Executive Summary
This article introduces the applications and features of the latest Honeywell programmable controller, MasterLogic-200 and HCiX10 touch panel, in the Anmao Highway tunnel monitoring system.

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Project Overview

The highway from Ankang to Maoba and then to the border between Shaanxi and Sichuan provinces is an important part of the Baotou-Maoming route (shortened to the “Anmao Highway” hereinafter) of the national expressway system, as well as an important component of Shaanxi Province’s expressway network comprised of “three north-south, four east-west and five radial highways”. The total length of this route is 104.582km, including 85.614km stretch from Ankang to Maoba, and 18.968km stretch from Maoba to the border between Shaanxi and Sichuan provinces. The highway from Ankang to Maoba and then to the border between Shaanxi and Sichuan provinces is a project featuring highly difficult construction, the most complex of construction environments, and the largest bridge-to-tunnel ratio within Shaanxi Province’s expressway network, with its 33.173km (twin-tube)/23 tunnels (including 19.538km/4 extra-long tunnels and 8.022km/5 long tunnels), wherein bridges and tunnels account for 77.8% of the total length of the highway. The construction of this project is of great importance to China’s expressway network, as well as to the implementation of strategies for developing West China, tightening the economic links between Shaanxi and Sichuan provinces, improving regional transportation conditions, boosting economic and social development along the route and contributing to breakthrough developments in the South Shaanxi region.

Control System Components and Type Selection

A Central Monitoring Center for the Anmao highway tunnel monitoring project has been set up at the Highway Management Section. The Central Monitoring Center communicates with 90 sets of local control PLCs and 14 sets of master control PLCs located at 23 tunnels and 14 transformer stations by means of a redundant fiber optic ring network, thereby providing remote monitoring of the operating status or operation of tunnels and transformer stations. Honeywell’s industrial level man-machine interface “HCiX-10” has also been set up at each transformer station so that real time monitoring and control of the mechanical and electrical equipment within tunnels under its management can also be provided from within the transformer station.

The system’s network architecture uses fiber optic switching to construct a self-healing redundant fiber optic ring network to ensure that network connection is restored automatically in case of even a single network break point, thus guaranteeing the reliability of data transmission at each PLC node over the backbone network. The Honeywell MasterLogic PLC supports TCP/IP-based industrial Ethernet, provides open and efficient network protocols, facilitates system expansion and interconnectivity, and offers good openness, facilitating communication and integration between master control PLCs at transformer stations and regional PLCs within tunnels under their management.
In order to demonstrate the design philosophy of "distributed control and centralized management" in this system, the master control PLCs at transformer stations need to conduct centralized monitoring for all mechanical and electrical equipment within tunnels under their management. The system therefore has relatively high reliability requirements. Our design uses Honeywell MasterLogic-200 redundant controllers, each supporting redundant power supplies and redundant CPUs to satisfy field requirements. For tunnel area controllers offering monitoring and management of mechanical and electrical equipment within designated tunnel zones, redundant-power-supply & single-CPU controllers are utilized. At each transformer station, Honeywell’s industrial level man-machine interface HCIX-10: is used to facilitate the provision of field-level monitoring and management on various types of mechanical and electrical equipment inside the tunnels.
The MasterLogic-200 Series redundant controller can reach 25MB without having to expand its internal memory. It can also integrate USB, serial ports and Ethernet, and supports multiple kinds of communication protocols such as MODBUS, Profibus, etc. In addition to satisfying system design requirements, it also significantly saves the costs of other accessories selected and adopted within the system and provides a guarantee for successful future system expansion. The MasterLogic-200 redundant system offers highly efficient synchronous data interchange to ensure that the system switches over automatically when errors are detected. Both the master machine and backup machine of the ML-200 redundant system will perform information synchronization automatically during each scanning cycle, ensuring that the backup machine will provide control in place of the master machine immediately in the event of any problem occurring with the master machine. This ensures that the tunnel system offers a high degree of usability and guarantees the long-term, continuous and stable operation of the tunnel control system.

Control System Functions

The tunnel’s regional controller system accomplishes tunnel section control. It centralizes outfield equipment into small areas and allows for two-way communication between the computer at the monitoring and management office and outfield equipment to enhance communication efficiency and strengthen local manual control capabilities. Regional controllers are installed inside specially reserved cavity rooms and are set from the tunnel’s entry/exit points, near traverse holes or inside transformer stations. They primarily offer the following functions:

Traffic detection

The traffic flow conditions of tunnel sections are detected in real time using microwave vehicle detectors at tunnel openings and loop-coil vehicle detectors inside the tunnels.

The parameters detected include: vehicle type classification, vehicle flow rate, lane occupancy rate, and average vehicle speed, etc.
Traffic guidance control
Traffic control is divided into manual control and automatic control. Manual control: when communication is normal, tunnel management office on-duty staff conduct remote manual control on traffic guidance equipment through various monitoring workstations based on field requirements, wherein the information displayed by variable information symbols can be entered manually by operators; when communication is abnormal, relevant staff use the field touch screens to manually implement operating states preset in the regional controllers. Automatic control: field regional controllers carry out automatic control on tunnel areas based on the data collected and relevant instructions sent from tunnel management offices. Coordination of control for the entire tunnel is accomplished by tunnel management offices. Traffic guidance control facilities include gantry-type variable-message signs, traffic signal lights, and variable lane control signs, etc.

Cross-channel automatic control
In this project, vehicle cross portal doors are set up inside the tunnels. The input/output signals for vehicle cross portal doors come from the regional controllers of nearby sites, which provide automatic door control and detection of door position numbers, etc. All fire prevention rolling shutter doors and their control boxes are controlled by tunnel fire fighting systems and tunnel power supply systems.

Automatic fan control
The PLC communicates with the soft starter through the communication interface to provide detection of the fan’s status feedback signal. The regional controller allows remote automatic control of the fan’s forward rotation, reverse rotation, starting and stopping, via the input and output of digital signals to the fan control box. Fan control boxes, soft starters, fan local manual control, and control circuits are all controlled by the power supply system.

The fan’s automatic controls manage the number of operating fans, their wind speeds, wind directions and operating times based on visibility, CO concentration and traffic volume data detected, thereby achieving energy-saving and controlled operation ensures an optimum product life. It also performs corresponding smoke removal handling in case of fire based on the specific requirements of different locations, ensuring tunnel safety and a comfortable operating environment.

Automatic lighting control
Automatic tunnel lighting control can be detected via program computation based on conditions including outside brightness data, variations in traffic volume, daytime and night time, etc. By turning lighting circuits on or off, the brightness at entries, exits and inside tunnels can be adjusted to ensure safe and smooth traffic flow, achieve energy-saving operation while satisfying lighting requirements, and detect the status of in-tunnel lighting and lighting control equipment.

Manual lighting control can be achieved through either low-voltage lighting distributing boxes inside transformer stations or field lighting distributing boxes.

Project Operation
This project was successfully commissioned and went into operation on December 30, 2010. The entire highway was formally opened to traffic on March 10, 2011. Through implementation of this project, we have experienced the powerful functionality of Honeywell MasterLogic-200 PLC, which is simple to use and easy to debug and maintain.

Application Experience
The following experience has been acquired through the design, implementation and commissioning of the tunnel monitoring system for the Baotou-Maoming highway from Ankang to Maoba and then to the border between Shaanxi and Sichuan provinces:

- The system architecture for tunnel monitoring systems constructed using Honeywell MasterLogic-200 PLC is clear and straightforward. The monitoring layer is equipped with two levels of monitoring and management, i.e. the Central Monitoring Center and transformer station touch screen field monitoring. The control layer is also equipped with transformer station master controllers and tunnel regional controllers to realize the “distributed control and centralized management” design philosophy.
The implementation of MasterLogic-200R PLC’s IO bus redundancy is very simple. The remote IO interface module supports electrical/fiber optic conversion without needing to configure other network accessories so that the system’s high reliability and high availability can be ensured without additional investment.

The MasterLogic-200R PLC’s redundancy configuration is relatively simple, i.e. you only need to move the “A/B side” DIP switches on two CPUs to “A” and “B” positions respectively, put a “√” mark in the “ONE IP Solution” option within the SoftMaster Network Manager setting toolbar, and complete the IP setting of the master CPU, which must be set to an even number. Then you simply download into the master PLC. When the synchronous fiber optic cables on master and backup CPUs are connected, data is automatically transferred from the master CPU to the backup CPU to provide the redundancy capability.

Due to the fact that the equipment controlled by the tunnel monitoring control system is relatively unitary, and large in quantity, with most equipment consisting of fans, lighting devices and traffic signal lights, all with similar control methods, if each piece of equipment were to be programmed one at a time, the workload would be extremely high, with a high rate of errors and numerous modification difficulties. The use of Honeywell PLC custom function blocks in PLC programming by setting up a function block for each kind of equipments and allocating function blocks to specific pieces of equipment dramatically saves programming times and programming workload.

References

- MasterLogic-200R User Guide
- Fast Ethernet I/F Module 2MLL-FEnet User’s Guide
- SoftMaster User’s Guide
- Digital Input/Output Modules ML 200 DI/DO Module User’s Guide
- XDesignerPlus User Manual

For More Information
Learn more about Honeywell’s MasterLogic-200 controller visit our website www.honeywellprocess.com or contact your Honeywell account manager.

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