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Design and Development of Mobile Application for Aluminum Electrolysis Cell Control

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Abstract: *To solve the problem of low timeless interactivity and limited flexibility in traditional cell control systems for aluminum electrolysis, this study carries out a mobile visualization upgrade and transformation of the cell control system based on the cross-platform development framework of uni-app front-end and Flask micro-service back-end. The research has realized core functions such as visualization of production reports, chart display of process parameters, real-time monitoring of electrolysis cell status, and multi-dimensional query of control parameters. It also integrates message push and voice recognition technologies to achieve functions such as over-limit alarm push for process parameters, intelligent scheduling notification for pole-changing operations, and rapid voice input of key parameters such as cell temperature. After being deployed and applied in an aluminum company in Henan, this application has significantly improved the real-time performance of production control and operational convenience.*

Keywords: *Aluminum Electrolysis Cell, Cell Control System, Mobile Application, Uni-App*

1. Introduction

With the rapid development of the digital economy, mobile Internet technology is reshaping the operational models of various industries profoundly. Smart-phones and the commercial implementation of 5G technology are popular, mobile client technology has achieved remarkable results in fields such as finance, telecommunications, government affairs, and retail[1]. Traditional PC-based applications can no longer adapt to the requirements of modern industrial production for real-time performance, mobility, and intelligence. As an important pillar of the national economy, the aluminum electrolysis industry urgently needs to adapt to this wave of digital transformation.

The aluminum electrolysis cell control system is one of the most important control systems in the aluminum electrolysis industry. It mostly adopts the mode of "centralized-monitoring + on-site operation", and realizes the parameter adjustment and status monitoring of the electrolysis cell through the PC-based cell control system in the workshop control room[5]. The PC-based application of the cell control system can no longer meet the needs of users in aluminum plants. Users are eager to obtain various data on electrolysis production, control, and management conveniently on mobile-based anytime and anywhere, so as to get the status of electrolysis cells timely, carry out lean management better, and provide the stable, efficient and real-time production of aluminum enterprises.

On the basic of the current report and curve functions in mobile-based of the cell control system, this study researches technologies such as message push[3] and voice recognition[4] to realize functions such as notification and reminder of electrolysis cell operation information, push of alarm information of electrolysis cell process parameters, and voice input of measurement parameters. It truly enables multi-level users of the enterprise to get the status of electrolysis cells anytime and anywhere according to their permissions, improves the management level of the enterprise, and enables operators to obtain electrolysis cell data in anytime within the workshop, thereby significantly improving the flexibility of production management and emergency response capabilities.

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2. System Design of Mobile Application for Aluminum Electrolysis Cell Control

The aluminum electrolysis cell control system is one of the most commonly used applications in the aluminum electrolysis industry, and it is generally deployed on the PC side with a C/S architecture. At present, production technicians manage and learn about electrolysis cells through functions such as reports (daily report, shift report, effect report), process curves, and control parameters provided by the cell control system, these can ensure that the daily operation tasks (aluminum extraction, pole changing, bus-bar lifting) of electrolysis cells and process control parameters (voltage, feeding interval, cell temperature, two levels, etc.) are in a normal and stable state.

With the development of business and the rapid development of IT technology, the only PC-based application of the cell control system in the aluminum electrolysis industry can no longer adapt the needs of users in aluminum plants. Users at all levels are eager to get various data on electrolysis production, control, and management conveniently on mobile terminals anytime and anywhere, so as to timely get the status of electrolysis cells, better carry out lean management, and provide guarantee for the stable, efficient and real-time production of aluminum electrolysis enterprises. Therefore, it is necessary to develop a mobile application for the cell control system based on the functions of the existing cell control system, and realize the functions of message push and voice input to facilitate the convenient operation of on-site operators.

2.1 System Architecture Design

The system consists of three parts: data source, middleware, and upper-layer application. The data source of the system mainly comes from the data of the cell control system, with a small amount of electrolysis operation and manual measurement data; the middleware is a cross-platform development framework of SQL Server database, Uni-app front-end + Flask back-end service, and third-party SDK; the upper-layer application uses components such as u-Charts of uni-app to visualize the original functions of the cell control system such as cell control reports and process curves on the mobile phone, intuitively display the change trend of the process indicators of the electrolysis cell, and realize the real-time monitoring of the electrolysis cell[5]; futhermore, the technologies of message push and voice recognition are studied, and the corresponding SDKs are integrated to implement the new functions of over-limit alarm push of process parameters, intelligent scheduling notification of pole-changing operations, and rapid voice input of KPI parameters such as cell temperature[6]. The system architecture is shown in Figure 1.

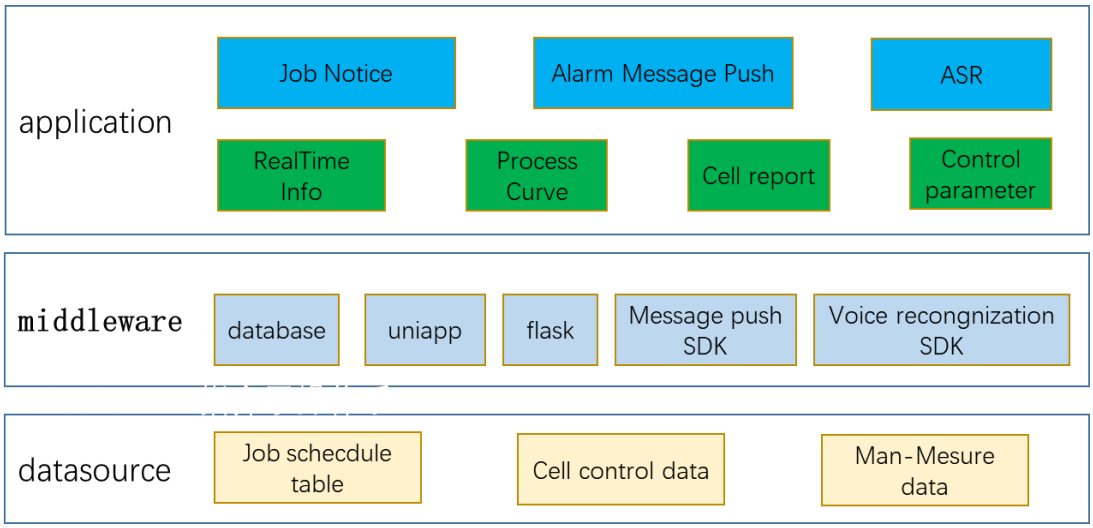

Figure 1 System architecture diagram of cell control mobile application.

2.2 System Function Design

According to the current report and curve functions of the PC-based cell control system and the Touch-based Interaction of Mobile User Interface(MUI), the functions of the mobile-based aluminum electrolysis cell control mainly include five parts: "Home", "Report", "Curve", "Voice Input", and "My". The system functions are shown in Figure 2.

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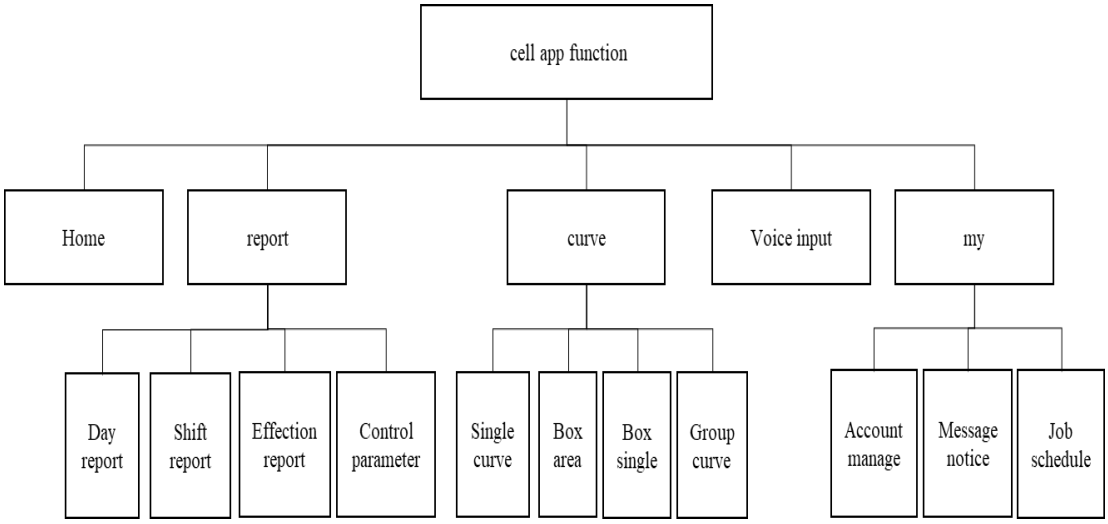

Figure 2 System function diagram.

(1) Home module: Displays the original instant information function of the cell control system in the form of a list, mainly including voltage, set voltage, target voltage, feeding status, working status, control mode, set NB, swing time, effect coefficient, flashing effect, fault, etc.

(2) Report module: Mainly displays the relevant data of the daily report, shift report, and effect report of the electrolysis cell and the real-time viewing of the current control parameters of the electrolysis cell.

(3) Curve module: Displays the relevant data of the process indicators of the electrolysis cell in the form of line charts, box plots, etc. It mainly includes four functions: single curve display, box plot work area, box plot single cell, and curve group display.

(4) Voice input module: Studies voice recognition technology to realize the voice recognition input of manual measurement data such as cell temperature, aluminum output, and two levels in the electrolysis production process, minimize manual input and improving data quality.

(5) My module: Including message push, job scheduling, and user management functions[2]. Study the message push technology to realize the directional push of over-limit alarm message such as electrolysis cell temperature, iron-silicon content, bath level, al level and molecular ratio, so that user can timely get the operation status of various process indicators and take an Emergency Handling; the electrolysis cell usual job information management function provides the notification, reminder, and query functions of the aluminum extraction and pole-changing job schedule; user management realizes user management functions such as user permissions and password modification.

2.3 Network Topology Design

The aluminum electrolysis cell control system is one of the most important control systems in aluminum electrolysis production, and its control effect directly affects the stability and safety of the electrolysis cell. The mobile application of the cell control system needs the mobile phone can access to the data of the cell control system, that is, the external network can access the data of the cell control system. Considering to minimize the impact on the cell control system and based on the safety of data, the front-end of the cell control mobile application is deployed on the Tencent cloud server, the back-end service is deployed on the industrial 4G DTU deployed in the computing station. In terms of data transmission, the front-end and back-end services realize secure data transmission through VPN. The back-end service of the system obtains data by deploying an industrial 4G DTU in the computing station of the cell control database server to build a wireless network to access the data of the cell control system. The network topology is shown in Figure 3.

Therefore, the cell control mobile application is deployed on the Tencent cloud server. Ngix reverse proxy and VPN Client are installed on the cloud server. Users deploy an industrial 4G DTU before the cell control data server of the computing station through the VPN Server. The VPN client and back-end service are deployed on the industrial 4G DTU. The industrial 4G DTU and the cell control database server are in the same network to obtain the data on the cell control database server, so as to realize that the users on the mobile phone side obtain the cell control data through the industrial 4G DTU.

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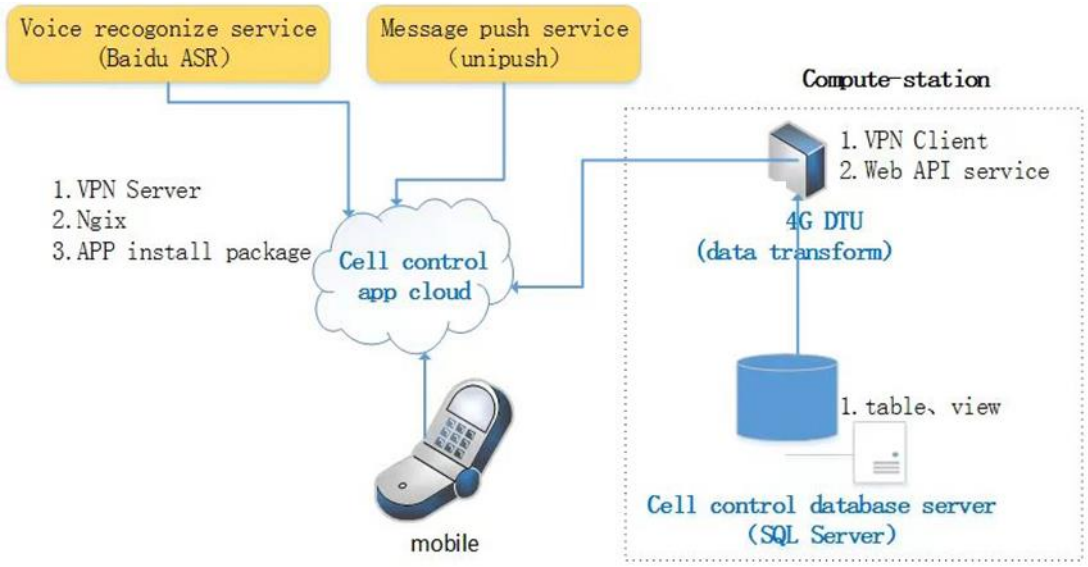


Figure 3 Network topology diagram.

3. Development of Mobile Application for Aluminum Electrolysis Cell Control

3.1 Development Environment and Technology Selection

The development of mobile applications mainly includes mobile APP, applet, mobile web, etc. The application on the mobile APP side needs to adapt to the two operating systems of IOS and Android, so it is necessary to develop two sets of codes respectively. In this study, the front-end uses the uni-app cross-platform front-end framework for mobile development, and uses HBuilder as the front-end development environment. Uni-app is based on Vue.js syntax and has the characteristics of "write once, run on multiple terminals", which can simultaneously compile and generate application programs for multiple platforms such as Android, iOS, and H5. By using the rich component library and API of uni-app, the user interface is quickly built to realize the functions of real-time monitoring data display, remote control operation interface, early warning information prompt, etc. At the same time, using the conditional compilation function of uni-app, performance optimization and function adaptation are carried out for different platforms to ensure the smooth operation and good experience of the application on each platform.

The back-end is based on the Python, selects the Flask framework to build the service, and uses Pycharm as the back-end service development environment[6]. As its lightweight and flexible characteristics, API interfaces are quickly built to process data requests and instructions sent by the front-end. In terms of data processing, the pandas library is used for data cleaning, transformation, and analysis, and the numpy library is used for numerical calculation; the scikit-learn library is used to realize the over-limit alarm of electrolysis cell process indicators and the scheduling of pole-changing operations; the SQLAlchemy library is used to realize the interaction with the database (such as MySQL) to complete the storage and query operations of data. At the same time, combined with servers such as gunicorn, the concurrency processing capability and stability of the back-end service are improved.

3.2 Abnormal Alarm Message Push

At present, there are many products of third-party message push services, such as Jiguang, uni-push, etc. Uni-push is an integrated unified push service launched by DCloud in conjunction with Getui Company. It builds in the system-level push of mobile phone manufacturers such as Apple, Huawei, Xiaomi, OPPO, VIVO, Meizu, and Google FCM, as well as third-party push such as Getui. It is an efficient mobile message push solution. Considering that the front-end framework uses uniapp, this system uses unipush to realize the notification of alarm information such as over-limit of cell temperature and iron-silicon content, and the notification of pole-changing and aluminum-extracting operations[7].

The message push of uniapp includes single push, batch push, group push, and group push. Single push (toSingle): push messages to a single user; toList (batch push): push messages to a specified batch

ISSN 2616-5767 Vol.8, Issue 4: 1-9, DOI: 10.25236/AJETS.2025.080401

of users; group push (toApp): push messages to all users of the APP who meet the screening conditions, supporting fixed-speed push, timed push, and supporting the intersection, union, and complement functions of conditions; group push (toGroup): Getui provides customized solutions for live broadcast rooms to solve the massive message transmission in live broadcast rooms. Uni-push supports offline message storage and high-concurrency push. Even if the mobile phone is in an offline state, it can receive messages after the network is restored, ensuring the timely delivery of production tasks[8].

This article mainly uses the single push (toSingle) and toList (batch push) functions of uniapp. With the label and alias functions, according to user role, the single push (toSingle) or toList (batch push) method is used to batch push the over-limit alarm messages of key parameters such as voltage, temperature, and current efficiency of the electrolysis cell to the corresponding operators. At the same time, using the timed-push and custom message body of uni-push, the notification time is planned in advance, and the detailed pole-changing operation content, requirements, and other information are carried to push the operation information to the duty-user. The key code for message push is as follows:

```
APPID = ""
APPKEY = ""
MASTERSECRET = ""
CID = ""
HOST = "http://api.getui.com/apiex.htm"
def pushMessageToSingle():
    push = IGeTui(HOST, APPKEY, MASTERSECRET)
    template = NotificationTemplateDemo()
    message = IGtSingleMessage()
    message.isOffline = True # isOffline
    message.offlineExpireTime = 1000 * 3600 * 12      # offlineExpireTime
    message.data = template # (0:any;1:wifi;2:4G/3G/2G)
    message.pushNetWorkType = 0
    target = Target()
    target.appId = APPID
    target.clientId = CID
    target.clientId = ALIAS
    try:
        ret = push.pushMessageToSingle(message, target)
        print(ret)
    except RequestException as e:
        requstId = e.getRequestId()
        ret = push.pushMessageToSingle(message, target, requstId)
        print(ret)
def NotificationTemplateDemo():#
    template = NotificationTemplate()
    template.appId = APPID # set APPID and APPKEY
    template.appKey = APPKEY
    style = Style0()
    style.title = str("warning info")
    style.text = str("cell tempreture over")
    style.logoUrl = ""
    style.isRing = True #
    style.isVibrate = True
    style.isClearable = True
    style.channel = " channel ID"
```

ISSN 2616-5767 Vol.8, Issue 4: 1-9, DOI: 10.25236/AJETS.2025.080401

```
        style.channelName = " channelName "
        style.channelLevel = 3    #
        template.style = style
        template.transmissionType = 1
        template.transmissionContent = "1001#cell tempretrure is 953℃, over standard 950℃"
        return template
pushMessageToSingle()
```

3.3 Voice Recognition Input

In the mobile application of aluminum electrolysis cell control, voice recognition technology brings new breakthroughs to operation and management. Uni-app mainly supports the voice recognition of iFLYTEK and Baidu. Baidu voice recognition can convert recorded audio files in a specific format into text, which is suitable for various scenarios such as voice interaction of mobile applications, voice content analysis, intelligent hardware, and intelligent customer service in call centers.

This article uses Baidu's voice recognition service to realize the voice input of aluminum output, cell temperature, etc. When developing the mobile phone application, access Baidu's voice recognition SDK, complete the application for API keys, development environment configuration, and other operations according to the official documentation, and realize the basic integration of voice recognition functions. Using the voice recording and recognition interface provided by the SDK[9], a voice input entrance is built in the application. When the user clicks the voice input button, the mobile phone microphone starts to record the voice. After the recording is completed, the voice data is automatically sent to Baidu's voice recognition server. The server quickly converts the voice into text information based on the deep neural network algorithm and returns it to the mobile phone application interface for display. At the same time, the application can set the functional scenario of voice input. For example, when querying the data of the electrolysis cell, the user says "No. 1001 cell temperature 953℃, electrolyte level 26cm, aluminum level 18cm" through voice. After the system recognizes the text, it automatically retrieves and displays the result "No. 1001 cell temperature 953℃, electrolyte level 26cm, aluminum level 18cm". After the user confirms the recognition result, the data is saved to the database according to the rule template {cellno:1101, ddate:2025-05-28 0:00:00, cellt:953, bathdep:26, aldep:18}. The Voice recognition input process is shown in Figure 4.

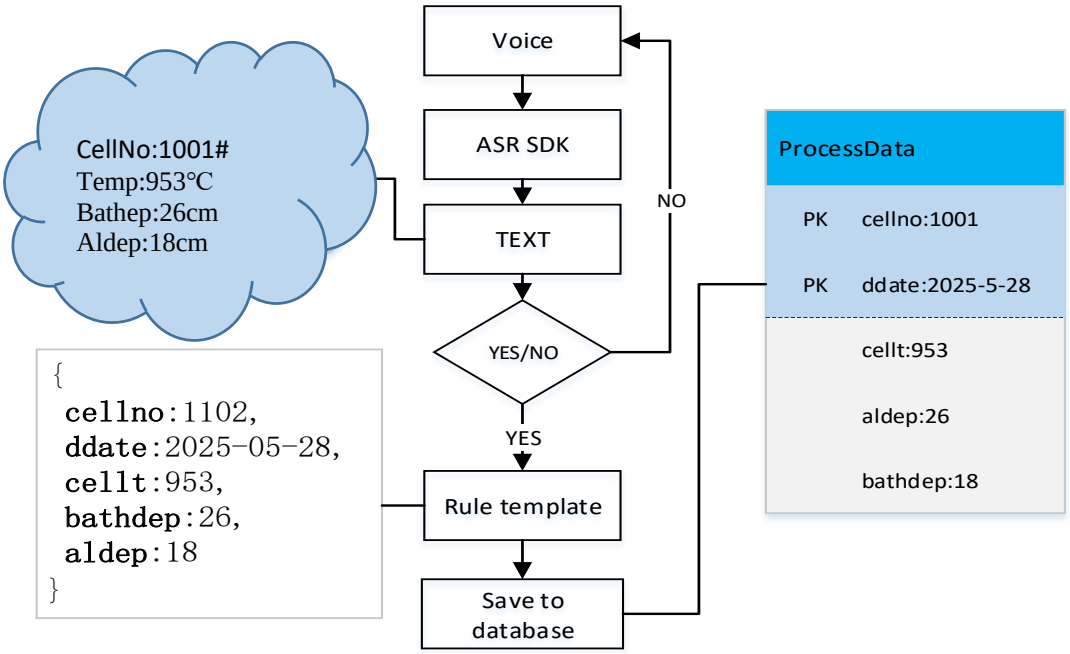
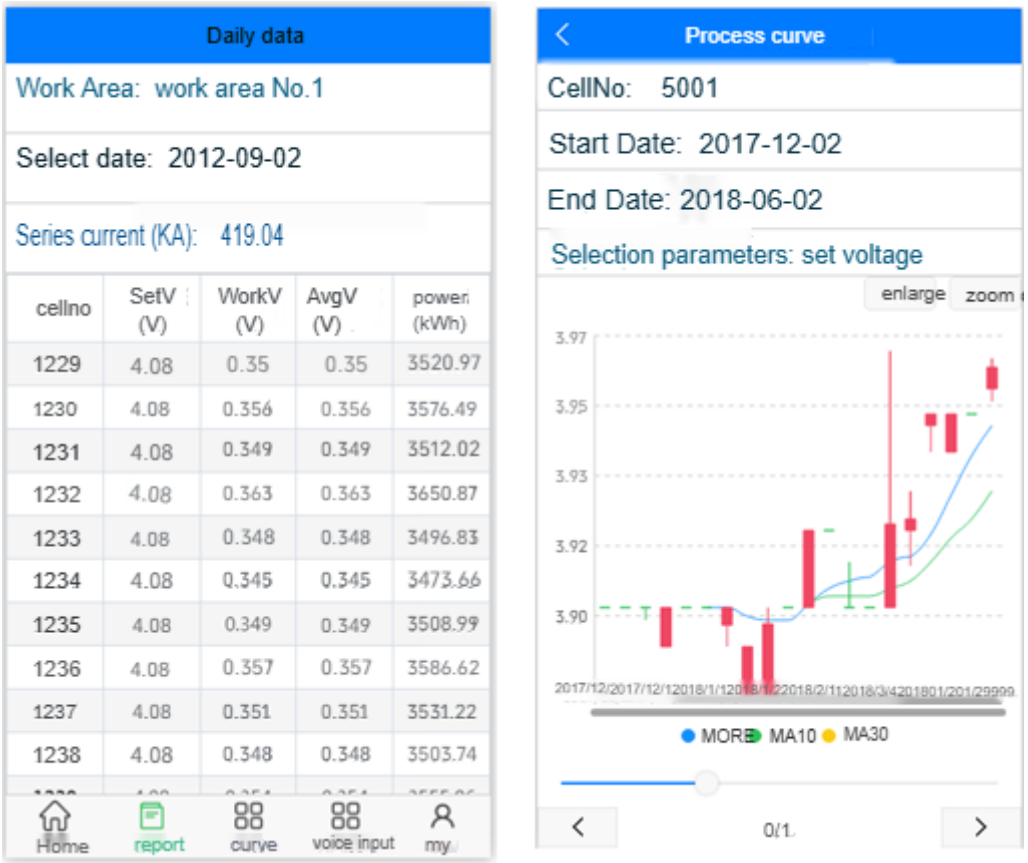


Figure 4 Voice recognition input process.

ISSN 2616-5767 Vol.8, Issue 4: 1-9, DOI: 10.25236/AJETS.2025.080401

4. System Application

The intelligent management mobile application for aluminum electrolysis cells has been deployed in the electrolysis workshop of an aluminum company in Henan. Application practice shows that the system helps operators find the abnormal states of electrolysis cells rapidly by the functions of real-time access to electrolysis cell operation data and push of process parameter over-limit alarm information, and minimize the abnormal response time from an average of 20 minutes to 10 minutes, effectively improving the real-time control of the production management over the operation status of electrolysis cells and the efficiency of Emergency Handling. The System UI diagram is shown in Figure 5.



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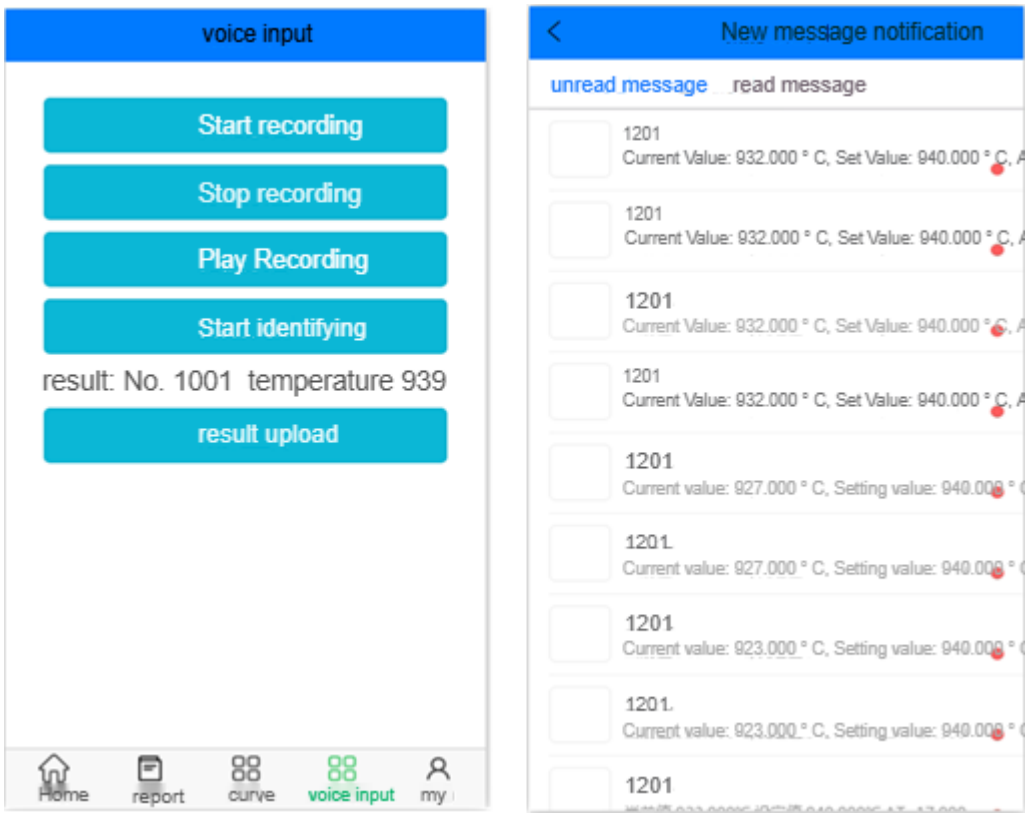

Figure 5 System UI diagram.

In terms of technical architecture, the cross-platform application built based on the uni-app framework realizes seamless adaptation of multiple terminals, coupled with the efficient data processing capability of the Flask micro-service back-end. This architecture truly breaks through the management barriers of different levels of the enterprise, enabling the decision-making level, management level, and operation level to get the operation data of electrolysis cells through mobile terminals anytime and anywhere. In particular, front-line operators can retrieve the key parameters of the cell in real time within the workshop, significantly enhancing the flexibility of production management and the speed of emergency response.

5. Conclusion

This paper adopts a cross-platform development framework of uni-app front-end and Flask micro-service back-end architecture to implement visualization upgrades on mobile-based for the traditional cell control system of aluminum electrolysis cells. On the basis of realizing the core functions such as visual display of production reports, dynamic display of operation curves, real-time monitoring of cell status, and multi-dimensional query of control parameters, the technologies of message push and voice recognition are researched and integrated to realize the functions of over-limit alarm push of process parameters, intelligent scheduling notification of pole-changing operations, and rapid voice recognition input of key parameters such as cell temperature. It solves the problems of low timeless and limited flexibility of the traditional cell control system, supports the management to remotely control the operation status of the electrolysis cell through the mobile, helps the operators to realize the real-time retrieval and quick input of parameter data within the workshop, and significantly improves the real-time performance of production control and operational convenience.

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