Design of Underground Mine Locomotive Monitoring and Tracking Management System

Song Jin-xing\textsuperscript{a}, Liu Yu-fang\textsuperscript{b,a}\textsuperscript{*}

\textsuperscript{a}School of Energy Science and Engineering, Henan Polytechnic University, Jiaozuo 454003, China
\textsuperscript{b}Institute of Resource and Environment, Henan Polytechnic University, Jiaozuo 454003, China

Abstract

For low safety coefficient of coal system and locomotive management, management system of underground mine locomotive monitoring and tracking is designed. This system uses the low-power RFID technology. Vehicle positioning substation collects real-time data from electronic tag. These data are transmitted to the latest wireless communication substation of mine through WiFi, and then to ground central station through industry Ethernet network. The ground central station achieves the collection of underground mine locomotive monitoring and tracking information, analysis and processing, real-time visualization, historical data storage, report inquires the printing, etc.

Key words: Underground locomotive positioning; GIS; Internet of Things; Management system

1. Introduction

Most of China coal mine are remote, underground laneway are vertically and horizontally, distribution of equipments and workers personnel are wide, complex and flexible, their fluidity big, communication between the ground and locomotive is difficult\textsuperscript{[1]}\textsuperscript{~}[2], so real-time dynamic mastery of the distribution and underground locomotive is very significant. In order to take the necessary assistance measures in time

\textsuperscript{*}Corresponding author. Tel.: 13183128602.
E-mail address: songjinxing@hpu.edu.cn

© 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
Selection and/or peer-review under responsibility of Conference ESIAT2011 Organization Committee.
and decrease the loss and impact to the minimum, it is very necessary to rapidly judge
the number and position of locomotive in danger at outstanding events. In underground
stations to establish a complete and real-time management system of locomotive
monitoring and tracking, can strictly manage and real-time supervise underground
locomotive station, arrangement, passing in and out laneway, and so on. At the same
time, the information of specific locomotive quantity, accident situation, rescue equipment
can be got as soon as possible to insure high efficiency of emergency rescue and
disaster relief. At present, our country underground mine locomotive positioning mainly
depends on wire communication. For rail locomotive, now it is the most to use
orientation relay + wire communication[3]~[4]. On account of the limit of technique,
cost and locale installation environment, orientation relay can’t be high-density installed,
only on key situation, such as turnout, station, etc. and can’t realize precise positioning
during the course of locomotive run. Aiming the above situation, management system
of underground mine locomotive monitoring and tracking is designed. This system uses
the low-power RFID technology. Vehicle positioning substation collects real-time data
from electronic tag. These data are transmitted to the latest wireless communication
substation of mine through WiFi, and then to ground central station through industry
Ethernet network. The ground central station achieves the collection of underground
mine locomotive monitoring and tracking information, analysis and processing, real-
time visualization, historical data storage, report inquires the printing, etc.

2. System Layout

2.1. Requirement analysis

On the basis of system design goal, connecting the actual needs of coal mine
underground locomotive management, the design of underground coal mining
locomotive monitoring and tracking management system is realized, including the
following contents:

- Display underground laneway exploitation and basic layout by graphics mode.
- Check locomotive’s number, serial number, move direction and section number
everywhere.
- According to the vehicle dispatching plan, real-time control underground traffic
signal lamp and command locomotive run safely.
- In time alarm to remind locomotive driver when the locomotive offside or in danger .
- Repeats actual locomotive transportation process within specified time.
- Automatically calculate locomotive and account production assignment, create and
print every kind of related production report.
- Reflect working status of system inside equipment, to examine and eliminate system
fault in time.

System feasibility can be analyzed after requirement analysis.

2.2. Feasibility analysis

The promotion of Internet of Things technologies and concepts has the vital
significance for promoting our coal mine enterprises' safe production management level.
Based on the two dimensional code and RFID technology, WiFi position technology,
the Internet of Things connect personnel, equipment and network, to exchange information and communication, through wireless Ethernet and industrial Ethernet, to realize intelligent identification, location, monitoring and achieve "human and human", "things and things" and “human and things” collaborative work, intelligent management of innovation applications. Unifying the actual need of coal mine underground locomotive management, the system should have underground locomotive positioning and tracking information collection, analysis, real-time display, historical data storage, report query, and the function of printing, and so on. The several research and development can come true through Internet of Things technology and GIS technology.

3. System Design

3.1. System design principles

- Display underground laneway exploitation and basic layout by graphics mode.
- Realize the effective recognition, monitoring and intelligent scheduling of underground coal mine locomotive, make management system fully embody "humanity, information and high automation" and realize the goal of wisdom mines.
- For mine managers real time provide locomotive position, serial number, running direction, car number, section number of single tramcar, final section position and lighter state, turnout position, and so on. In case produce coal mine safety accident, through this system can immediately know in dangerous area trapped locomotive quantity and position, and guarantee the high-efficient rescue and relief work.
- Ensure system design safety, expansibility and maintenance, easy operation.

3.2. System design principles

3.2.1. System working principle

Underground mine locomotive monitoring and tracking management system, which is mainly used in underground locomotive locating and tracking, is made of positioning sub-station installed on the locomotive(including shoot antenna, take-over antenna, object identifier), identification card installed over the ceiling of underground tunnels, wireless communication sub-station installed in the mine laneway and ground station software. Identification cards are installed over the ceiling of underground laneway at the interval of 2m. Wireless communication sub-station is commonly installed on the key position, such as import and export, crossroads. If two key positions are relatively far apart, the sub-station can be installed every 100 meters along tunnels straight-line distance. When the locomotive carrying positioning RACES through identification card controlling area, identification card immediately emits a representative information of
the identity characteristics, which is received by object identifier of positioning substation carried by locomotive and translate to the nearest wireless communication RACES, then to ground stations. After ground stations receive communication encoded signal, it can realize underground locomotive tracking information collection, analysis, real-time display, historical data storage, statements inquiry and printing, etc. It uses wireless Ethernet protocol to connect positioning sub-station installed on the locomotive and wireless communication RACES over the laneway, and can support video, voice, data and so on many kinds of media information, and can receive the ground under real-time various dispatching instructions. System topological structure is shown as figure 1.

This article mainly discusses the design process of management system of underground mine locomotive monitoring and tracking.

3.2.2. System function design

System function design is shown as figure 2.

- Map browse function: as system uses GIS electronic map, users can amplify, reducing, translation, roaming and navigation browsing operation.

- Visualization monitoring function: real-time dynamic tracking and visualization monitoring underground locomotive. With the Chinese character, simulation diagram and table shape, in computer terminals and graphic display equipment real-time show locomotive position, car number, section number of single tramcar, final section position and lighter state, turnout position, and so on.

- Schedule function: automatically dispatch locomotives to safely and efficiently transport according to running plan made by operator. System has alarm function at the time of locomotive offside, such as sound or light warnings.
• Hardware malfunction diagnosis function: at any time reflect system equipment and sensor work state, and complete automatic alarm, processing or warning before the personnel on duty treats.

![System Topology Diagram]

• Information management function: automatically statistics management of wagon and the production task statistics management, and generate and print various related production management reports.
• Data query module: mainly complete searching and summarizing the original data by various condition, this function realization consists four parts, raw data filtering, further details conditions queries, browse inquiry results and summarize the qualified data. Query modules include:
  -- inquire the dynamic distribution of underground locomotive and quantity;
  -- inquire any designated position locomotive and real-time display and track;
  -- inquire any locomotive track on the designated date, for the analysis of accident reason and improve the scheduling strategy provide the basis;
  -- inquire the scheduling table;
  -- inquire the personnel and locomotive assignment schedule.
• Report print function: can print all the query and summarized information.
• System maintenance function: this module can be finished only by system super user. The items of this module include: basic information maintenance, operation personnel maintenance, every laneway sub-station maintenance, database maintenance, on-duty situation browse, identification card initialization.
4. Closing

Underground mine locomotive monitoring and tracking management system expands mining rail net existing capacity, to increase traffic density of mining locomotive, real-time provide the position information, avoid traffic accident, greatly enhance the safety transportation and production efficiency.

References


