

Analysis of the Production Planning Process for Midea Air Conditioning Products Based on Flexible Manufacturing

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ABSTRACT

As intelligent manufacturing and flexible production become increasingly important in the manufacturing industry, the design of scientific, efficient and flexible production plans has become essential for improving operational efficiency and customer responsiveness. Taking Midea's air conditioning products as the research object, this paper examines the formulation process, hierarchical structure, supporting information systems and adjustment mechanisms of production planning. Based on flexible manufacturing theory, it analyzes planning strategies for a product system characterized by multiple varieties, multiple models and seasonal demand fluctuations. The analysis shows that Midea's production planning process has formed a relatively complete closed loop composed of demand forecasting, master production scheduling, medium and short term scheduling, execution monitoring and feedback adjustment. Information systems such as ERP, MES and APS provide an important technical basis for flexible planning. However, problems remain in demand forecasting accuracy, cross departmental coordination, supplier response and the timeliness of plan adjustment. This paper proposes optimization measures involving intelligent forecasting, system integration, supplier collaboration and rapid on-site response. The findings provide practical implications for production planning in large scale home appliance manufacturing enterprises.

KEYWORDS

Midea air conditioners; Flexible manufacturing; Production planning process; Master production schedule; Digital manufacturing

1. INTRODUCTION

1.1. Research Background

Global manufacturing is entering a new stage of intelligent and digital transformation. Under this trend, production scheduling is no longer a simple operational arrangement, but a key mechanism through which enterprises coordinate demand, capacity, inventory and delivery commitments. For manufacturers with diversified products and fluctuating market demand, the capability to build efficient, accurate and resilient production plans directly affects operational performance and market competitiveness [1].

The home appliance industry faces intensified demand volatility, more segmented consumption scenarios and shorter delivery expectations. In the context of green consumption and market upgrading, customers increasingly require products that are adapted to specific usage scenarios, while enterprises need to maintain cost control and delivery stability [2]. Flexible manufacturing therefore becomes an important approach for coping with small batches, multiple varieties and short lead times.

Midea Group provides a typical case. Its air conditioning business deals with strong seasonal fluctuations, numerous product models and high delivery requirements. How to use scientific production planning to realize flexible scheduling, on-time delivery and efficiency improvement is therefore a question with both theoretical and practical value [3].

1.2. Research Significance

This paper focuses on the production planning process of Midea's air conditioning business. By combining the theory of flexible manufacturing with the practice of production planning management, it analyzes the planning hierarchy, process mechanism, information support and dynamic adjustment logic of the enterprise. The theoretical value of this study lies in linking flexible manufacturing theory with an enterprise level planning process in the Chinese manufacturing context. The practical value lies in identifying the strengths and bottlenecks of planning formulation, execution and feedback, thereby providing references for other large scale manufacturers with diversified product structures.

2. THEORETICAL BASIS AND LITERATURE REVIEW

2.1. Flexible Manufacturing Theory

Flexible manufacturing refers to the ability of an enterprise to adjust production capacity, switch product models and reconfigure resources rapidly when market demand changes. The current manufacturing environment is increasingly characterized by small batches, multiple varieties and short delivery cycles. As a result, the key objective of flexible manufacturing is not only to maintain production efficiency, but also to improve responsiveness and adaptability [4]. In this context, the production plan is no longer only a static scheduling tool. It becomes a dynamic coordination mechanism that connects market demand with manufacturing resources.

For home appliance manufacturers, flexible manufacturing requires the coordination of product modularity, capacity allocation, material supply, equipment status and delivery commitments. Studies on performance evaluation in white-goods manufacturing indicate that digital capability and operational coordination are important conditions for sustaining enterprise performance [5]. Data-driven cyber-physical production approaches further show that real time data and cloud-based collaboration can support personalized and flexible product development, which provides a conceptual basis for flexible planning in complex manufacturing systems [6].

2.2. Production Planning Management

Production planning is the process of arranging production schedules and allocating resources according to market demand, available capacity and inventory status. Its core goal is to ensure timely delivery while improving resource utilization and reducing operating costs. A complete production planning system usually includes several levels. The master production schedule converts sales forecasts and orders into medium- and long term production targets. Material requirements planning decomposes the master schedule into requirements for components and raw materials. Capacity requirements planning checks whether capacity is sufficient under the planned load. Detailed scheduling then arranges production tasks at the level of days, shifts or workstations.

In a flexible manufacturing environment, the traditional hierarchical planning structure faces higher dynamism and stronger requirements for feedback speed. Thus, enterprises need to rely on digital systems to build a closed-loop management process covering plan formulation, execution monitoring, deviation warning and feedback adjustment. Advanced planning and scheduling, manufacturing execution systems and enterprise resource planning systems become key infrastructures for translating flexible manufacturing principles into operational decisions.

2.3. Research Progress

International research on flexible manufacturing and digital production planning has gradually shifted from static optimization to dynamic coordination between planning and execution. Earlier studies on digital generativity emphasized that digital infrastructures can support open-ended recombination and enable organizations to continuously reconstruct operational processes [7]. Research on experiential computing also suggests that digital technologies are increasingly embedded in everyday production and consumption environments, changing how firms collect information, coordinate resources and respond to users [8].

Recent research has further examined customization, co-creation and innovation performance. User engagement strategies and customization capabilities are regarded as important factors for product innovation success [9]. Studies of innovation accumulation indicate that current innovations can provide foundations for future innovations, which is consistent with the iterative logic of flexible production systems [10]. At the same time, research on generativity proposes that digital systems can expand the range of possible combinations and enhance organizational adaptability [11]. Consumer research on product creativity and product appeal also implies that product design and production processes need to support differentiated market responses [12].

Chinese research has developed alongside industrial digitalization. It mainly focuses on digital innovation management [13], organizational transformation under Internet of Things environments [14], the reshaping of enterprise boundaries by smart connected products [15], and case-based analyses of technology evolution and innovation diffusion in domestic firms [16]. Studies on consumer data participation highlight that enterprises can use user data to support research and development as well as product iteration [17]. Overall, existing studies provide important theoretical support for analyzing Midea's production planning process from the perspectives of flexible manufacturing, digital systems and process coordination.

3. OVERVIEW OF MIDEA AIR-CONDITIONING BUSINESS

3.1. Enterprise and Product Overview

Midea Group, founded in Foshan, Guangdong Province, is a representative technology-oriented home appliance manufacturer in China. Its air conditioning business includes household air conditioners, central air conditioners, heat pumps and multi-split systems. In recent years, the domestic home appliance market has faced growth pressure, while the air conditioning market has remained highly competitive because of weather changes, consumption upgrading and product innovation. Industry reports indicate that competition in the air conditioning sector has become particularly intense [18].

As one of Midea's core businesses, the air conditioning division has a broad product portfolio and a large production system. Household air conditioners emphasize the integration of functions with usage scenarios. Through modular structural design, products can be combined according to different user needs and specific environments. For humid, high-altitude and other special environments, more adaptive products have also been developed. These characteristics require the production planning system to support diversified models, flexible capacity allocation and rapid response to market changes.

3.2. Manufacturing System and Information Support

Midea's air conditioning division can be understood as a production network characterized by headquarters coordination and multi base collaboration. Different production bases undertake different tasks such as new product trial production, mass production, regional market supply and supplementary capacity during seasonal demand peaks. By connecting factories through unified

information systems, the enterprise can form a flexible manufacturing network. ERP, MES, APS and supply chain management platforms support digital scheduling, automatic monitoring and cross-plant coordination.

In product development and mass production, Midea also emphasizes modular design, supplier collaboration and continuous product iteration. Suppliers may participate in the development of customized molds and components. After product launch, user feedback and operating data can be accumulated for the design of the next generation of products. The logic of recombination in digital innovation suggests that such modular and data enabled practices can improve the flexibility of value creation and operational adjustment [19].

4. ANALYSIS OF THE PRODUCTION PLANNING PROCESS

4.1. Hierarchical Structure of Production Planning

The production planning system of Midea's air conditioning business can be summarized as a four-level structure. First, the strategic level determines annual or quarterly production targets and capacity directions. Second, the master production schedule integrates sales orders and demand forecasts, and allocates medium-term output targets by product model and month. Third, monthly plans are decomposed into weekly plans that specify production lines, materials and labor arrangements. Fourth, daily and shift-level schedules are adjusted according to temporary orders, equipment status and material availability.

This hierarchical structure helps maintain the stability of the overall plan while reserving sufficient flexibility for short term changes. The master production schedule provides the benchmark for capacity and material preparation, while the weekly and daily plans provide the operational basis for shop floor execution. Such a structure is consistent with the logic of flexible manufacturing because it combines top-down target control with bottom-up feedback correction.

4.2. Formulation Process of Production Plans

The formulation of the production plan begins with the collection of sales forecasts. The planning department analyzes historical sales, market research, promotional arrangements and customer orders to estimate future demand. The forecast is then compared with actual orders, and deviations are corrected to improve the rationality of the demand data. After demand is confirmed, the master production schedule is generated. It defines how many units of each product model should be produced and when they should be produced.

The master schedule is then decomposed into weekly and daily schedules. The scheduling system considers actual capacity, line availability, material supply and labor arrangements to determine specific production sequences. Before release, the draft plan is reviewed by production, procurement, logistics and quality departments. Once approved, the plan is implemented on the shop floor. During execution, MES tracks production progress in real time. If deviations occur, the information is fed back to the planning department, and the plan can be adjusted through rolling updates.

4.3. Cross-Departmental Coordination and Information Systems

Effective implementation of the production plan depends on systematic cross departmental coordination. The sales department provides demand forecasts based on market research and customer orders. The planning department integrates internal and external information and designs the master schedule. The procurement department secures raw materials and components according to the schedule. The production department executes the plan and feeds back output and quality data.

The quality department monitors potential defects, while the logistics department coordinates finished-goods delivery.

Information systems are essential for linking these departments. ERP supports order, inventory and financial data. MES captures shop floor execution data. APS supports scheduling optimization under capacity and material constraints. Supply chain platforms enable suppliers to receive demand signals and abnormal warnings. The transformation of enterprise boundaries under smart connected products suggests that information sharing and platform-based coordination can extend production planning beyond the internal organization [15].

4.4. Plan Adjustment Mechanism from the Perspective of Flexible Manufacturing

When demand fluctuations, equipment failures or supply chain disruptions occur, Midea needs a plan adjustment mechanism that can maintain production continuity. The core of the mechanism is rolling planning. By regularly refreshing the schedule, the enterprise can incorporate new orders, inventory changes and capacity constraints into the plan. In the case of urgent orders, the production department can adjust priorities. When local capacity becomes tight, different factories can share load information and reallocate production tasks.

The adjustment mechanism also depends on rapid abnormal-event feedback. If a production line faces equipment downtime, material shortage or quality problems, MES can transmit the abnormal information to the planning department. The planning department then coordinates with procurement, logistics and production units to revise the production sequence or redistribute capacity. Studies on Midea's air conditioning design paradigm also emphasize user-centered design and rapid scenario adaptation, which require a corresponding flexible manufacturing and planning system [20].

5. PROBLEMS IN THE PRODUCTION PLANNING PROCESS AND OPTIMIZATION SUGGESTIONS

5.1. Main Problems

Although Midea has built a relatively complete multi-level production planning system and has introduced digital systems into planning management, several problems may still affect flexible response and execution efficiency. The first problem is insufficient demand forecasting accuracy. Seasonal demand fluctuations, diversified product categories and rapid changes in consumer preferences make it difficult for traditional forecasting methods based mainly on historical data and managerial experience to match actual market changes.

The second problem is the insufficient integration of data across systems. ERP, MES, APS and supply chain platforms may all operate, but if data standards and update frequencies are inconsistent, departments cannot coordinate quickly when the production plan changes. As a result, production execution, procurement and logistics may fail to keep pace with plan adjustments. The third problem concerns supplier coordination. When key materials are unstable or delivery is delayed, the production line may face stoppages or rescheduling pressure.

The fourth problem is that the response to abnormal events is not always fast enough. Although MES can transmit shop floor problems, the process of judgment, coordination and plan revision may still lag behind market and production changes. The fifth problem is the limited frequency and scope of rolling planning. When urgent orders or sudden line stoppages occur, the enterprise may not be able to immediately rearrange the production plan and implement the adjustment. Research on data enabled lean production indicates that continuous data integration and process innovation are crucial for improving operational flexibility [21].

5.2. Optimization Suggestions

First, Midea can improve the intelligence of demand forecasting. Machine learning methods can be used to integrate historical sales, terminal retail data, promotion schedules, weather conditions and macroeconomic indicators. A multi-level demand forecasting model can be built for different regions, product categories and time horizons. Rolling calibration windows can be set to continuously reduce forecast errors and improve the reliability of the master production schedule.

Second, Midea can establish a unified data-sharing platform to strengthen the integration of ERP, MES, APS and supply chain management systems. Data items related to orders, materials, capacity, inventory and delivery should be synchronized in real time. Semantic consistency should be ensured across systems so that any plan change can immediately trigger corresponding updates in procurement, production and logistics.

Third, supplier collaboration should be strengthened. A supplier collaborative planning platform can be introduced to share medium- and long term material forecasts, short term rolling requirements and abnormal warnings with key suppliers. Combined with performance evaluation and incentive mechanisms, suppliers can lock capacity in advance and share inventory information. This would reduce the risk of material shortages and late deliveries.

Fourth, rapid on-site response should be enhanced. Edge computing devices can be installed to collect and judge equipment status and quality problems with lower latency. A cross-functional rapid response team composed of process, equipment, planning and logistics personnel can be established. Once an abnormal event occurs, the team can evaluate the impact, formulate an adjustment plan and coordinate implementation. Data-driven enterprise-user interaction research suggests that continuous data collection and interaction can support product and process innovation, which also applies to production planning optimization [22].

6. CONCLUSION

Taking Midea's air conditioning business as the research object, this paper analyzes the production planning process from the perspective of flexible manufacturing. The study shows that Midea has formed a relatively complete planning system covering demand forecasting, master production scheduling, weekly and daily scheduling, execution monitoring and feedback adjustment. ERP, MES, APS and supply chain platforms provide important technical support for digital scheduling and multi base coordination.

However, the analysis also indicates that the production planning process still faces problems such as inaccurate demand forecasting, insufficient cross departmental and supply chain coordination, slow abnormal-event response and limited rolling adjustment. To address these problems, this paper proposes four optimization strategies: improving intelligent demand forecasting, integrating information systems, strengthening supplier collaboration and optimizing rapid on-site response. These measures can help Midea improve the scientific nature and flexibility of its production planning, enhance resource utilization, shorten delivery cycles and strengthen market responsiveness. The conclusions also provide references for other manufacturing enterprises with diversified products and flexible production requirements.

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