axis of product development into two major categories: market-driven spindle and technology-driven spindle.

The results of the research found that under the design of new technologies, the success factors of product development are usually based on design strategies and marketing methods. For manufacturing, it is regarded as a tool parameter, and the product supply is often completed in the form of an OEM. If the product emphasizes market-driven, the brand shaped by quality and technical stability becomes a source of competitive advantage. After the product market matures, the factors for successful product development are complex and diverse. In addition to considering competition and innovation, companies must adapt resource allocation to meet market and customer needs while maintaining flexibility and strategic resilience to enhance product competitiveness.

Since most products have their life cycle, from initial policy, positioning, to the development phase of design and engineering. Since most products have their life cycle, from the initial policy, positioning, to the development stage of design and engineering, product development needs to consider the mass production and the feasibility of engineering technology. Since most products have their life cycle, from initial policy and positioning to design and engineering development, product development needs to consider mass production and engineering feasibility, and how products respond to technical constraints and consumers demand. In the process of competition and development, products must seek new changes, and more need to carefully evaluate product design strategies. From assessing competition, technology and resources, in response to market changes, companies can adapt to market competition and pursue maximum profits.

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