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Manufacturing of Touch Glass for Mobile Phones and Tablets: A Transformation from Traditional to Intelligent Manufacturing

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Abstract: The manufacturing of touch glass for mobile phones and tablets is undergoing a transition from traditional production modes to intelligent manufacturing. This transformation faces challenges such as a high reliance on manual labor and significant fluctuations in product yield. To address these issues, it is necessary to advance equipment intelligence, establish an IoT architecture, and optimize production processes. The shift toward intelligent manufacturing brings notable benefits, including cost reduction, shorter product iteration cycles, and enhanced customization capabilities. At the same time, it emphasizes collaboration across the industrial chain, green manufacturing practices, and improved resource utilization efficiency. Nevertheless, further optimization and development opportunities remain for future advancement.

Keywords: Touch glass manufacturing; Intelligent manufacturing; Technological change

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1. Introduction

With the promulgation of the Intelligent Manufacturing Development Plan (2021–2025), the mobile phone and tablet touch control glass manufacturing industry has actively responded to the call for intelligent development. Although traditional touch control glass processes have a foundation, they face challenges in the transition to intelligent manufacturing, such as high dependence on manual labor, significant yield fluctuations, and insufficient flexible production capabilities. Against this background, the industry has implemented multiple initiatives, including the iteration of intelligent cutting and precision processing equipment, intelligent upgrading of online inspection equipment, construction of IoT-based equipment interconnection architectures, and big data-driven process optimization. These efforts have achieved reductions in production costs, compression of product iteration cycles, and enhancement of customized production capabilities, while emphasizing collaborative innovation across the industrial chain, green manufacturing process innovation, and resource efficiency improvement. However,

there is still room for improvement, and industrial metaverse technology is expected to drive the industry toward higher levels of intelligence in the future.

2. Development history of glass manufacturing in the electronic display industry

2.1. Overview of traditional touch control glass process technology

Traditional touch control glass process technology primarily revolves around soda-lime glass and chemical strengthening processes. Soda-lime glass, as a base material, has become a common choice for early touch control glass due to its excellent optical performance and thermal stability. In the chemical strengthening process, ion exchange technology replaces smaller ions on the glass surface with larger ones, forming a compressive stress layer on the surface that significantly enhances glass strength and wear resistance. The grinding and polishing process is a key link, where through fine grinding of the glass surface, surface roughness is reduced, improving flatness and gloss to ensure touch operation sensitivity and visual effects. Screen printing is used to print various patterns and markings on the glass surface. This flexible process can meet different design requirements and has played an important role in traditional touch control glass manufacturing, providing basic appearance and functional support for devices such as mobile phones and tablets [1].

2.2. Challenges and limitations faced by industrial development

In the process of transitioning from traditional to intelligent manufacturing in mobile phone and tablet touch control glass manufacturing, the industry faces numerous challenges and limitations. Traditional manufacturing systems have high dependence on manual labor, where many processes require manual operation, not only consuming labor costs but also being susceptible to subjective factors, resulting in poor product quality stability [2]. Large yield fluctuations are also a major issue. The production process is interfered with by multiple complex factors such as equipment precision and environmental temperature/humidity, making precise control difficult and leading to inconsistent yield rates, increasing production costs and resource waste. Additionally, insufficient flexible production capacity for multiple varieties means traditional production lines have low flexibility. Switching product models requires significant time and resources for equipment adjustments and process optimization, making it difficult to quickly respond to diversified and personalized market demands, placing enterprises at a disadvantage in market competition.

3. Automation upgrading practices for glass processing equipment

3.1. Iteration of intelligent cutting and precision processing equipment

In mobile phone and tablet touch control glass manufacturing, the iteration of intelligent cutting and precision processing equipment is crucial. The CNC fully automatic glass cutting system has achieved significant improvements in dimensional accuracy, with positioning accuracy reaching ± 0.05 mm, greatly reducing dimensional errors compared to traditional cutting methods and better meeting the high-precision demands of mobile phones and tablets for glass [3]. At the same time, this system has made technological breakthroughs in production takt time, with substantially increased cutting speeds enabling multiple precise cuts per minute, effectively enhancing production efficiency. Laser drilling equipment also performs outstandingly, capable of achieving extremely small aperture processing with aperture accuracy controlled within ± 0.01 mm, while optimizing drilling speed to greatly shorten the time for single glass drilling. This improves product quality while

accelerating overall production rhythm, promoting the transition of glass processing from traditional methods to intelligent manufacturing and meeting growing market demands.

3.2. Intelligent upgrading of online inspection equipment

In mobile phone and tablet touch control glass manufacturing, intelligent upgrading of online inspection equipment is crucial. Machine vision defect detection systems utilize advanced image recognition technology to quickly and accurately identify subtle scratches, bubbles, and other defects on glass surfaces [4]. High-resolution cameras capture images, followed by deep learning algorithms for analysis and processing. Compared to traditional manual inspection, this greatly improves detection efficiency and accuracy while avoiding subjectivity in manual inspection. Laser thickness measurement equipment is also an important component. Based on laser ranging principles, it measures glass thickness in real time precisely, ensuring compliance with standards. Intelligent data analysis functions statistically analyze measurement data, timely identifying thickness deviation trends in production processes and providing basis for process adjustments, achieving effective quality control in glass production and promoting the transition from traditional to intelligent inspection in glass processing.

4. Construction paths for intelligent manufacturing systems

4.1. Intelligent transformation schemes for production lines

4.1.1. IoT equipment interconnection architecture

In constructing intelligent manufacturing systems for mobile phone and tablet touch control glass manufacturing, the IoT equipment interconnection architecture is a key link in the production line's intelligent transformation. By building this architecture, efficient data interaction and collaborative operation among equipment can be achieved. Sensors collect real-time data from production equipment in processes such as cutting, grinding, and coating, including parameters like temperature, pressure, and speed. These data are transmitted via wireless networks to edge computing devices for preliminary processing, filtering invalid information and extracting key data [5]. Subsequently, data are transmitted to industrial internet platforms, utilizing big data analysis technology for deep insights into production processes to optimize workflows. Meanwhile, through communication protocols such as MQTT and OPC UA, seamless docking between PLC controllers and industrial robots is achieved, ensuring precise coordination across links, improving production efficiency and product quality, and completing the transformation from traditional to intelligent manufacturing.

4.1.2. Big data-driven process optimization

In the intelligent transformation of mobile phone and tablet touch control glass manufacturing, big data-driven process optimization is crucial. By developing a production data middleware system, massive data in manufacturing processes are deeply mined and analyzed. Real-time collection of equipment operating parameters and product quality data, combined with data analysis models, precisely reveals associations between processes and product quality. Based on analysis results, dynamic correction of process parameters is achieved, ensuring each production process operates in optimal state, enhancing product quality and production efficiency. Additionally, big data predicts potential equipment failures, enabling preventive maintenance in advance to reduce downtime and ensure stable production line operation [6]. Thus, with big data as the core driver, continuous process optimization promotes the advancement of mobile phone and tablet touch control glass manufacturing toward intelligence.

4.2. Innovations in digital manufacturing management

4.2.1. Application of digital twin technology

In the process of advancing mobile phone and tablet touch control glass manufacturing toward intelligent manufacturing, digital twin technology plays a key role. By establishing virtual simulation models of glass hot-bending forming processes, process verification efficiency can be effectively improved [7]. Using this technology, actual hot-bending forming processes are precisely replicated in virtual space, simulating glass forming conditions under various process parameters. Engineers can observe potential defects in advance, such as bending deviation or surface unevenness, timely adjusting and optimizing process schemes to avoid time and resource waste from repeated trials in actual production. This not only significantly shortens process verification cycles but also markedly improves product quality and reduces production costs, promoting successful transformation from traditional models to intelligent manufacturing in mobile phone and tablet touch control glass manufacturing and enhancing overall industry production efficiency and competitiveness.

4.2.2. Development of intelligent scheduling algorithms

In advancing mobile phone and tablet touch control glass manufacturing toward intelligent manufacturing, development of intelligent scheduling algorithms is crucial. By applying genetic algorithms to solve dynamic scheduling optimization problems in multi-variety order mixed production, production efficiency and resource utilization can be significantly improved. Genetic algorithms simulate biological evolution mechanisms, encoding feasible solutions to production scheduling problems as chromosomes and using genetic operators such as selection, crossover, and mutation for efficient search in solution space. In multi-variety order mixed production scenarios, different products have varying process requirements, delivery dates, and order quantities. Traditional scheduling methods struggle to meet complex and variable demands. Using genetic algorithms comprehensively considers constraints like equipment capacity, material supply, and manpower arrangements, dynamically adjusting production plans to generate optimal or near-optimal scheduling schemes, effectively reducing production costs, improving on-time delivery rates, and helping enterprises gain advantages in fierce market competition [8].

5. Industry impact and development trends of intelligent transformation

5.1. Industrial benefits brought by technological innovation

5.1.1. Structured decline in production costs

In the transformation from traditional to intelligent manufacturing in mobile phone and tablet touch control glass manufacturing, structured decline in production costs is significant. Large-scale application of automated equipment substantially reduces labor costs. Intelligent production lines precisely control manpower input, processes like cutting and grinding that originally required extensive manual work are now efficiently executed by automated equipment, reducing labor demand and associated costs. Meanwhile, energy consumption is optimized through technological innovation. Intelligent control systems precisely regulate energy supply according to production flows, avoiding waste in non-essential links and achieving quantifiable energy reduction [9]. Additionally, intelligent manufacturing improves product qualification rates, reducing extra costs from defective items. From raw material procurement and production processing to finished output, intelligent management achieves efficient resource allocation across links, promoting sustained structured decline in production costs and enhancing enterprises' cost competitiveness in the market.

5.1.2. Benefits from compressed product iteration cycles

In the transformation from traditional to intelligent manufacturing in mobile phone and tablet touch control glass manufacturing, technological innovation brings significant benefits from compressed product iteration cycles. Leveraging digital R&D systems, enterprises achieve major breakthroughs in developing ultra-thin glass and 3D curved glass. Under traditional manufacturing models, developing a new glass product from design conception to sample output often involves lengthy trial and adjustment processes, with cycles potentially lasting months or even years [10]. After intelligent transformation, relying on advanced technologies like digital simulation and big data analysis, R&D personnel can quickly simulate product performance and predict potential issues in virtual environments, substantially reducing actual trial times. For example, in ultra-thin glass development, digital means precisely analyze relationships between material properties and manufacturing process parameters, rapidly optimizing production processes and shortening development cycles from months to weeks; the same applies to 3D curved glass development, using intelligent algorithms to optimize curved design and forming processes, dramatically increasing product iteration speed and enabling enterprises to respond faster to market demands, gaining first-mover advantages in intense competition.

5.2. New trends in future industry development

5.2.1. Enhancement of customized production capabilities

In the transformation process from traditional to intelligent manufacturing in mobile phone and tablet touch control glass manufacturing, enhancement of customized production capabilities has become a key trend. Modular equipment combinations and flexible manufacturing systems provide strong support for personalized product demands. Through intelligent modular equipment combinations, production flows can be flexibly adjusted; different functional modules can be combined as needed to quickly respond to customized orders. Flexible manufacturing systems enables efficient production of multiple specifications and styles of touch control glass on the same line. The combination of these two allows enterprises to precisely produce touch control glass products with unique designs, dimensions, or functions based on specific customer requirements. This not only meets market demands for personalization in mobile phones and tablets but also improves production efficiency, reduces costs, enhances enterprise competitiveness in customized markets, and promotes continuous development of the mobile phone and tablet touch control glass manufacturing industry toward customization and refinement.

5.2.2. Industrial chain collaborative innovation model

In the intelligent transformation process of mobile phone and tablet touch control glass manufacturing, the industrial chain collaborative innovation model is emerging. Glass manufacturers and terminal brands jointly establish intelligent manufacturing laboratories, opening a new paradigm for deep industrial collaboration. In this model, glass manufacturers leverage their deep accumulation in glass manufacturing processes to provide solid quality foundation and technical support for products. Terminal brands guide product R&D directions with keen market demand insights. Through cooperation, joint exploration in intelligent manufacturing technologies optimizes production flows and improves product quality and efficiency. For example, jointly developing new glass materials with higher strength and better touch sensitivity; co-building intelligent production systems to achieve full-process intelligent management from raw material procurement to product delivery. This industrial chain collaborative innovation model will accelerate the intelligent transformation of the mobile phone and tablet touch control glass manufacturing industry, promoting the entire industry to new heights.

5.3. Sustainable development technology paths

5.3.1. Green manufacturing process innovation

In advancing mobile phone and tablet touch control glass manufacturing toward intelligent transformation, green manufacturing process innovation is crucial. Developing cyanide-free coating technology effectively reduces environmental toxic impacts from traditional coating processes. Cyanide is highly toxic, where improper handling during production can cause environmental pollution and personnel harm. Application of cyanide-free coating technology eliminates this hazard at the source. Meanwhile, construction of wastewater recycling systems is indispensable. Production generates large amounts of wastewater. Direct discharge not only wastes water resources, but also pollutes the surrounding water environments. Through wastewater recycling systems, wastewater is purified and recycled for reuse in production, achieving efficient water resource cycling, aligning with sustainable development concepts while reducing production costs, and promoting green and environmentally friendly development in the mobile phone and tablet touch control glass manufacturing industry.

5.3.2. Resource efficiency enhancement strategies

In the transformation from traditional to intelligent manufacturing in mobile phone and tablet touch control glass manufacturing, resource efficiency enhancement strategies are crucial. By implementing IoT-based energy management systems, precise monitoring and regulation of energy consumption in production processes can be achieved. Sensors real-time collect equipment energy data, where data analysis technology identifies energy waste points and high-consumption links, optimizing energy allocation to ensure equipment operates at optimal energy states, effectively achieving targets for reducing energy consumption per unit output value. In addition, intelligent means optimize raw material procurement, inventory management, and production scheduling, reducing raw material stock backlog and waste, improving utilization rates. Meanwhile, intelligent equipment achieves more precise operations, lowering defective rates and reducing resource waste from unqualified products, comprehensively enhancing resource utilization efficiency and promoting sustainable industry development.

6. Conclusion

The transition from traditional to intelligent manufacturing in mobile phone and tablet touch control glass manufacturing has undergone numerous key changes. Technological evolution shows a clear trajectory. During intelligent transformation, technologies such as automated production and data-driven decision-making have gradually matured and been applied. Industrial implementation has also accumulated rich experience, including optimizing industrial chain collaboration and improving production efficiency and product quality. However, there is still room for improvement: insufficient standardization of equipment interconnection protocols affects efficient inter-equipment collaboration; reliability of industrial AI algorithms needs enhancement to ensure stable and precise production processes. In the future, industrial metaverse technology is expected to shine in virtual factory construction. By building highly realistic virtual production environments, production schemes can be simulated and verified in advance, reducing costs and enhancing innovation capabilities, promoting touch control glass manufacturing toward higher levels of intelligence.

Disclosure statement

The author declares no conflict of interest.

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