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A Brief Analysis of the Development of the Wire and Cable Industry and Quality Test Technology in Shaanxi Province in the Age of Artificial Intelligence

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Abstract: As the "industrial blood vessel" of the national economy, wire and cable products underpin the safety of infrastructure and power systems. The rise of artificial intelligence (AI) is driving the transformation of cable quality testing from manual operation to intelligent mode. As a major energy base in China, Shaanxi Province has formed a distinctive cable industrial cluster, yet faces prominent problems such as low intelligent quality test level and insufficient high-end supply. This paper sorts out the development status of Shaanxi's wire and cable industry, analyzes the bottlenecks of traditional quality test technology, and elaborates the enabling value of AI from four dimensions: defect identification, non-destructive testing, whole-process quality control, and intelligent supervision. On this basis, it summarizes the practical challenges of AI-industry integration, and proposes targeted development paths including building a provincial AI quality test service center, promoting industry-university-research collaboration, upgrading industrial clusters, formulating local standards and constructing an intelligent supervision system, so as to provide references for the high-quality development of Shaanxi's cable industry.

Keywords: Artificial intelligence; Wire and cable; Quality test technology; Shaanxi province

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1. Introduction

Wire and cable are widely applied in energy, power, transportation, and aerospace sectors, serving as critical infrastructure for national economic operation. With the advancement of the digital economy, AI technology has become a core driving force for industrial upgrading, bringing transformative opportunities for cable quality testing.

As an important comprehensive energy base and UHV power transmission hub in China, Shaanxi Province boasts a large-scale cable industrial cluster closely linked to local pillar industries. According to Shaanxi's 15th Five-Year Plan, AI will be empowered to penetrate key industrial scenarios including R&D design, pilot verification, manufacturing and operation management [1]. For provincial quality supervision

institutions, promoting the integration of AI and cable quality testing is not only an inevitable requirement to serve local industrial development, but also a concrete practice to implement the national strategy of quality and technological power. This paper takes Shaanxi as a research sample to discuss the integration path of AI technology and the cable industry.

2. Status of wire and cable industry in Shaanxi province

2.1. Growing demand driven by characteristic industries

Shaanxi's huge demand for cables comes from three major fields: first, the large-scale development of new energy and UHV transmission projects in northern Shaanxi, which drives the demand for high-voltage and extra-high-voltage cables; second, the strong demand for special cables from aerospace, rail transit and high-end equipment manufacturing industries; third, the Xianyang power transmission and transformation equipment industrial cluster, which has formed a collaborative industrial pattern of "power transmission equipment & wire and cable" led by leading enterprises.

2.2. Urgent demand for intelligent upgrading of industrial clusters

Shaanxi's cable industry has formed a large industrial cluster dominated by medium and low voltage power cables, mining cables and general rubber-sheathed cables, with some enterprises extending to UHV and new energy special cables. However, the industry is generally large but not strong, with a high proportion of small and medium-sized enterprises, insufficient high-end production capacity, and low intelligence level in production and quality test links. With the construction of new power systems and the development of Qinchuangyuan Innovation-driven Platform, local enterprises have an increasingly urgent demand for digital and intelligent transformation.

3. Pain points of traditional cable quality test technology

Wire and cable are core infrastructure of power systems, and their service life directly affects the stability and safety of the whole system [2]. Cable quality test covers appearance, size, electrical performance, mechanical performance, and other links, which is the key to ensuring product quality. At present, cable quality test mainly relies on manual visual inspection and mechanical testing, with prominent limitations in efficiency and precision.

3.1. High dependence on manual work with limited efficiency and accuracy

Traditional appearance inspection and partial discharge quality test rely heavily on manual operation, which is susceptible to subjective factors and personnel status. For micro defects such as millimeter-scale water marks and insulation scratches, manual quality tests have a high miss rate, leading to defective products flowing into the market and potential safety hazards.

3.2. Disconnection between quality test and production without real-time control

The traditional mode is dominated by offline sampling inspection, which cannot realize online synchronous quality testing on production lines. Quality problems in production cannot be found in time, often resulting in batch unqualified products. Most quality test data are recorded on paper and scattered in different links, failing to support process optimization through data analysis.

3.3. Insufficient high-end quality test supply for special scenarios

For special cables used in aerospace and UHV fields, high-precision non-destructive testing is required for internal defects and weather resistance, which cannot be well met by traditional testing equipment. Meanwhile, traditional technology lacks support for full life cycle management, quality traceability, and fault early warning.

3.4. Scattered quality test resources with low supervision efficiency

Cable manufacturers are widely distributed across the province. Traditional supervision relies on offline spot checks, and quality test data from different regions and institutions cannot be shared, making it difficult for regulatory authorities to dynamically grasp the overall product quality situation.

4. Innovative Application of AI in cable quality test

4.1. High-precision appearance defect quality test based on machine vision

Intelligent cable quality inspection equipment equipped with machine vision and deep learning algorithms can convert visual information in the physical world into computable data through digital image processing and pattern recognition, so as to realize the quality test, identification, and tracking of objects or processes [3]. It can fully meet the real-time quality test requirements of high-speed production lines, control appearance quality from the production source, and reduce the outflow of defective products.

4.2. Internal defect quality test combining AI and non-destructive testing

AI technology is integrated with rapid testing technologies including infrared thermal imaging, X-ray fluorescence spectroscopy, ultrasonic testing, and partial discharge quality test, to automatically identify and quantitatively analyze internal defects such as conductor wire breakage, insulation layer bubbles, and shielding layer damage, providing reliable technical support for refined quality control of special cables [4].

4.3. Whole-process quality control based on multi-source big data

With the architecture of “terminal real-time collection + cloud intelligent analysis”, quality test data can be synchronized to the cloud platform in real time. AI algorithms can conduct quality trend analysis and fault cause tracing, promoting the transformation of quality management from post-inspection to pre-prevention.

4.4. Provincial intelligent quality supervision platform

A provincial cable quality big data platform integrating enterprise production data and supervision sampling data can realize dynamic monitoring, accurate traceability, and risk early warning of product quality across the province, providing intelligent decision support for market supervision departments.

5. Challenges of AI-industry integration in Shaanxi

(1) Low willingness of small and medium-sized enterprises

Most small and medium-sized cable enterprises still attach more importance to production than quality testing. The high upfront cost of intelligent testing equipment leads to insufficient investment in intelligent transformation.

(2) Lack of compound talents

The application of AI in local testing institutions is still in the initial stage. Professionals who master both cable quality test knowledge and AI algorithm technology are in short supply, resulting in a mismatch between technology and practical demand.

(3) Unsmooth achievement transformation and lack of standards

The transformation efficiency of AI technological achievements through platforms such as Qinchuangyuan needs to be improved. There is still a lack of unified national standards for quality test indicators, algorithm accuracy, and data format.

(4) Imperfect collaborative mechanism

AI enterprises, cable manufacturers, testing institutions, and research institutes have not established a normalized cooperation mechanism. A complete integrated development ecology of "R&D-testing-application-standard" has not yet been formed.

6. Targeted development paths

6.1. Build a provincial AI cable quality test technology service center

Provincial testing institutions should give full play to their own testing capabilities and technical advantages, and take the lead in promoting the R&D and application of AI testing technology. First, upgrade intelligent testing equipment and introduce advanced devices such as AI cable quality inspection machines and X-ray intelligent non-destructive testing systems, to build an authoritative AI testing technology verification platform in the province. Second, build a provincial wire and cable quality big data platform, integrating enterprise testing data, supervision sampling data, and risk monitoring data, to realize quality trend analysis, fault tracing, and risk warning through AI algorithms, and provide data services for enterprises and market supervision departments [5]. Third, carry out AI testing technology promotion services to reduce the transformation threshold for small and medium-sized enterprises.

6.2. Construct a government-industry-university-research collaborative innovation system

Led by testing institutions and supported by the Qinchuangyuan platform, an innovation alliance for AI cable quality test technology should be established together with universities, leading enterprises, and AI companies. The alliance will carry out joint technical research for high-end special cables, promote the transformation of scientific and technological achievements, and co-build talent training bases to cultivate compound professionals.

6.3. Promote intelligent upgrading of industrial clusters

Taking the Xianyang power transmission and transformation equipment cluster as a pilot, leading enterprises such as XD Group and Shaanxi Chint Intelligent Electric will be guided to take the lead in intelligent transformation, realize full-process intelligent quality testing on production lines, and form a demonstration effect [6]. Supported by AI quality test technology, local enterprises will be encouraged to extend to high-end fields such as aerospace, UHV and new energy, and build a whole-industry-chain quality control system.

6.4. Accelerate standard formulation for standardized development

Testing institutions should take the lead in formulating local standards for AI cable quality test technology,

clarifying requirements for quality test indicators, algorithm accuracy and data format, and promoting the connection between local standards and industry/national standards. Standard publicity and implementation supervision should be carried out to guide the standardized development of the industry.

6.5. Build a provincial AI quality supervision system

A quality supervision system featuring "intelligent quality test & big data analysis & precise supervision" should be constructed. By integrating production and testing data across the province, quality portraits of enterprises will be formed. AI algorithms will be used for risk monitoring and targeted spot checks, so as to improve the accuracy and efficiency of quality governance.

7. Conclusion

AI technology brings historic opportunities for the upgrading of the wire and cable industry and quality test technology. Shaanxi has unique industrial scenarios and a demand foundation for AI application. Provincial quality testing institutions should give full play to their technical advantages, take intelligent quality test upgrading as the starting point, build a collaborative innovation system and a big data platform, and promote the in-depth integration of AI and the local cable industry, so as to accelerate the industry's transformation toward high-end, intelligent and characteristic development.

Disclosure statement

The author declares no conflict of interest.

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