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The Advent of Decentralized Intelligent Pump Solutions

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ABSTRACT

The end-users of process pumps continue to strive for lower total cost of ownership (TCO) of process pumping systems. The challenge has been the task of effectively obtaining process system data through centralized distributive control systems (DCS) and then utilizing it to implement custom solutions. These custom solutions utilize system data such as vibration spectra, pressures, flows, acoustics, consumed power, and others, coupled with advanced tools such as Artificial Neural Networks and other algorithms that have been applied or developed by the original equipment manufacturers. Technological advances in devices such as digital signal processors and wireless communication systems are enabling the premier manufacturers of pumps to develop effective intelligent pump solutions. The domain expertise that these manufacturers possess can now be delivered through these devices so that solutions are implemented at the exact time and place they are required. These devices will be local to the pump system, outside the main distributive control systems, and will hold algorithms that have been developed to provide intelligent solutions specifically designed for a unique pump or class of pumps.

Manufacturers of pumps have already been called upon by the end-users to provide pump service and repair, parts, reliability enhancements and diagnostics, all as part of the pump package. These new intelligent pump devices will allow the pump manufacturers to have live access to pump performance characteristics through web-based systems and therefore, enable optimal delivery of pump services and solutions.

Introduction

Fierce global competition, high energy costs, and increasing environmental awareness have driven the end-users of process pumping systems to reconsider how these systems are engineered. Therefore, there is a need for these end-users to evaluate the effectiveness of centralized control systems and to consider decentralized solutions that are evolving and being implemented, due to new, rapidly developing, electronic technologies.

There are many technologies that are either being implemented or are under development for the purpose of pump system optimization. This paper addresses the development and deployment of “de-central” data acquisition devices that are local to the pump system, gathering system data either through the plant network and / or connected directly to sensor loops. These data acquisition devices will have high speed microprocessors capable of sampling data, so that vibration spectral analysis and / or motor current signature analysis can run locally and in conjunction with diagnostic algorithms designed specifically for the pump system. The diagnostic results from these de-central systems will be fed back into the plant maintenance system, or to any remote location, so that planned maintenance activities can be deployed effectively. Also, the capability exists for this new type of data acquisition device to either implement automated control to protect the pump system against premature failure and / or optimize pump system efficiency. A pump which is coupled with an electronic device that can monitor, diagnose, communicate, and control is what is referred to today as an “Intelligent Pump.”

Background

Process plants are equipped with centralized control systems, or Distributive Control Systems (DCS,) that are designed to automate pump system control. The operators of these plants utilize the DCS to monitor and control the process so that end products are produced cost effectively and with the highest quality. As should be expected, these DCS systems where designed with optimal process control in mind and not for effective equipment monitoring and diagnostic capabilities.

Over the past decade, the end-users of process pumps have focused resources to increase the availability of their process pump systems. Certainly, the type of pump system and total Life Cycle Cost (LCC) affected the priority of this campaign. However, when looking at the proactive end-user, most embraced evolving from the “run to failure” approach, which had been the accepted practice, to the “effective planned maintenance” approach. It has been argued which maintenance philosophy is the best, but it seems as though most have embraced planned maintenance techniques as the optimum way for pump system optimization. Herein lays the challenge that the end-users of these process systems have been fighting – how to effectively utilize live pump system data, which is currently networked into their DCS, or to monitor pump systems that are not equipped with the correct sensors needed, to deploy a predictive maintenance program?

The path that most end-users have taken has been the deployment of “walk around” manual data acquisition systems (handheld devices) that take data on a route basis. This data is then either manually or electronically analyzed for diagnostic results and then deployed into centralized maintenance systems. This type of decentralized solution is better than the run to fail method, but is not optimal. The aspiration of the proactive end-user’s machine asset manager would be to have access to live, high speed pump system data, coupled with automated diagnostic results or remote connectivity of this data by those considered experts on the pump system being monitored.

Today, these new intelligent pump solutions are evolving due to the rapid advancement of electronic data processing and communications. What was thought not long ago as being too expensive, not reliable, and technically not possible, is rapidly becoming a reality.

Enabling Technologies

The relocation of sophisticated pump diagnostic techniques from the realm of remote computing equipment, onto or nearby the pump, is being enabled by three evolving technologies relating to hardware, software, and new wireless communication sciences.

Hardware

Hardware advancement can be further categorized into computational and sensor hardware:

- Computational hardware components, such as Digital Signal Processors (DSPs) and Field Programmable Gate Arrays (FPGAs,) provide extremely high speed computational capability. These devices are optimized for digital signal processing techniques such as Fast Fourier Transforms (FFTs) and digital filtering that are often applied in pump diagnostic algorithms. The availability and low cost of these devices make it practical to embed them into local monitoring and diagnostic pump systems, thus providing the capability to embed and execute sophisticated diagnostic algorithms, in real time, directly at the pump. The actual pump system diagnosis can now be acted upon locally, at the pump by this monitoring and diagnostic system or transmitted to the plant maintenance system, DCS system, or other remote systems as real diagnostic information instead of raw sensor signal data.

- Intelligent sensor hardware provides the capability to assist the pump data acquisition and diagnostic system, so that diagnostic processing is done optimally and fast, by acquiring, scaling and digitizing the sensor signals independently. These intelligent sensors also lend themselves to forming either wired or wireless sensor networks which reduces the cost of deploying intelligent pump systems.

Software

Advanced software techniques, such as Artificial Neural Networks (ANN,) utilized to detect particular anomalies, can now be implemented locally, and in real-time, at the pump. The utilization of these software techniques, which require high speed processing, will significantly lower the cost of implementing localized pump diagnostics by minimizing the required quantity of invasive sensors, while at the same time, increasing the reliability of these intelligent pump systems.

Wireless Communications

While wireless sensor technology is not new, it has taken some time for this technology to gain acceptance. Issues such as cost, reliability, and most importantly, the lack of industry standards have hindered growth. Coinciding with the development of intelligent pumps, wireless sensor networks are becoming more powerful (with regards to processing speed), reliable, and cost effective, mainly due to emerging standards such as Wi-Fi®, Bluetooth®, and ZigBee™. Wi-Fi® and Bluetooth® have been used broadly by many industries, while ZigBee™ has been developed specifically for monitoring and control.

One of the new emerging technologies, or concept, is that of wireless system networks which are sometimes referred to as "smart dust" or "motes." Motes can derive their power from a variety of sources including, batteries, solar power, and the utilization of residual vibrations to harvest energy for power. There are literally thousands of applications for this new emerging technology for markets such as military surveillance, domestic applications, and industrial machine monitoring.

Motes are an integral part of the wireless sensor network systems, which comprise of the sensor, mote, and the radio. The mote is basically a very small, low powered computer which is used to monitor one or more sensor type which includes: temperature, light, sound, position, acceleration, vibration, stress, weight, pressure, humidity, and others. Motes then transmit either unprocessed or processed data using a radio link. Typically, these radios enable the mote to transmit to a distance up to 200 feet.

The wireless sensor network industry is growing rapidly thus giving the user of intelligent pump systems the ability to locate sensors on machinery where it is extremely difficult to run cables and / or apply power to the sensors and wires to retrieve data. A clear cost advantage exists when one considers the cost of running wires for sensors back to the data acquisition devices.

Example Applications

The intelligent pump type solution actually corresponds with what is occurring in many different industries today. The automobile industry, for example, utilizes onboard computers to control: engine performance; all electrical components and to perform automated diagnostics. These computers onboard the vehicle control the engine and all electrical operations, and actually are embedded with diagnostic routines that make adjustments as the vehicle operates. General Motors Corporation (GM) has developed the Onstar® Service Business that utilizes Onstar® wireless mobile phone technology to send data from the customer's vehicle to the Onstar® Service Centers. Through this technology, GM can actually: unlock a vehicle remotely; locate the vehicle though the onboard GPS System; send emergency help; send a monthly diagnostic report to the customer.

One example of a pump system that would benefit from an intelligent pump type solution is one that has a varying system or process fluid. One of the inherent facts about pumps is that they operate optimally at their best efficiency point, like to have fluids that are consistent, and certainly must have adequate NPSHa to meet the performance requirement of the end-user.

- A hypothetical case may be a pump that sees varying specific gravity fluids. One of the problems that could occur, for this type of pump system, is the possibility of a resonance when the pump sees certain specific gravities. If this is an intelligent pump, vibration spectra or the motor current signature could be monitored and watched by certain onboard diagnostic routines. The end user could be either warned of any detrimental running condition and / or the intelligent pump unit could automatically send out control signals to change the system or vary the speed of the pump in order to avoid pump system damage. Also, just like the capability of the Onstar® Service Business of GM, intelligent pump systems could actually send diagnostic reports to the end-user as requested.

Conclusion:

The advent of intelligent pumps is providing the end-users of pump process systems a significant opportunity to lower the total life cycle cost. The advancement of hardware, software, and wireless communication technologies will continue to lower the cost required to deploy these intelligent pump systems. Meanwhile, the manufacturers of pumps will continue to develop advanced monitoring techniques and algorithms which will enhance other services such as: onsite pump maintenance, pump upgrade solutions, automated diagnostics and / or system control, and remote diagnostics.