Innovative Application of Digital Platform for Foundry Blast Furnace Based on Longchao Yunzhou Industrial Internet Platform

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Abstract. Modern industrial applications and enterprises are actively adopting the concept of industrial Internet to achieve operational transformation and upgrading. As a novel technical means of industrial operation, the industrial Internet platform provides real-time collection, free transmission, precise analysis, intelligent feedback and other functions to support scientific decision-making of business and efficient allocation of manufacturing resources. Wave Cloud Island Industrial Internet Platform, with its unique Cloud Island operating system, can carry out distributed management of the operations of the steelmaking industry and foundry blast furnace enterprises on multiple management nodes distributed in different components of the operation system. The system's computing and management nodes enable large-scale access to industrial equipment and data collection, as well as the analysis of industrial data from operating systems to optimise blast furnace parameters. The platform can be modelled, customised and standardised to serve different applications, applied for monitoring, diagnostics, forecasting and decision-making for the optimisation of blast furnace resources and equipment, the value chain and the industrial life cycle.

Keywords: Yunzhou operating system, foundry blast furnace, industrial internet, digital transformation

1 Introduction

As a new type of modern industrial eco-infrastructure, the industrial Internet, with its novel application mode, builds a network connecting industrial elements and industrial chains through information generation and communication technologies. Currently, modern industrial application fields and enterprises are actively adopting Industrial Internet to support scientific decision-making, efficient allocation of manufacturing resources, and transformation and upgrading of enterprise operations with its advantages of real-time collection, free transmission, precise analysis, and intelligent feedback. People tend to associate the concept of operating system with the consumer Internet, believing that it manages the software and hardware resources of smart devices such as

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computers. However, this concept is increasingly being applied to modern industrial fields, such as prioritising the supply and demand of system resources, the operation of networks and the management of file systems, and the control of input and output devices. In China, particularly in the manufacturing and industrial sectors, the Industrial Internet has become a key element of national infrastructure development and economic development, revolutionising industrial sectors that may require human interaction with technological intelligence and facilitating the operation of manufacturing industries such as foundry and steelmaking that require human intervention.

Wave Group, one of China's most dominant industrial Internet operators, is an Internet technology solutions provider headquartered in Jinan. The operator's main goal is to provide digital transformation services to various industries and regions and contribute to the development of the global digital infrastructure industry. The Longchamp Yunzhou Industrial Internet Platform, a core product of the Longchamp Group, is data-driven and ensures collaborative integration of hard and services based on the edge of its cloud network. This paper will focus on the technological innovation application of the Longchao Yunzhou Industrial Internet Platform in China Foundry Blast Furnace and how it can be utilised in industrial operations to promote economic development. By analysing in detail the architectural framework and implementation path of the Longchao Yunzhou Industrial Internet Platform, and its direct application in the foundry blast furnace and steelmaking industries, this paper will reveal how the platform can help enterprises achieve digital transformation and lean production.

Longchamp Yunzhou Industrial Internet Platform is an intelligent transformation solution for the manufacturing industry based on Longchamp Group's profound accumulation of Internet technology and experience in the industrial field. The platform is data-driven and provides a technology-optimised industrial service ecosystem for the manufacturing industry by integrating the upstream and downstream technologies of "cloud, network and edge". Its core products include industrial data centre, industrial digital twin and industrial data intelligence, covering multiple levels such as industrial operating system and Internet platform.[1] Cloud Island OS is the core of Longchamp's Cloud Island Industrial Internet Platform, which is deployed in a distributed cloud architecture and is responsible for the distributed management of different operating nodes located in different locations in the industry or workshop. These nodes form part of the complete architecture of the Internet platform, providing large-scale access to different industrial thermal blast furnace equipment and data to control different systems for analysis and optimisation parameters. The Cloud Island operating system connects the different gateways and industrial control devices in the plant through the cloud for optimisation of parameters, process control and execution.

2 Discussion

The architectural framework of the Wave Cloud Island Industrial Internet Platform is based on the Cloud Island operating system, which is deployed in a distributed cloud architecture. The complete architecture of the Internet platform has multiple management nodes, which are distributed in different operational aspects of the casting blast

furnace and can be centrally and uniformly managed in the cloud. Essentially, the operators of the casting blast furnace do not need to be physically present at a specific node to manage it. The Cloud State Operating System is responsible for the distributed management of the different operational nodes located in different locations in the industry or shop floor. The operation of the Yunzhou OS is based on a bottom-up four-layer collaborative architecture of "cloud-network-end", which includes a collection and control layer, an industrial image, a system kernel and an application service layer. Each layer has different elements and components that work with the other layers to perform specific functions in the thermal blast furnace process, This is shown in Figure 1.

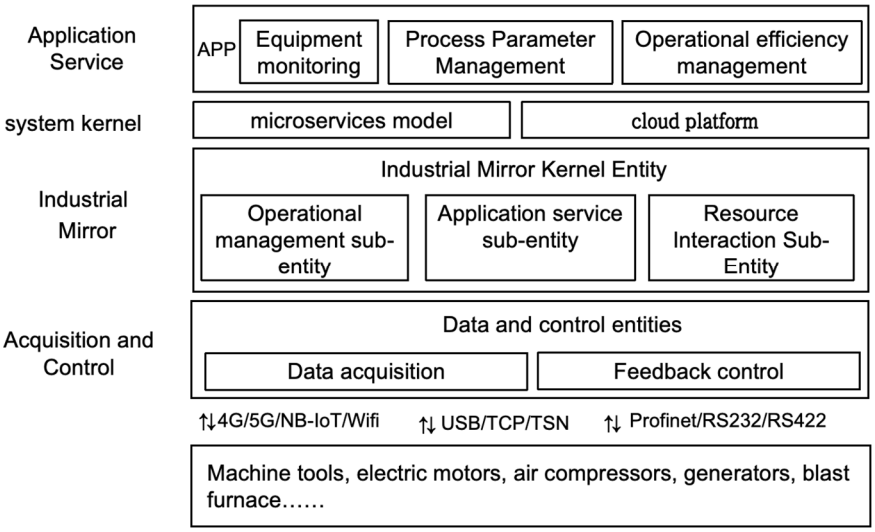

Fig. 1. A summarized architectural depiction of the Inspur Industrial Internet Platform.

2.1 The Acquisition and Control

The Acquisition and Control Layer is the first layer in the CloudZoo OS architecture and consists of data and control entities that are responsible for data acquisition and feedback control. The main role of this layer is to establish connectivity and access to the foundry blast furnace industrial equipment and to establish a data transfer channel between the physical resources and the CloudZone OS on the Internet platform. In addition, the layer is responsible for sending optimised industrial parameters and blast furnace scheduling instructions to the physical equipment, blast furnace production lines and workstations. The Acquisition and Control Layer also provides data and channel functions for locating any possible malfunctions within the blast furnace system, for optimising the relevant processes and for seamless collaboration between the physical industrial operators and machines. The different components of the acquisition and control layer include edge intelligent gateways, industrial buses, soft PLCs, feedback controllers with hardware and software integration, VR/AR wearables, sensor devices,

etc. The Edge Intelligent Gateway links to the underlying device controller's blast furnace protocol, establishes devices online and creates command channels. The industrial bus is responsible for data acquisition and feedback control of non-industrial controller devices or devices without data interfaces.

2.2 Industrial Mirroring

Industrial mirroring is the second layer of the CloudBoat OS architecture, and its core composition includes the industrial mirror kernel entity, which is further subdivided into the operation management sub-entity, application service sub-entity and resource interaction sub-entity. In the application scenario of thermal blast furnace, industrial mirroring technology can simulate the physical objects in the relevant industrial process with high precision and map these physical objects into their corresponding virtual twin space. Within this virtual twin space, the process of the thermal blast furnace can be simulated to operate and optimise its operating state.[2]The core essence of the industrial mirroring layer is to realise real-time transmission of blast furnace data, record storage of historical data, and precise positioning according to specific application requirements. This level provides an in-depth analysis of the blast furnace's physical space activities to provide a strong basis for decision support or closed-loop control, ensuring that two-way iterative optimisation can be achieved between the equipment entity and the virtual mirror system. The industrial mirror system of Yunzhou OS relies on the real operating data of the blast furnace and the feedback control commands of the intelligent application to accurately map, interact and integrate, and intelligently feedback control the physical and virtual entities in the system .[3] In order to achieve the set goals, the industrial mirroring system of Yunzhou OS integrates multiple components of the blast furnace physical entity and sensor system, including the edge module, the industrial protocol conversion system, and the virtual-reality fusion system. In terms of information flow construction, the system is based on four core elements: metadata dictionary, association analysis, information flow model, and information storage. It is worth mentioning that the operation data of Yunzhou Mirror System strictly follows the industrial law of square blast furnace to ensure its authenticity and accuracy.

2.3 System Kernel

The system kernel is the core cornerstone of the industrial Internet operating system, carrying multiple well-designed digital models that efficiently manage information flow based on a microservice architecture. The system kernel is mainly constructed by two major core entities: cloud platform and microservice models. The cloud platform, as a key technology container, not only provides strong support for the deployment, isolation and distribution of industrial resources and business models, but also ensures the flexibility and scalability of the system. The incorporation of cloud-native technologies as code containers within the system greatly accelerates the iteration speed of industrial functions and endows the system with the toughness to cope with various types of impacts. The microservices model further refines the system architecture by

breaking down large and complex applications into a series of small and compact service units. These service units are independent, responsible for performing system upgrades, while efficiently managing internal data resources, hardware resources and external interfaces, achieving flexible system upgrades and optimal resource allocation. Another major role of the system kernel is to build the bridge of the industrial ecosystem, which seamlessly connects industrial operators, production processes, data assets and physical equipment, and facilitates the deep integration and precipitation of industrial knowledge and experience. In this process, industrial digital models are formed and continuously improved, which integrate the industrial technology principles, knowledge accumulation, basic processes and modelling tools of the foundry blast furnace, and realise the digital transformation of industrial knowledge by means of standardisation, software and modularisation.[4] Specifically, these digital models cover multiple dimensions, including but not limited to: refined process models for different products of the blast furnace, parameter models with precise process formulas, fault models for fault diagnosis and correction, component models providing detailed 3D descriptions of industrial components, and simulation models simulating physical conditions such as blast furnace temperature. Together, these models form an indispensable industrial digital model system in the industrial Internet operating system, providing solid support for the intelligence and efficiency of industrial production.

2.4 The Application Services

The Application Services Layer follows a zero-code design philosophy and builds a development environment tailored to the specific activities of the foundry blast furnace. In this layer, operators of the blast furnace industrial process are able to rely on the microservices model to flexibly combine and build industrial APPs tailored to specific needs, which not only perform in-depth industrial analyses, but also aim to optimise the overall production process. Given the highly dynamic adaptability of the Yunzhou operating system in industrial scenarios, a series of APPs optimised for foundry blast furnaces have been assembled within the system, such as the "Yunzhou Design Simulation Platform" and the "Equipment Health Monitoring Management System", which significantly enhance the industrial process through the implementation of a predictive maintenance strategy. They significantly improve the efficiency and reliability of industrial processes by implementing predictive maintenance strategies. The core of the application services layer consists of three APP entities: equipment monitoring, process parameter optimisation and operational efficiency management. These entities work together to perform in-depth data modelling, structured classification and systematic abstraction to accurately solve operational problems and meet the individual needs of the blast furnace industry, while the industrial technology elements in the APP have been carefully refined and standardized to build a basic framework for industrial applications, ensuring efficient reuse in the blast furnace production process and accelerating technological innovation and process optimization. The overall architectural design of Yunzhou OS cleverly integrates the diversified blast furnace industrial scenarios, the deep industrial knowledge accumulation and the constantly iterative ecosystem. Through the bridge of industrial APP, the system realises a closed-loop process from

self-learning, self-decision-making to self-execution and self-adaptation, which gives unprecedented intelligence and flexibility to industrial processes. In addition, the system also has the ability to extract machine data at high speed and generate accurate images of machine movement sequences, which not only greatly improves operational efficiency, but also makes real-time monitoring of component status and life prediction possible, providing solid technical support for the intelligent transformation of blast furnace production.

The innovative application of Yunzhou OS in the steel industry has demonstrated its strong potential to drive lean production and provide customised solutions for complex industrial processes such as blast furnaces and the uncertainties of low-carbon and zero-carbon technology transition.[5] The system is deeply involved in key aspects of steelmaking and foundry blast furnace operations, such as oxygen supply regulation, slag making management, scrap treatment, end point accurate prediction and oxygen lance position optimisation, relying on advanced data models and real-time calculation capabilities to achieve fine dynamic regulation of the blowing process.[6] Experts in the field of steelmaking and blast furnace technology can standardise and optimise the production process based on the lean production concept and the demand for high-quality real-time data with the help of the industrial internet platform built by Yunzhou OS. As the two pillars of the digital platform, the kernel platform and the industrial mirror system of Yunzhou OS undertake the core tasks of model training and operation optimisation, real-time parameter calculation and visual display of results respectively. This architecture not only promotes the intelligent upgrading of the production process, but also effectively reduces the annual operating cost of the blast furnace converter through the in-depth integration of on-site lean management and data-driven modelling, and occupies a significant proportion of the total cost reduction of industrial operation. The industrial internet architecture of Yunzhou OS builds an integrated operation platform for steelmaking and foundry blast furnace operations, realising data integration and sharing across equipment and production systems. This platform not only enhances collaboration between users and partners, but also ensures significant improvements in safety, energy efficiency, and overall effectiveness of production operations, supported by a wide range of applications.

In order to meet the urgent demand for networked and intelligent transformation of blast furnace operation, "Yunzhou OS" has carefully designed specific application scenarios covering each operation element and created an open industrial application platform that supports zero-code development. This digital platform is designed to create a development environment conducive to industrial big data storage, operation process management, model construction and design innovation, while ensuring seamless and efficient interconnection between operators, users and machines, thus promoting a leap in operation management efficiency. The platform is highly flexible and scalable, capable of modelling, customisation and standardisation for different applications, and is widely used in blast furnace monitoring, fault diagnosis, performance prediction and decision support, aiming to optimise the utilisation of blast furnace resources, equipment management, value chain integration and industrial lifecycle management.

3 Conclusion

Industrial Internet digital platforms have been promoted in China as a core driver of national infrastructure and economic development, leading the traditional industrial sector, particularly in manufacturing areas such as foundry and steelmaking, which rely on intensive manual labour, into a new era of technological smart transformation. This process deeply embodies the strategic concept of "two modernisations" integration, that is, accelerating the vigorous development of industrial Internet platforms and promoting the deep synergy of platform system construction and application. The successful practice of Longchao Yunzhou Industrial Internet in foundry blast furnace is a profound practice of the concept of fine production management, through the accurate process control and health status monitoring of foundry blast furnace industrial equipment, achieving significant efficiency improvement. The platform focuses on creating a networked, scenario-based, intelligent management service system tailored for foundry blast furnace enterprises, ensuring that all aspects of the production process enjoy a high degree of availability and intelligent operation advantages. The architecture of the industrial Internet platform is well-designed, and the many management nodes throughout the operation of the foundry blast furnace are woven together into a cloud-based centralised control network, which realises an all-round control of the production process. The core objective of the platform is to build a storage, management, modelling and design and development environment tailored for industrial big data, while ensuring seamless and efficient interaction between physical operators, users and machines, thus significantly improving the efficiency and accuracy of operation and management.

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