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Research Article

INTELLIGENT PLANT CONFIGURATION MANAGEMENT IN NUCLEAR POWER PLANT VALVES POSITION MONITORING USING INTERNET OF THINGS

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A R T I C L E I N F O

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A B S T R A C T

In the present competitive world, the nuclear industry is committed to lowering the operations and maintenance cost and also increasing the productivity and efficiency while maintaining safe and reliable operation. The present operating model of nuclear power plants is dependent on large technical staffs that put the nuclear industry at long-term economic disadvantage. Technology can play a vital role in nuclear power plant configuration management by setting a labor costs by automating manually performed plant activities. In proposed system will support the continued safe operation by providing the technical means to monitor components in plants today that are only routinely monitored through manual activities. The wireless-enabled valve position indicators are able to provide a continuously available valid position indication rather than only periodically. In real-time ,the valve positions indication using affordable technologies are vital to plant configuration when compared with long-term labor rates, and provide information to plant engineering for maintenance and management applications. The Internet of Things (IoT) network to enable many different devices to communicate between each other across the same network.

INTRODUCTION

In Current operating nuclear power plants (NPPs) in the United States have received permission to extend their operating authority to 60 years. Now the nuclear industry is preparing to extend operating licenses to 80 years. While NPPs are preparing the continuation, it is important to remain Competitive in the electricity generating market. In addition to recent shutdown decisions, there are other nuclear stations that are also at risk of being shut down due to budgetary reasons in energy competitive market. The nuclear industry has already taken most of the economic benefits available through power up rates and more reliable operations (high capacity factors, shorter outages). To upgrade the nuclear competitive position, the industry must focus on reducing the embedded workload in the ongoing operation and support of the NPPs. One of the ways to improve operational efficiency of NPPs is by average advancements in sensor and wireless communication technologies. The area explored and presented in this paper is implementing intelligent plant configuration management with IOT capability. Configuration management is an established concept Plant configuration management is an essential element of NPP design, construction, and operation. Plant configuration control ensures that changes to the plant and systems are properly identified, screened, designed, tested, implemented, and recorded in a timely manner.

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Nowadays the operating module of nuclear power plants is reliant on huge technical staffs that put the nuclear corporation at long-term budgetary disadvantage. This dependency is caused by NPPs having a large number of systems with many operations that are manually performed. Work processes tend to be fairly involved due to nuclear quality and documentation requirements. NPPs conduct a substantial number of supervision activities on an ongoing basis to verify that plant components are in their required positions (open/close, on/off, etc.) for current and upcoming plant configuration. Most plant administration has to be verified by a second person and sometimes even a third person in high-risk situations. With rising labor costs, this puts nuclear energy at somewhat of a long-term economic disadvantage compared to non-nuclear energy generation sources. Dependence on large technical staff also presents human error opportunities, regulatory compliance impact, and personnel safety risk. The United States companies operating NPPs are dedicated to strengthening the industry's promise to excellence in safety and steadfastness, assuring future viability through efficiency improvement, and driving regulatory and market changes so that nuclear energy facilities are fully recognized for their value. To achieve these goals, they are partner with Nuclear Energy Institute's multiyear development called Delivering the Nuclear Promise: Advancing Safety, dependability, and financial Performance. Taking advantage of conventional and emergency sensor technology solutions (in particular, wireless sensors) would effectively augment the best practices identified under the Nuclear Promise. Information from some of the conventional

sensor technology solutions that could be utilized to benefit configuration management in the nuclear industry include thermocouples, resistance temperature detectors ,pressure, flow, neutron flux, water chemistry (e.g., ph and conductivity), and position indicators. Conventional sensor technologies could be upgraded (if possible) to include wireless communication capability. Emerging sensor technology that would benefit the nuclear industry includes fiber optics sensors sensor systems based on field programmable gate arrays, hydrogen sensors, and self-powered wireless sensor nodes.
The paper focuses on automating manual valve position indication (VPI) using commercially available passive resistive sensors and transmitting the information over a wireless network based on internet of things.

The wireless-enabled VPI technology presented in this paper will provide technical means to monitor components (manual valves in this case) in plants today that are only continuously monitored through manual activities. This information can be used for a variety of plant engineering, maintenance, and management applications.

The Internet of Things (IoT) network are used to authorize the many different devices broadcast the data between each other over the same network.

A prototype system was implemented .The results of this work. i.e., online knowledge of current valve position and plant configuration, will also allow operators to make better or more informed decisions, and will provide VPI records for use in the investigation of an event. Additionally, this capability can benefit the nuclear industry by reducing labor costs, reducing radiation dose, reducing nuclear and personnel safety challenges, and improving plant and regulatory performance.
The paper is organized as follow: Section II presents the work related to the project. Manual valve and VPI sensors are discussed in section III. Section IV consists of works done in proposed system. Modeling and results are mentioned in section v. Finally conclusions are presented in section VI.

Related Work

Much of advanced technology was proposed to find the valve position indication. In 2011.Hashemain and W. C. Bean proposed the as new sensors emerge, new qualification procedures and standards must be developed, tested, and implemented. New sensors will undoubtedly have to be qualified to these expected conditions, but currently qualified sensors will most certainly be incorporated into these new NPP designs, too. They will therefore face requalification for the expected new conditions. At present, no generally accepted performance or qualification testing exists for fiber-optic and wireless sensors that would enable their broad acceptance in the nuclear industry and, thereby, enable the realization of these sensors 'financial benefits. In particular, long-term operability and reliability have not been shown for many of these platforms. There have also been few truly objective comparisons between nuclear-qualified sensing and communication platforms and these emerging technologies. The qualification of fiber-optic sensors for next-generation NPPs must address concerns over radiation darkening.

Wireless sensor networks provide NPPs with the capability to employ distributed processing, thereby increasing overall system redundancy and the potential to reduce hands-on maintenance and to improve reliability.

In 2015.Agarwal, J. W. Buttles, L. Beaty, and J. Naser proposed proof-of-concept prototype intelligent plant configuration management system using available wireless component position sensors to help reduce operating costs for field-based component position verification activities as well as reduce operational challenges due to component position errors. The work focuses on position sensors for selected manual valve types. The wireless network implemented in this work is based on The Internet of Things network since it enables many different devices to communicate between each other across the same network. The proof-of-concept prototype presented in this paper would benefit the nuclear industry in several ways including reduced labor costs, reduced radiation dose, reduced nuclear and personnel safety challenges, and improved plant and regulatory performance.

In 2016 Wireless sensors are becoming very popular in industrial processes for measurement and control, condition monitoring, predictive maintenance, and management of operational transients and accidents. In the last five years, many sensor manufacturers have teamed up with companies who make wireless transmitters, receivers, and network equipment to provide industrial facilities with integrated networks of wireless sensors that can be used to measure process temperature, pressure, vibration, humidity, and other parameters to improve process safety and efficiency, increase output, and optimize maintenance
activities.

Manual Valve and Valve Position Indication Sensors

Any commercial NPP has thousands of manual valves for general isolation, control, and/or regulation of the flow of fluids for balance of plant activities. Line-up of manually operated valves is one of the important plant configurations. Activities performed more frequently in NPPs by field workers because the manual valves traditionally do not come with continuous position indication devices. Knowledge about valve position is essential to permit plant operations. Based on discussions with subject matter experts in the area of valves used in NPPs, the following solenoid valve were selected for this project.

Many types of VPI sensors, such as fixed position limit switches, revolution counting, proximity switches, shaft encoders, and linear variable differential transformer were investigated. The pros and cons of each VPI sensor type.

Were evaluated using the following guiding characteristics: (1) low power and continuous linear response; (2) low sensor cost; and (3) low installation cost without compromising valve integrity/qualification. The benefits of wireless-enabled over wired VPI sensor. The passive-type position indication sensor (a sensor that does not require any power to generate a signal) offers the lowest power requirements and will be one of the preferred choices for a position indicator. A resistive sensor (an example of passive sensor type) has the advantage of offering continuous position indication and is a good choice for a VPI. Low sensor cost is important because there are thousands of manual valves in a typical NPP. Retrofitting large number of manual valves with expensive sensors would defeat the purpose. Low installation cost and the ability to not compromise the valve integrity/qualification is required to maintain the certification of use in an NPP.
The MagnetoPot is a type of resistive sensor that best met the desired sensor characteristics for this project. For this work,

The MagnetoPot sensor consists of a resistive strip and a small internal magnetic attractor inside a cylinder. The resistive strip and internal magnetic attractor are designed in a 3-pin electrical configuration when an exterior magnet is in the proximity of the sensor, it attracts the internal magnetic attractor. As the external magnet is moved along the length of the MagnetoPot, the internal attractor moves along the length of resistive element changing the resistance valve from 0 to 10 K ohms.

The voltage response of both cylindrical and rotary MagnetoPot sensors to an external magnet is studied before they are installed on identified valves. In the case of the rectangular MagnetoPot, the external magnet is moved from one end of the strip to the other end in 0.25-inch intervals. The output voltage is recorded at every step. Similarly, in the case of the rotary MagnetoPot, which is to be used on solenoid valves, the external magnet is moved along the circular resistive strip for 90-degrees (from any starting point) in 10 Degree intervals. The output voltage is recorded at every step. The voltage responses of both rectangular and rotary Magneto Pots are linear.

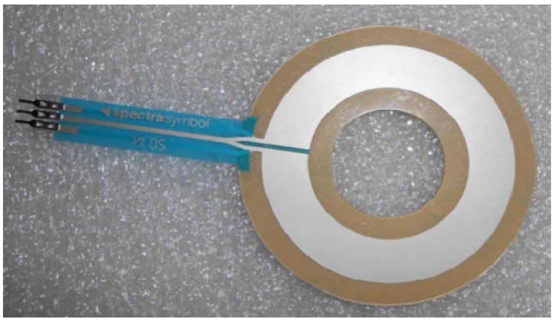


Fig 1 MagnetoPot potentiometer sensors in Rotary form

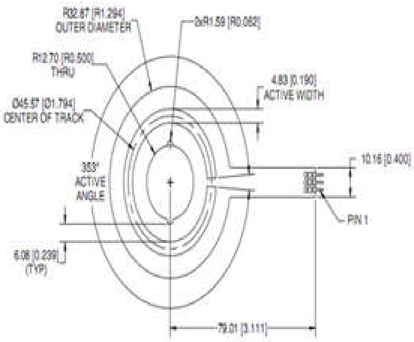


Fig 2 Internal part of rotary form

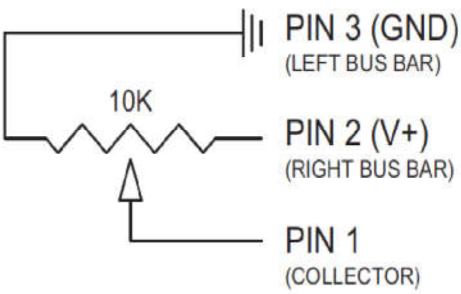


Fig 3 Electrical schematic of Potentiometer sensors

Proposed System

This proposed system support the continued safe operation of today's fleet of light water reactors by providing the technical means to monitor components in plants today that are only routinely monitored through manual activities. The wireless-enabled valve position indicators that are the subject of this work are able to provide a continuously available valid position indication, rather than only periodically. The work utilizes The Internet of Things (IOT) network to enable many different devices to communicate between each other across the same network. The results of this work, i.e., online knowledge of current valve position and plant configuration, will also allow operators to make better or more informed decisions, and will provide VPI records for use in the investigation of an event. Additionally, this capability can benefit the nuclear industry by reducing labor costs, reducing radiation dose, reducing nuclear and personnel safety challenges, and improving plant and regulatory performance.

In proposed system the VPI has the characteristic as follow

1. It enables for large range of switches and sensors.
2. Suitable for use in explosion proof areas and requires no regular maintainace.
3. It can be reset easily when valve end position change due to wear and tear.

Power plant side

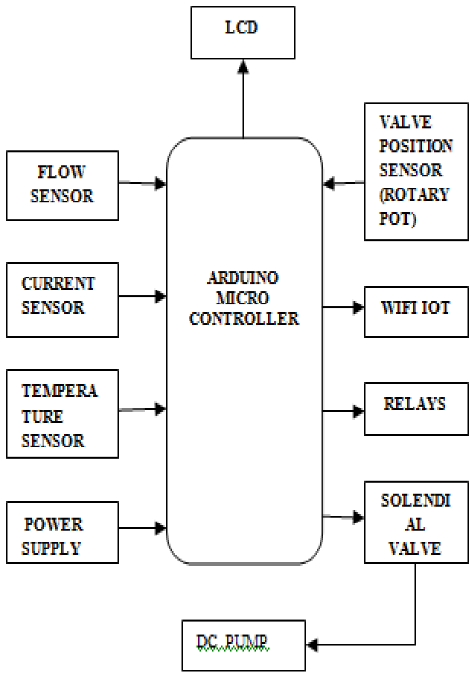
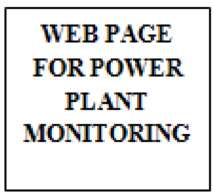


Fig 4 Block Diagram of Proposed System Arduino Uno

Server side



Arduino Uno

Arduino Uno is a microcontroller based on the data sheet. It has 14 digital input or output pins of which 6 can be used as pulse width modulation(PWM) as output,6 analogy inputs, a 16 MHz quartz crystal, a USB connection, an ICSP header and reset button. The Microcontroller simply connected to the computer with a USB cable or a power with an AC to DC adapter or battery to get started the purpose of Arduino is used to transmit the command through the signal. It can be powered using power supply or by using USB cable.

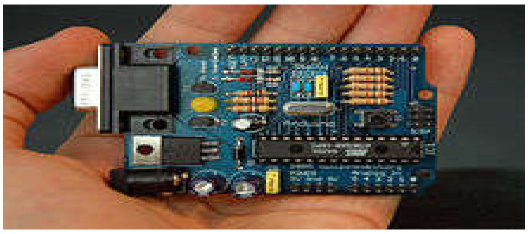


Fig 5 Arduino

The supply voltage is 6 to 20 volts either it is an Ac or DC supply. The Arduino can be able to communicate with the other Arduino or with other microcontroller.

Flow Sensor

Flow measurement is the quantification of bulk fluid movement. Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area.

Current Sensor

A current sensor is a device that detects electric current in a wire, and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for the purpose of control.

The sensed current and the output signal can be

- Alternating current input
- Direct current input

Temperature Sensor

A device which is designed specifically to measure the hotness or coldness of an object.LM35 is a precision IC temperature sensor with its output proportional to the temperature with LM35, the temperature can be measured more accurately than with a thermistor. It also possesses low self heating and does not cause more than 0.1 °C temperature rise in still air.

Solendial valve

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid. In the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports.

Work Flow:

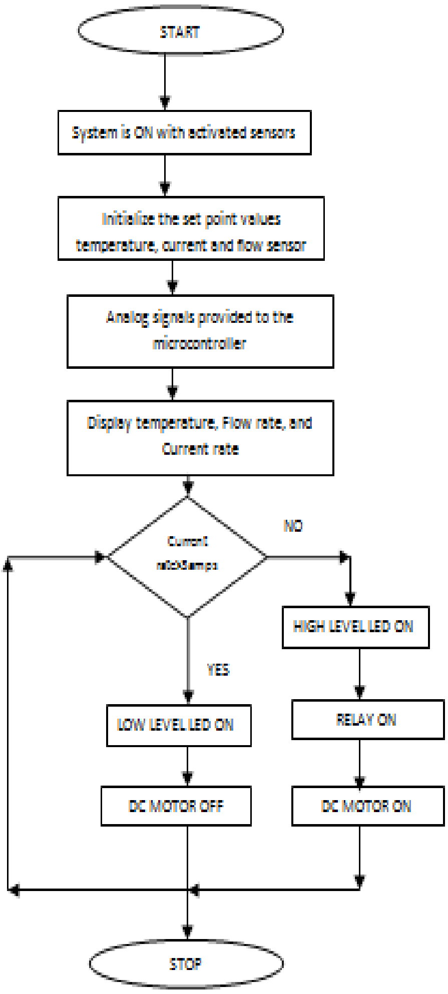


Fig 5 the flow chart of VPI sensor in nuclear power plant.

1. When the system is ON, sensors are activated.
2. Initialize the set point valves of the temperature,current,flow.
3. Input in analog valves are provided to Arduino microcontroller.
4. Lcd will display the valves of flow rate,temperatureand current values.
5. then current rate >3 amps ,low level Led will on and dc motor off, otherwise high level Led will on and relay on, dc motor will run.
6. Continue the process and stop.

MODELING AND RESULTS

The hardware results shows the effective working of the power plant valve position monitoring using IOT.The flow sensor,current sensor ,temperature sensor are used in this project.the Arduino uno board was interfaced with these VPI sensors,LCD display and Solendial valve.

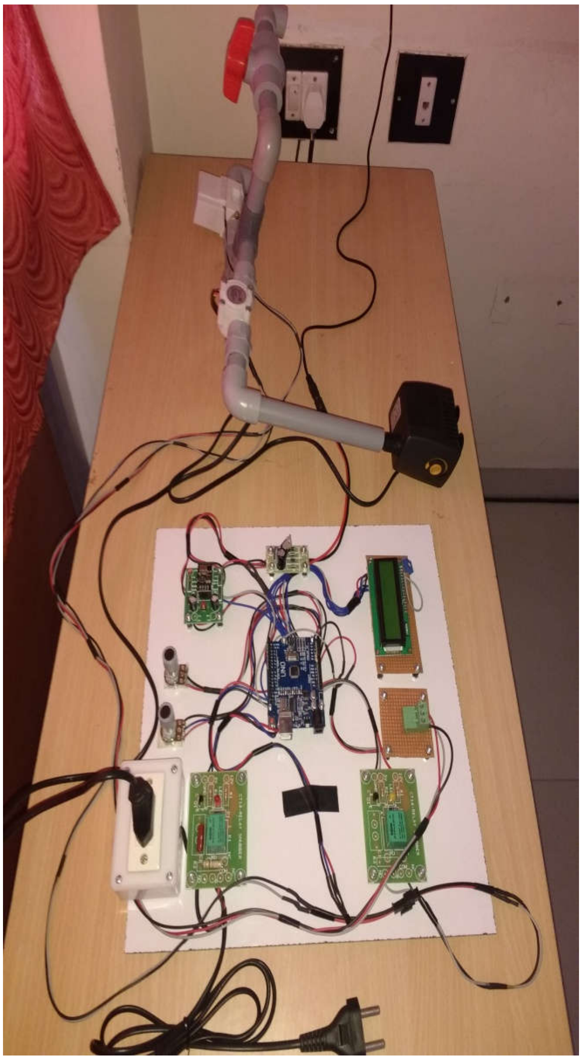


Fig 6 Full view of valve position monitoring in IOT

RESULT

1.When high level led is on, dc motor on

2. When low level led is off, dc motor off

CONCLUSION

The wireless online monitoring of manual valves for plant configuration management in NPPs addressed some of the concerns associated with their current operating model. In particular, the focus was to reduce cost and increase productivity by automating manual operations and reducing possibilities of human errors. The results of this work will allow operators to make better or more-informed decisions To adopt the work presented in this paper, it is important to carryout cost-benefit analysis in a facility that is representative of environment observed in a power plant.This is definitely part of path forward research activities. To perform cost-benefit analysis of the technology, concerns related to increasing robustness of the installed wireless sensors electronics to electromagnetic interference and cyber security and robustness of wireless communication in a plant environment, longevity self-power and radiation tolerant wireless sensors for remote monitoring as part of path forward efforts.

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