Vibration Monitoring System for Industrial IoT

Powering Edge Intelligence with TEXOL Aurora

- ☆ Utilizing Vibration Monitoring Application
- ☆ TEXOL Aurora Introduction
- ☆ Case Study
- ☆ Aurora Function List

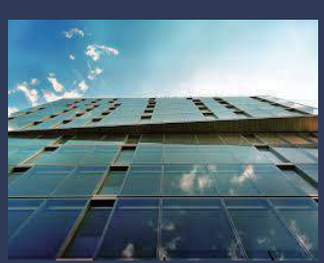
TEXOL | 凌群科技顧問股份有限公司 Taiwan Link Solution Co.,Ltd.

Machine Health Prognosis with Aurora

With Intelligent Manufacturing times coming, factories are starting to look for solutions to transform towards smart factories in order to increase utilization, create superior products, and reduce operating costs. The first step in this process is real-time Machine Health Prognosis. By monitoring machine status, in order to judge the condition of machines in real time, factories can be remotely managed intelligently and efficiently. Manufacturers and maintenance personnel require a simple and reliable method to control monitoring and diagnosis of machines.

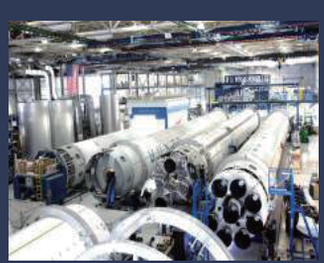
TEXOL's Aurora provides a machine status prognosis solution that does not require frequent on-site maintenance and service trips. With this solution, users can monitor critical assets, track equipment performance, and receive alarm notifications. This will substantially reduce costs and ensure field equipment is better monitored and controlled.

Application



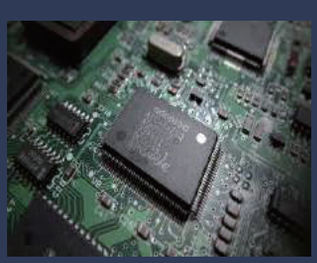
Panel Factory

- The huge handling equipment reducer, motor and skid rail.
- All kinds of pumps, exhaust gas turbines and generators.



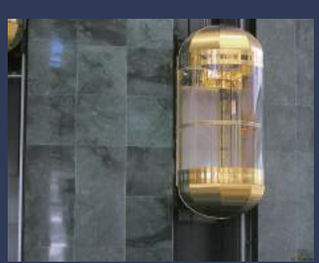
Manufacturing plant

- The machining spindle and moving axis in machine tools.
- All kinds of pumps, exhaust gas turbines and generators.



SEMI factory

- Surrounding environment and floor virbraiton.
- Machine arms inside the device.
- All kinds of pumps, exhaust gas turbines and generators.

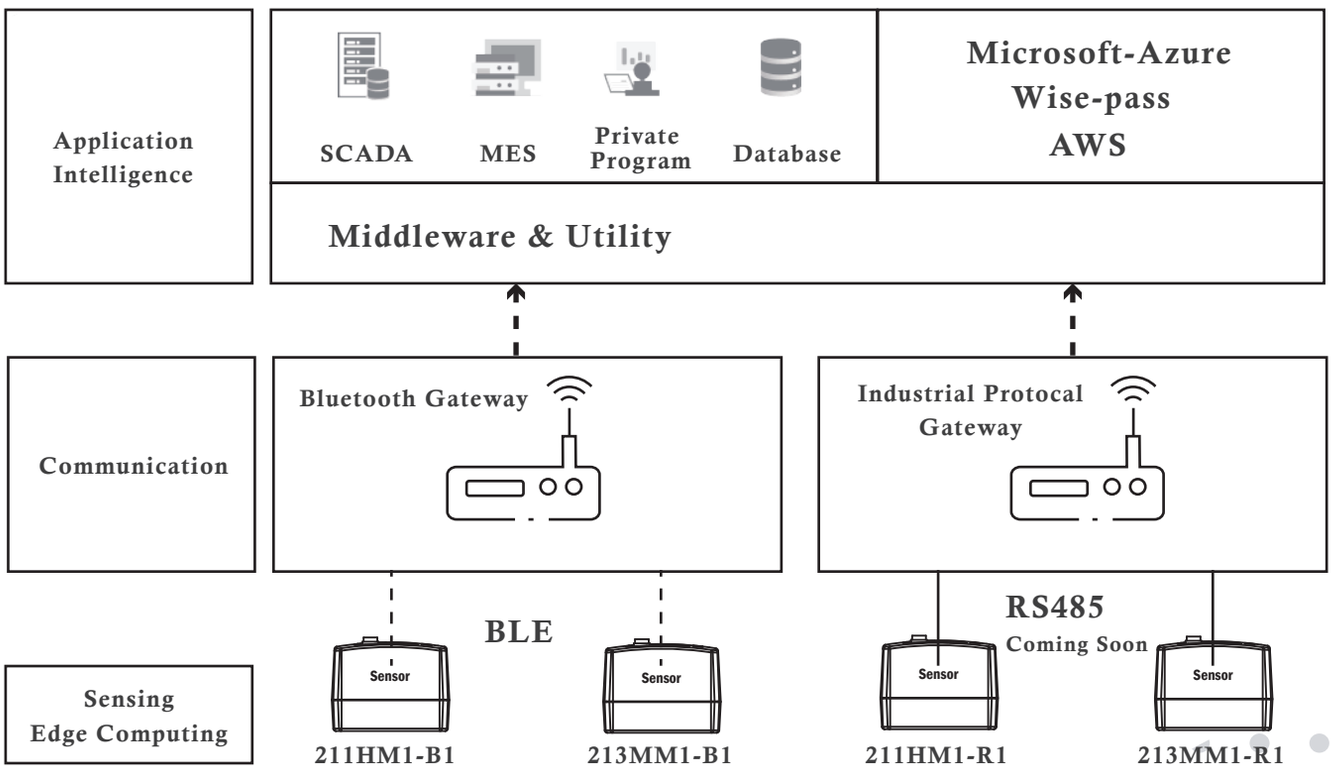


Elevators

- Hoist and reducer real-time condition

Aurora Architecture

Aurora is equipped with key functionalities aimed at edge applications. With data acquisition capabilities integrated with connectivity and intelligence functions, prognosticating field data becomes an easy task.



Advantage of Aurora

Optimizing Efficiency with Realtime monitoring

For industrial machine arms, dry pumps, chillers, power distribution cabinets, and other equipment, Aurora serves as a hub for data acquisition, storage, and reports, as well as alarm notifications. Aurora maximizes equipment efficiency with the provision of accurate data.

Intelligence of algorithm

Multiple feature values can be defined, which can effectively confirm problems in machine's components, and achieve accurate machine health status prediction through multiple reference indicators.

Adaptability to different types of machine

Aurora can be deployed on all machines, not affected by the signal cable installation. It supports real-time data collection by continuous or triggered mode, which allows for effective data collection no matter the environment of the machine.

Aurora Architecture

Model			211HM1-B1	213MM1-B1
量測規格	物理量		振動	振動
	軸向		單軸向	三軸向
	範圍		+/- 50 g	+/-16 g
	靈敏度		20.1 mV/g	0.488 mg / LSB
	頻率響應		5 - 10 kHz	5 - 5 kHz
	解析度		16-bit Sigma Delta ADC	16-bit
運算規格	CPU		Arm® Cortex®-M7 32-bit RISC core	Arm® Cortex®-M7 32-bit RISC core
	最大工作頻率		480 MHz	480 MHz
	Flash memory		2 Mbytes	2 Mbytes
	RAM		1 Mbyte	1 Mbyte
環境耐受	工作溫度範圍		0 - 65 °C	0 - 65 °C
電氣特性	輸入電壓		18 - 24 VDC	18 - 24 VDC
	消耗功率		0.45 W	0.45 W
	電源反接保護		V	V
特徵萃取與失效判定	最大運算速度		1 次/s	1 次/s
	取樣頻率		12,800 S/s	25,600 S/s
	連續取樣		V [1*]	V [1*]
	觸發取樣	軟體觸發	V [1*]	V [1*]
		硬體觸發	X	X
	時域訊號清理		V	V
	設備轉速識別		V	V
	時域特徵	總量 (mm/s)	V	V
		峰值 (mm/s)	V	X
		峰對峰值 (mm/s)	V	X
		峰值因數值	V	X
	損傷模式健康指標	頻帶健康指標值	10 組/軸	3 組/軸
		階次帶健康指標值		
	失效判定	警示	V	V
		警報	V	V
通訊	硬體介面		無線通訊	無線通訊
	通訊協議		UART over BLE 4.2	UART over BLE 4.2
	工作頻率		2.4 GHz	2.4 GHz
	傳輸距離		20m (依環境因素有所改變)	20m (依環境因素有所改變)
	上行內容	原始訊號	X	X
		時域特徵	V	V
		損傷模式健康指標	V	V
		失效判定	V	V
	下行內容	取樣模式	V	V
		時域訊號清理模式	V	V
		損傷模式定義	V	V
		失效判定閾值	V	V
		算法更新	X	X
外觀	尺寸 (含天線)		40 x 46 x 63 mm	40 x 46 x 63 mm
	尺寸 (未含天線)		40 x 46 x 34.7 mm	40 x 46 x 34.7 mm
	外殼		耐高溫工程塑膠	耐高溫工程塑膠
	密封方式		殼體封膠	殼體封膠
	電源接點型式		整合式 1m 尾端散線	整合式 1m 尾端散線
	工作狀態指示 LED		V [2*]	V [2*]
	通訊狀態指示 LED		V [3*]	V [3*]
裝置管理	上線		V [4*]	V [4*]
	啟用		V [5*]	V [5*]
	停用		V [5*]	V [5*]
	下線		V [5*]	V [5*]
	取樣模式設定		V [5*]	V [5*]
	時域訊號清理模式設定		V [5*]	V [5*]
	機器損傷模式設定		V [5*]	V [5*]
	警示警報閾值設定		V [5*]	V [5*]
	算法更新		X	X

How to prevent unpredicted failure of stoker crane robots in smart panel factories

Paint Point

Financial downtime losses caused by unpredicted failures of the stoker crane robots in a panel factory is huge.

Panel factories want to cost-effectively prevent unpredicted stoker crane robot failure without increasing their annual maintenance cost on the robots.

Challenges

※ How to time-effectively build accuracy-acceptable models of health prediction for each type of robots?

※ How to deploy a monitoring system for all gear boxes on all stoker crane robots cost-effectively?

※ The stoker crane robots usually have wide range of movement. How to transmit the sensor signal out?

Real engagement

TEXOL provided professional training course to our customers to build up a robust AURORA monitoring system following the engagement process described below by themselves. The gear boxes are the most fragile components in a stoker crane robot. The gear teeth often wear and then break.

First of all, users collected the design diagram of the gear boxes and calculated the theoretical spectrum features of gear teeth wear. Meanwhile, they used DynaView spectrum and feature analyzer to collect the vibration signals of gear boxes when they were in operation. In DynaView, they observed the vibration signals to define a signal cleaning strategy to the unsteady-state signals. They also investigate the theoretical spectrum features of gear teeth wear in a real spectrum.

Secondly, users deployed couple endnodes which have been configured in the spectrum features of gear teeth wear and other fail-modes to all gear boxes in dozens of stocker crane robots. They have successfully observed the long-term trends of these features in DDMS. They also have formulated a set of alert levels of the health condition which are very robust and then deployed them to the smart endnodes using DDMS.

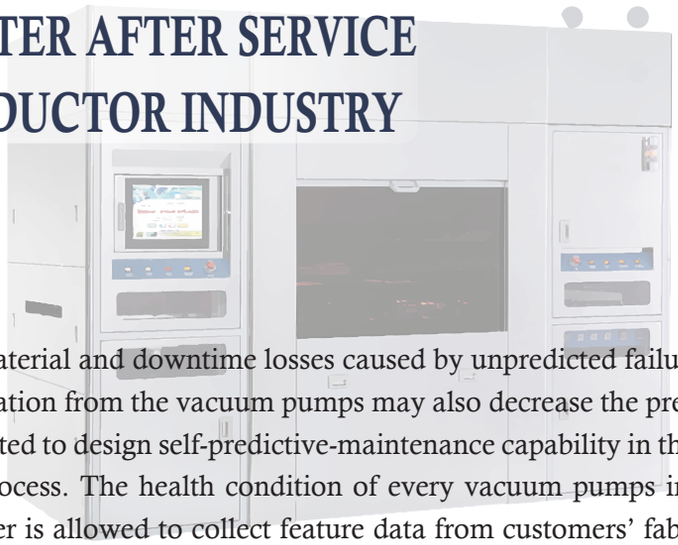
Furthermore, big data analysis team fetches health feature data of robots using MQTT protocol to optimize the production and maintenance schedule of all stocker crane robots in one production line.

Benefits

Dozens of stoker crane robots in one panel plant are now being monitored by Aurora system. The accuracy is closed to 90%. A panel plant can save 300 to 500 thousand USD yearly by preventing unpredicted failures of the stoker crane robots.

Number of stoker crane robots	Rate of accuracy	Cost-saving
>20 set	>90 %	USD$300,000-USD$500,000

USING AURORA TO BUILD A BETTER AFTER SERVICE INFRASTRUCTURE TO SEMICONDUCTOR INDUSTRY BY A STEPPER MAKER



Paint Point

The semiconductor fabs are suffering the financial material and downtime losses caused by unpredicted failures of the vacuum pumps in steppers. The abnormal vibration from the vacuum pumps may also decrease the precision of mask aligning. Stepper makers are then requested to design self-predictive-maintenance capability in their steppers to provide a more robust manufacturing process. The health condition of every vacuum pumps in a stepper shall be online monitored. The stepper maker is allowed to collect feature data from customers' fab to provide better maintenance service.

Challenges

※ How to time-effectively build accuracy-acceptable models of health prediction for the vacuum pumps in the stepper?

※ How to deploy a monitoring system for all vacuum pumps on all steppers cost-effectively?

Real Engagement

While the key parts in a vacuum pump damage, the vacuum pump generates abnormal vibration and may decrease the precision of mask aligning in a stepper.

First of all, the stepper makers collected the design diagram and the range of rotational speed of the vacuum pumps and calculated the theoretical spectrum features of several basic fail modes. Meanwhile, they used DynaView spectrum and feature analyzer to collect the vibration signals of the vacuum pumps when they were in operation. In DynaView, they observed the vibration signals to define a signal cleaning strategy to the unsteady-state signals. They also investigate the theoretical spectrum features of unbalancing, misalignment, bearing damage in a real spectrum.

Secondly, they deployed couple Aurora endnodes which have been configured in the spectrum feature definitions of the fail-modes to all vacuum pumps in one stepper at their customers' side. The feature data was stored by Aurora middleware and then be daily fetched by the stepper makers.

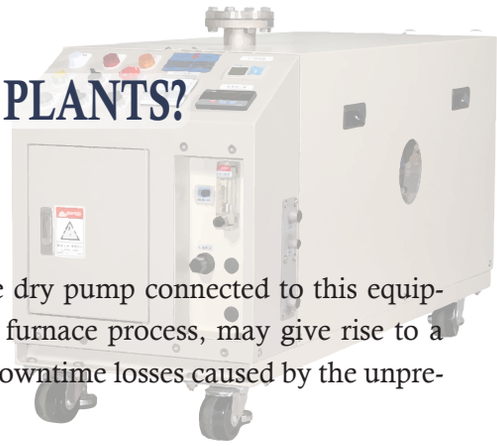
Next, they are going to formulate a set of alert levels of the health condition and then deployed them to the smart endnodes using AURORA utility.

Furthermore, the IT team of the semiconductor plant will aggregate the feature data and the alert status of these vacuum pumps to DCS using MQTT to be simultaneously informed with the stepper maker.

Benefits

One stepper in a semiconductor plant is now being monitored by Aurora system. The stepper maker is now capable of giving their customer better maintenance and service architecture. The semiconductor plant is suffering very low risk from unpredicted failures of the vacuum pumps in a stepper now.

HOW TO PREVENT UNPREDICTED FAILURE OF DRY PUMP IN SMART SEMICONDUCTOR PLANTS?



Paint Point

The wafers in equipment sometimes get irreparable damaged when the dry pump connected to this equipment suddenly crash. Those crash, especially happen to the oxidation furnace process, may give rise to a financial material loss of 50 – 100 thousand USD each time. Financial downtime losses caused by the unpredicted crash is not even included in this calculation.

Therefore, semiconductor plants want to cost-effectively prevent unpredicted dry pump crash without increasing their annual maintenance cost on the dry pumps.

Challenges

※ How to time-effectively build accuracy-acceptable models of health prediction for each type of dry pumps?

※ How to deploy a monitoring system for all dry pumps extremely cost-effectively?

Real engagement

TEXOL provided professional training course and consulting service to our customers so that they are able to build up a robust AURORA monitoring system following the engagement process described below by themselves.

The rotors are the most fragile components in a dry pump. The pair of rotors shall keep very close distance and not contact in normal operation. However, the crystal in the air duct is sometimes sucked into the rotors and leads to the friction between them. When more and more crystal come into the rotors, they get wear or they suddenly get stuck. This is one of the major crash modes of dry pumps.

First of all, users collected the design diagram and the operational condition of the dry pumps and calculated the theoretical spectrum features of several major crash modes.

Meanwhile, they used DynaView spectrum and feature analyzer to collect the vibration signals of more than 20 Ebara dry pumps. In DynaView, they investigate and benchmark the theoretical spectrum features of motors and rotors in a real spectrum.

Secondly, the users deployed several 4-channel PC-based monitoring systems DynaMon which have beenconfigured in the spectrum features of rotor wear and other fail-modes to dozens of dry pumps. DynaMon system not only monitors the health conditions online, it also records the vibration signals periodically. These signals are compatible with DynaView so the users keep investigating and benchmarking the new features if they appear.

Simultaneously, a cost-effective Aurora wireless monitoring system including numerous smart BLE endnodes, gateways and a data and device management software (DDMS) is being deployed to the other dry pumps gradually.

Benefits

The DynaMon monitoring system successfully sent an alert to users 27 days before a real crash of the dry pump. A wafer material loss of 100 thousand USD supposed to happen by this one-time crash is successfully fended off.

Hundreds of dry pumps in one semiconductor plant are now going to be monitored by Aurora system. A semiconductor plant can save 500 to 700 thousand USD yearly by preventing unpredicted crash of these dry pumps.

USING AURORA HEALTH CONDITION MONITORING SYSTEM TO PREVENT UNPREDICTED FAILURE OF MOTORS, ROLLORS AND REELS IN PAPER FORMATION FACTORIES.

Paint Point

A paper formation machine is driven by a high horsepower motor and the power is then transmitted to different subsystems by a transmission mechanism composed of numerous shafts, belts and gearboxes. A paper formation process sometimes suddenly stops due to the crash from any one bearing in the transmission mechanism or anyone in the rollers and reels in the subsystems. Those crash may give rise to a financial downtime loss of 50 – 100 thousand USD each time.

Requirement

Paper formation factories want to cost-effectively prevent unpredicted crash of motor, bearings, belts, and gearbox without increasing their annual maintenance cost on the paper formation machines.

Real engagement

Our customers chose couple motors, shaft assemblies, belts, gearboxes and more than fifty bearings whose rotational speed is high enough for vibration signal acquisition to be monitored.

An Aurora health condition monitoring system including numerous smart BLE endnodes, six gateways and a data and device management software (DDMS) is deployed. Meanwhile, we configured several basic spectrum features of several major crash modes of the motors, shaft assembly, bearings, belt and gearbox into individual endnodes. The Aurora system benefits our customers according to these pre-configured crash models from the first day it was deployed. This practice substantially reduced our customers' effort on the signal collection and the spectrum features studying.

Besides the Aurora health condition monitoring system, TEXOL also provided Fluke 810, training course and consulting service to our customers. Fluke 810 is not only a handheld vibration tester but also the most advanced troubleshooting tool for mechanical maintenance teams.

The unique diagnostic technology helps our customers quickly identify and prioritize mechanical problems. Fluke 810 discloses the plain-text crash mode, fault severity (slight, moderate, serious, extreme), repair details, cited peaks, and the spectra. Our customers regularly inspect the motors and bearings using Fluke 810. Once Fluke 810 disclose a new crash mode which is not built in Aurora system, they configure the band of the cited peaks into Aurora system using the web-based DDMS and then push the configurations into the BLE endnodes. After a period of time, say three to six months, our customers have an advanced troubleshooting and monitoring system by a most time and cost efficient way.

Benefits

Comparing with a traditional PC-based monitoring system, the Aurora health condition monitoring system successfully saved 100,000 USD in the system cost for our customers.

A paper formation machine is now monitored by the Aurora system. A paper and pulp factory possesses two paper formation machines can save 50 to 100 thousand USD yearly by preventing unpredicted crash of the motors, shaft assemblies, belts, gearboxes and more than fifty bearings.

USING AURORA HEALTH CONDITION MONITORING SYSTEM TO PREVENT UNPREDICTED FAILURE OF MOTORS IN A STONE POLISHING MACHINE IN A STONE PROCESSING PLANT

Paint Point

The stone processing plants are suffering the financial downtime losses caused by unpredicted failures of the motors in the stone polishing machine. In one stone polishing machine there are usually dozens of motors in charge of polishing and motion control. The crash of each one of them will stop the stone polishing process. Since the lead time of the motor is at least three months, the stone processing plant has to pay additional 20 – 30 thousand USD for the inventory of the backup motors. In order to cut off the inventory cost, the health condition of every motor in the stone polishing machine is requested to be online monitored and the plant manager shall be properly informed before the motor going to crash.

Challenges

※ How to time-effectively build accuracy-acceptable models of health prediction for the motors in the stone polishing machine?

※ How to deploy a monitoring system for all motors in a stone polishing machine cost-effectively?

Real engagement

The motors are the key parts with the longest lead time in a stone polishing machine.

First of all, users deployed forty endnodes which have been configured in the spectrum features of unbalance, misalignment, loosing and other fail-modes to all motors in one stone polishing machine.

Secondly, all feature data were sent via MQTT protocol to WISE-PAAS dashboard where users are capable to observe the long-term trends of these health condition features.

Users are allowed to formulated a set of alert levels of the health condition and then deployed them to the smart endnodes using AURORA utility by themselves.

Benefits

One stone polishing machine is now being monitored by Aurora system. A stone processing plant can save 20 – 30 thousand USD of the inventory cost of the backup motors by preventing unpredicted failures of the motors in the stone polishing machine.

Comparing with a traditional PC-based monitoring system, the Aurora health condition monitoring system successfully saved 50,000 USD in the system cost for our customer.

TEXOL
凌群科技顧問股份有限公司
新竹縣竹北市文興路261號6F
03-6579836