Central Monitoring System of Exothermic Reactors

TECHNICAL AREA:

This disclosure relates generally to remote monitoring of exothermic reactors, and more specifically, to a central monitoring system of exothermic reactors.

BACKGROUND:

The context of this invention is that each device, regardless of type, model, or series (generation) integrates into a broader network via a CMS. Each device will "check-in" with a CMS. Devices are ubiquitous technology, distributed across the globe providing power at micro and macro scales. Types, models, and series will have various embodiments of hardware.

Examples of types: Stationary (commercial/industrial, high-density housing complexes, single family dwellings); Mobile (airplanes, surface ships, automobiles, space-craft, and personal accessories transported on persons).

Examples of models: various models will be used in different operational environments and have associated differences in performance standards, communication suites, and hardware/software combinations. Some models will exclusively use wireless (WiFi) connections. Some models will have embodiments that augment the communications suite to allow for radio frequency (RF) communication, use of cellular and mobile networks, satellite communication links, wired Ethernet connections, etc. As the telecommunications industry advances, the devices shall have the ability to host emergent technologies. For consistency in this IvD, the concepts and arrangements will assume connectivity by wireless or WiFi technology into the broader "internet of things" (IoT). Diagrams that depict additional means of transmitters and receivers assume a general data communication link between the device and a CMS.

Examples of series: Successive design improvements and modifications will be denoted by a series designator (a, b, c, etc.). Series is synonymous with "generation" or generational advances in design.

EXISTING TECHNOLOGIES:

Existing communication technologies shall be installed into the device. Such technologies are Performance Monitoring and Fault Localization (PMFL - see IH IvD-

050 by James Hartanto), which includes a suite of sensors. PMFL is a data collection system and shall be remotely accessible by the CMS.

In the marketplace, I found no current exothermic reaction devices that are connected on a network. There are industrial-scale exothermic nuclear fission reactors and fossil-fuel reactors that generate heat and are connected on a network, none of them generate excess energy, represented by an Integrated Power Ratio greater than 1 (measured as Energy Out divided by Energy In).

However, there are a number of existing systems and methods for devices to communicate within an information network: conventional commercial power-generation, home heating-cooling control products, and facility security systems. Devices, sensors, contacts, camera systems, etc. within information networks transmit and receive information via a variety of means. Examples may include closed-loop circuits, wireless networks, wired networks, satellite communications and radio frequencies. Another example of remote connectivity is the remote disable function for Apple's iPhone. When the iPhone is lost, Apple sends a signal to remotely wipe the data from the phone and permanently lock it.

Some existing devices, sensors, etc. transmit information on the "internet of things" (IoT) network. Legal scholars suggest to look at "things" as an "inextricable mixture of hardware, software, data and service." Networks merge into increasingly complementary and overlapping systems on the IoT. Exothermic reaction devices and CMS shall integrate into the IoT but maintain the ability to transmit data via alternate means, such as radio frequency, satellite communications and emergent technologies.

PROBLEMS WITH EXISTING TECHNOLOGIES:

Existing information networks, such as the IoT, do not integrate exothermic reaction devices and a CMS to monitor and maintain control of the fleet of exothermic reaction devices. The IoT hosts power-controlling devices on the smart grid (such as house thermostat controls, home water heaters, battery cells, etc.) and CMSes (such as home security and alarm monitoring systems). In isolated and rugged environments where exothermic reaction devices and a CMS operate, I have found no evidence of connecting the devices and systems via alternative communication means (cellular, satellite, RF, emergent technologies).

I have found no existing exothermic reaction devices that produce more energy than the energy consumed as power input. Batteries, which load energy and then dispense energy over time, do not actually produce more energy than they ultimately consume. Every energy-producing asset has an integrated power ratio to measure the performance of the device. The basis for this ratio is a comparison of the energy produced divided by the energy consumed as power input. In all current technologies, the integrated power ratio is less than one; each device consumes more power than it consumes.

SUMMARY OF THE PROPOSED SOLUTION AND THE ADVANTAGES IT PROVIDES:

In this document, “device” refers to the reactor system, comprised of the exothermic reactor and its control and monitoring components, including but not limited to a (Central Processing Unit (CPU), transmitters, receivers, data connections, location detection devices, amongst others). “Performance Monitoring and Fault Locator” (PMFL), includes the sub-system of sensors that monitor and control the reactor. “Reactor” refers to the chamber within the device where an exothermic reaction occurs. Each local device has hardware that controls the device and the reaction. Each device provides excess power to its host appliance or application and is connected to a Central Monitoring System (CMS). The CMS allows IH as the exclusive service provider to monitor and enable/disable the device remotely.

The connected system of devices and a CMS exploits the strength of the IoT and also provides technical means for devices and nodes beyond wired and wireless IoT networks to send and receive information. The deliberately-scheduled periodic connectivity between each device and the CMS allows for safe operation (detecting a runaway reactor), prevention of theft and reverse engineering, and enablement of data aggregation to optimize performance across the fleet. The CMS will expect and report integration of devices within its domain. The devices will consistently seek connectivity with the CMS.

The specific programming language controlling device and CMS actions will vary by type/model/series. The general methods include the following steps: 1. devices “checking in” to a CMS, 2. actions upon a device exceeding the performance envelope, and 3. “isolated-device plan,” are eligible for invention.

The Integrated Power Ratio is a parameter that measures the performance of an exothermic device and can detect devices that are operating in one of the following zones: non-functioning, sub-optimal, optimal, or unsafe. If the integrated power ratio of an exothermic reactor is below 1, the exothermic device is not functioning properly and the device or the CMS will take the appropriate maintenance or corrective actions. If the integrated power ratio is above 1 but below a pre-determined threshold, the device may not be operating in an optimal mode but can be fine-tuned (remotely or on-site) to improve performance. If the integrated power ratio is between a pre-determined minimum and maximum threshold, it may be concluded that the device is operating normally and no alarm or action is needed. If the device is operating beyond the established maximum operational threshold (the unsafe zone), the CMS or device will take appropriate actions to protect the device and prevent harm.

DETAILED DESCRIPTIONS OF THE PROPOSED SOLUTION AND FIGURES:

1. Connectivity. See Figure 1. The exothermic reaction devices and CMS are connected via the IoT network, where available. As various types and models of devices are deployed to isolated, rugged extreme environments (examples such as underwater, underground, inner and outer space, and others), the redundant means of transmitting data and receiving commands prevents unsafe runaway devices and accounts for the fleet of devices and the CMS that supports and controls them. For each type/model/series of devices, the CMS uses PFML data to determine what, if any, actions it needs to take to maintain safe operation of the device and protect it against tampering or intellectual-property theft.

2. Exothermic Reaction Device design. See Figure 2.

a. Exothermic reactor captures excess heat from an exothermic reaction to supply power to a broader electric grid and also direct power to batteries, machines, devices, appliances and other applications.

b. Sensors. The device employs sensors at various collection points in and around the reactor, feeding the CPU with diagnostic data necessary for the device and the CMS to analyze and make decisions regarding the performance, safety, and maintenance of the reactor. Examples of sensors include: reactor pressure (ambient and interior), temperature (ambient and internal), power input(s) and output(s) such as voltage and current, gases produced, etc.

c. Auxiliary power. The device may require input power to initiate the reaction. The transmitters also require energy to send and receive information.

The CPU requires electricity to perform work. Auxiliary power source(s) provide continuous power to these components in absence of steady-state reactions (i.e. when the device is turned off or not operating).

d. Geolocation detector. This component relies on reports from parent CMSes, adjacent exothermic reaction devices, and other inputs such as satellite signals or network cables to track and report physical location.

e. System clock. This is used to trigger the transmission of certain reports and provides a reference for the CPU to time-stamp sent reports.

f. Central processing unit (CPU) actions. The CPU performs data collection, analysis, and command tasks. Among those are analyzing data from the sensors, generating reports, and determining the most efficient method of data transmission between the exothermic reactors and CMS. The CPU analyzes changes in its geolocation across time (subterranean or beyond planet Earth).

g. Transmitters. The device can transmit data via wireless or wired connections into the IoT. Various types, model, series host other platforms, such as radio frequency, satellite communications, and other means across the electromagnetic spectrum (flares, bursts, etc.).

3. Exothermic reactor Device act of "Checking-In" with the CMS. See Figure 3.
   a. Analysis. The advantages of the Central Check-In System are increased efficiency and safety across the fleet of exothermic reaction devices (reduced maintenance costs, identification and remote shutdown of runaway units), and accountability of devices (location, status, performance, etc.).
   b. The CMS will know:
      i. which device is reporting - device identification number
      ii. the report number from that device, so that that the CMS can file and recall reports
      iii. The device's operational status. In some embodiments, this may include:
         1. Running (on and expected to provide excess heat)
         2. Idle (on and not expected to provide excess heat)
         3. Equilibrating

4. Shutting Down (in the process of transitioning from running/idle/equilibrating to "off")
5. Off (not expected to accept or provide power)
6. Autonomous Mode. The device will operate for some period of time without communicating to the CMS.
7. Self-protection Mode. The device senses threatening conditions and establishes a more defensive posture to guard against intrusion and/or tampering.
8. Self-destruction Mode. The device has detected intrusion and an attempt at theft and is self-destruction.

iv. The devices' Performance Report (Figures 5c and 5d). In some embodiments, this may include:
1. An Integrated Power Ratio, which is the ratio of energy consumed divided by energy supplied.
2. Temperature(s)
3. Pressure(s)
4. Auxiliary power status
5. Connectivity (to the CMS or adjacent devices)
6. Location
7. Fuel status

v. Time of previously sent report

vi. Any type/model/series-specific device information (such as location, fuel status, usage history, etc.)

4. Device and CMS Actions while in operation. See Figure 4a. Exothermic Reactor Device Reporting Actions.

a. The device's CPU pulls the time from the system clock.
b. Once the time periodicity is met, the CPU generates a General Check-In Report. The following lines are estimates of the information valuable to the CMS:
   i. Device ID #
   ii. Report #
   iii. Operational Status
   iv. Performance Data

v. Time of Previous Report Sent
vi. Model-specific Info
vii. Acknowledge receipt of report/ Awaiting Acknowledgement

c. The device transmits the report to the CMS
d. The CMS acknowledges receipt and continues to operate
e. Or, after X attempts of unacknowledged receipt, the device executes the Isolated Device Operation or takes other appropriate action. (See Figures 6c and 6d.)

Figure 4b. Concurrently, the CMS Executes Reporting Actions.

f. CMS is initiated
g. CMS is operational
h. CMS expects to receive reports from all devices at a specified periodicity
i. The CMS does/does not receive checking-in reports from all devices in accordance with (IAW) programmed expectations:
    i. If yes, the report shows either the device operating within normal parameters and continues operations and then files the report, or
    ii. If no, CMS queries device for an advanced (PMFL) report, which provides more detail than normal reports.
        1. CMS receives advanced PMFL report.
            a. If device is operating within key performance parameters/indicators (KPI), then the CMS files the report.
            b. If device is not operating within KPI, the CMS takes appropriate actions (maintenance, operate, change operational status, etc.).
j. If the CMS does not receive a report IAW expectations, it queries the device for a "check in report." It receives the general checking-in report and then files it.

Figure 4c. The CMS processes the device's report.

a. Is the device operating within optimal performance state?
    i. If yes, update the CMS database.

ii. If no, the CMS diagnoses the reported data against established parameters.

b. Is the reporting device within "sub-optimal" performance parameters?

  i. If yes,

    1. Is the device beyond the expected operating life?

      a. If yes, the CMS will queue a service technician to physically replace the device.
      b. If no, the CMS will queue a service technician to inspect the device for defective material or assembly.

  ii. If no, is the device at unsafe performance parameters?

    1. If yes, command the device to perform safe-shut down procedures and then queues a service technician to replace the device.
    2. If no, is the device responsive?

      a. If no, the CMS queues a service technician to replace the device.
      b. If yes, the CMS commands the device to perform safe-shut down procedures and queues a technician to replace the device.

5. Device Experiences an Unexpected Action. Part of the device's reporting criteria is to generate and send a report when the performance monitoring fault localization (PMFL) detects a reportable change in key performance indicators (KPI). The circumstances that prompt this report will vary; the general principle is that the sensors and locator detect unsafe conditions, unauthorized tampering or movement, or another excursion regarding some aspect(s) of the device's performance envelope. The device will either send a special report at the next scheduled interval, or if the device determines that it must shut down, it will send an Emergency Shutting-Down report to the CMS before shutting down.

Figure 5a. Device CPU detects that PMFL exceeds performance envelope.

a. Device is in operation
b. Device detects PMFL exceeded
c. Device determines classification of fault

d. Device executes a response based on the fault's classification

Figure 5b. Device's Internal Data Monitoring

a. The device Analyzes the PMFL Envelope
b. Device asks: "Based on data analysis and performance parameters, do I have to shut down?"
    i. If no, continue to operate and send a special report at next scheduled time interval
    ii. If yes, generate and send emergency shut down report to CMS
        1. Device shuts itself down

Figure 5c. Aspect #1 of the PMFL. This graph shows the conceptual ratio of the exothermic device's Integrated Power Ratio, showing a relationship between power in and power out. A device can be in a non-functional, sub-optimal, optimal, or unsafe zone. The non-functioning zone is below 1; the device is not producing excess energy. The suboptimal zone is where the integrated power ratio is above 1 but below a minimum positive threshold. The optimal zone is between the minimum and maximum positive thresholds, but not so much that the reaction is unsafe. The unsafe zone is above the tested safe limits of the reactor. The specific threshold of the safety zone will depend on the type, model and series of the reactor.

Figure 5d. Aspect #2 of the PMFL. In some embodiments, the PFML has sensors that monitor various performance parameters across the reactor. Units of measurement vary by parameter.

1. Temperature
2. Pressure
3. Integrated Power Ratio [as a function of "energy in" and "energy out"]
4. Fuel-level (remaining quantity in volume or in operating time)

The PFML also measures parameters or status of performance of the entire device.

1. Auxiliary power (as a percentage of fuel capacity and/or absolute operating time remaining)
2. Connectivity (to the CMS and/or other devices)
3. Location (geolocation, latitude, longitude, elevation, depth, altitude, etc.)

Figure 5e. PFML Data Over a Reporting Period (Time). This graph represents various performance data (y axis) collected over a specified time reporting period (x axis). Various embodiments of the device will have specific performance data. The Integrated Power Ratio (indicating the relationship between energy produced versus energy consumed) is unique to the exothermic reactor.

6. Isolated Device Plan. The device and the CMS are programmed to expect connectivity and adherence to operational reporting instructions. The CMS and each device has a parallel set of instructions once the CMS or the device concludes that a device becomes isolated. "Isolated" refers to the device's X attempts to send a check in report in Y duration of time. For the CMS, an isolated device has violated the routine and specified reporting expectations.

Figure 6a. Device actions.

1. Does the number of attempts to send a check-in report exceed "x" within the duration "y" with the CMS sending an acknowledgement?
    a. If no, continue to operate and transmit reports.
    b. If yes, the device enters "autonomous" mode.
        i. The device will generate and transmit a "check-in" report at the next time interval.

Figure 6b. CMS actions.

1. Does the CMS receive a report from a device that is in accordance with expectations?
    a. If yes, instruct the device to continue normal operations.
    b. If no, the CMS requests a specific report from the device.
        ii. Does the CMS receive the requested specific report?
            1. If yes, analyze the received report.
            2. If no, after "x" failed attempts, queue a technician to troubleshoot the device.

Figure 6c. Another Possible Decision Tree for an Isolated Device. In some embodiments, devices may be arranged in close physical proximity, or in series ("daisy chained"), in parallel or other arrangements.

1. Does the number of attempts to send a check-in report exceed “x” within the duration “y” with the CMS sending an acknowledgement?
    a. If no, send the report to CMS
        i. Instruct the device to continue normal operations.
    b. If yes, the device attempts to send and receive reports from an adjacent device. This is called a “relay.”
        i. Did the adjacent device acknowledge receipt of the report?
            1. If yes, continue to operate and send reports via the device relay. The device requests a technician to service the original device.
            2. If no, the device enters “autonomous” mode. The device generates a check-in report at next time interval. The device requests a technician to service the original device.

Figure 6d. Another Possible Decision Tree for an Isolated Device. In some embodiments, devices may be arranged in close physical proximity, or in series (“daisy chained”), in parallel or other arrangements. Additionally, some embodiments will have the ability to enter self-protection mode.

1. Does the number of attempts to send a check-in report exceed “x” within the duration “y” with the CMS sending an acknowledgement?
    a. If no, send the report to CMS
        i. Instruct the device to continue normal operations.
    b. If yes, the device attempts to establish a communications link with any adjacent device.
        i. Was the communication link established?
            1. If yes, send reports via the the device relay. Continue to operate. The device requests a technician to service the original device.
            2. If no, the device enters “self-protect” mode and will have a heightened defense posture to prevent tampering, theft, or reverse-engineering.
                a. The device continues to transmit reports at set intervals.

b. The device awaits CMS to acknowledge receipt of reports.
c. Does the CMS send a command (with a decryption key) to the device to change the devices' status from self-protect mode to normal operations mode?
    i. If yes, the device enters normal operations mode
    ii. If no, the device remains in self-protect mode until "unlocked" by the CMS.