Requirements for Prognostics System to Improve Business Process of Machinery Maintenance Service

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ABSTRACT

The number of companies that provide "predictive maintenance service" is increasing. If we can detect the sign of machinery failure from the collected data by IoT technologies, we exchange the parts or repair them in advance. By predictive maintenance service, people in a plant get merits to avoid great losses by unexpected troubles such as a sudden machinery failure, a manufacturing line stop and so on. As for maintenance service providers, they have such merits that they can maintain a machinery systematically and provide maintenance service by a limited number and skill of maintenance engineers.

In this paper, we firstly show the main processes for preventive maintenance service and predictive maintenance service, and then compare them and show the differences. In predictive maintenance, we have no regular manual inspection conducted in a preventive maintenance. We anticipate a maintenance task by the monitoring results of a machinery condition and make a plan for the task.

To solve the issues concerning preventive maintenance service provision, we propose not only the requirements for basic functionalities of prognostics system, but also the operational requirements for continuous service provision and the non-functional requirements to guarantee safe usage.

1. INTRODUCTION

The type of maintenance is changing from "corrective maintenance" to "preventive maintenance". Based on the recent IoT technologies used for collecting machinery health data, the number of companies, whose engineers maintain machineries predictively, is increasing. By predictive maintenance, a manufacturer has merits to avoid the great losses by unexpected troubles such as a sudden machinery failure, a manufacturing line stop and so on. A maintenance service providing company has such merits that they can maintain machineries systematically and provide the services by a limited number and skill of engineers.

If we provide predictive maintenance service, a prognostics system makes an important role to monitor a machinery health state and to predict the failure of machinery. We, however, have little research results concerning the requirements fulfilled by a prognostics system. In this paper, we show the processes of predictive maintenance service provided for machinery products that work in customers' plants, and we also propose the requirements for the system to support predictive maintenance service.

The structure of this paper is as follows. We firstly show the main processes for preventive maintenance service and predictive maintenance service, and then compare them and show the differences. We then propose the requirements of a prognostics system from the view of basic functional requirements, daily operational and non-functional ones.

2. MAINTENANCE SERVICE CHANGED BY PROGNOSTICS SYSTEM

2.1. Overview of Preventive Maintenance Service

In this section, we firstly overview preventive maintenance service that we don't use a prognostics system (see Figure1).

As for the maintenance services, we mainly provide the following two menu items:

1. Inspection, cleaning and repair of machineries
2. Inspection, cleaning and exchange of parts

We classify the two types of services by the provision frequency. The services of the following 1 and 2 are provided regularly and the following 3 is provided whenever a failure occurs.

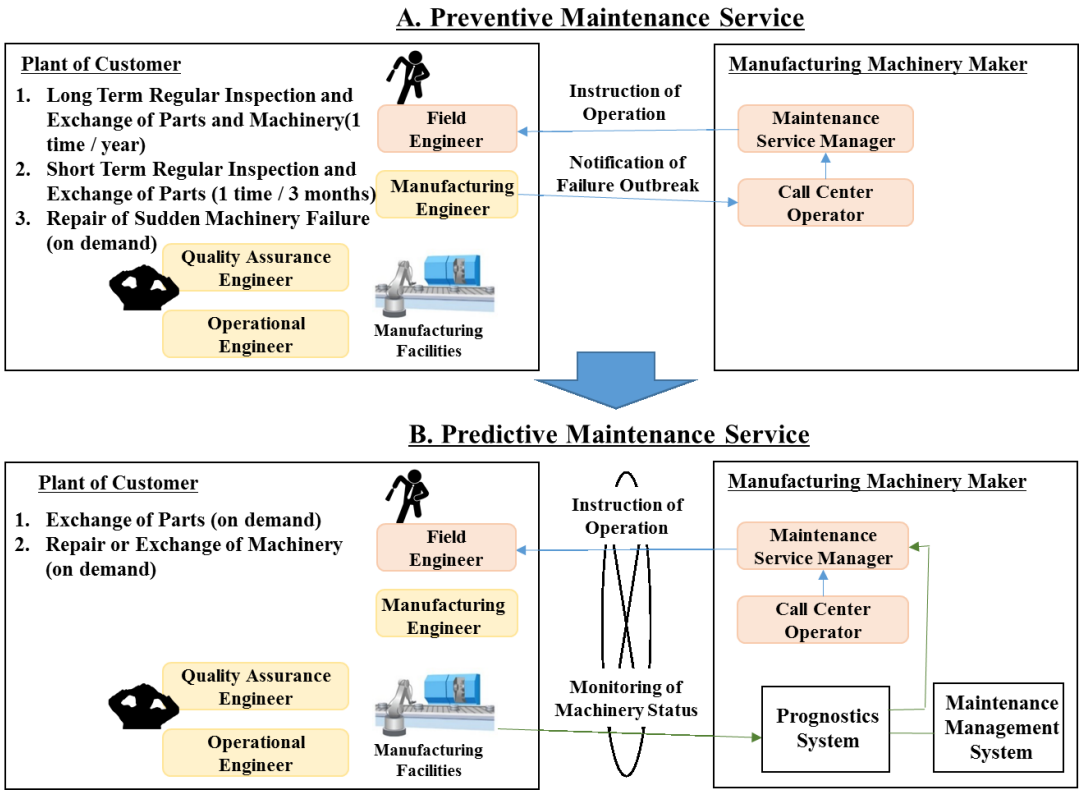

Figure 1. Preventive and Predictive Maintenance Service

1. Long term regular inspection and exchange of parts and machinery (e.g. 1 time / year)
2. Short term regular inspection and exchange of parts (e.g. 1 time / 3 months)
3. Repair of a sudden machinery failure (on demand)

We decide if we should exchange a part by the period of time and/or the number of usages recommended by the manufacturing machinery maker.

We next explain the role of people related to the service provision. In a plant of a customer who purchases and uses the machinery, the following engineers are involved in manufacturing activities.

1. Operational Engineer

   A main performer of manufacturing activities, operations of machinery, provision of parts, report of produced amount, and troubleshooting.

2. Manufacturing Engineer

   Monitoring of operating status and maintaining based on operation data.

3. Quality Assurance Engineer

   Monitoring the failure rate by operating data and inspection data, inspecting trouble, and instructing the improvements.

As for a manufacturing machinery maker, people having the following roles provide maintenance service cooperatively.

1. Maintenance Service Manager

   Planning of maintenance tasks, assignment of field engineers and management of maintenance task.

2. Field Engineer

   Going to a customer's plant according to a maintenance plan and performing maintenance tasks.

3. Call Center Operator

   Accept the claims and requirements from customers, and report them to a maintenance service manager.

When a manufacturing machinery makes a failure even if we perform regularly inspections correctly, a manufacturing machinery maker and a customer cooperatively solve the problem by the following communication.

1. An operational engineer discovers a failure of a facility and consults with a manufacturing engineer.
2. A manufacturing engineer considers that (s)he cannot deal with the failure, and makes a phone call to a call center of a manufacturing machinery maker.
3. An operator of the call center notifies the failure occurrence to a maintenance service manager. The manager assigns a field engineer and instructs the operation.

4. A Field Engineer goes to the plant with the necessary parts and tools, and starts the repair operation there.

2.2. Issues of Preventive Maintenance Service

We have the following issues concerning a preventive maintenance service in Section 2.1.

1. We always have such a risk that a machine suddenly makes a failure and a manufacturing line stops.
   A) As a result, a customer has a possibility that they cannot complete the manufacturing until deadline, waste the materials, and so on.
   B) A manufacturing facility maker has issues that the operational load of field engineers is not uniform and the manager does not know the suitable number of field engineer.
2. There are possibilities that we may exchange the parts wastefully because we do not know the exact lifetime of parts and facilities.
3. A manufacturing facility maker does not know the everyday health condition of facilities in a customer plant. As a result, they cannot provide the various proposals in advance.

Because of these issues, if a maker estimates the cost for service provision pessimistically, they sometimes reach the result that they cannot provide a maintenance service without a loss.

2.3. Changes of Maintenance Service Processes

In this section, we explain the changes of processes consisting of service processes if we provide the predictive maintenance service by a prognostics system.

2.3.1. Preventive Maintenance Service Processes

In preventive maintenance service processes, they usually provide the service using a phone and paper as a communication tool.

- Regular inspection
  - A field engineer inspects facilities and exchanges parts following the ruled method once a year.
  - A manufacturing engineer performs a facility inspection and parts exchange every three month.
- Repair of failure
  - When a failure occurs in a machinery, we try to solve the failure by the following procedure.
    - Stop the manufacturing line.
    - Check the facilities.
    - Expose the failure point.
    - Procure the parts.
    - Repair the machinery.

2.3.2. Predictive Maintenance Service Processes

In predictive maintenance, we collect the health data from the facilities via network and monitor them. We perform the following processes.

- When we detect the necessity of parts exchange
  - Sharing the model type of exchange parts and the exchange deadline
  - When the exchange part is a generic product
    - Confirm the existence of parts stock, and procure the additional ones if necessary.
    - Settle the manufacturing engineer's operation date.
  - When the exchange part is a special product
    - Confirm the existence of parts stock, and procure the additional ones if necessary.
    - Assign field engineers.
    - Settle field engineers' operation date.
- When we detect the possibility of a failure occurrence
  - Notify a predictive failure occurrence date to a maintenance service manager.
  - Assign field engineers.
  - Operate maintenance tasks by field engineers.
  - Report the maintenance task completion.

3. BASIC REQUIREMENTS OF PROGNOSTICS SYSTEM

3.1. Requirements to Provide Predictive Maintenance Service

We show the requirements to provide maintenance service continuously.

1. It is necessary to avoid such a risk that we stop the manufacturing line.
2. We can know the health condition of machineries from the remote sites safely.
3. We can not only predict the failure occurrence but also support processes consisting of predictive maintenance service.
4. We can easily operate the prognostics system without the specific skills.

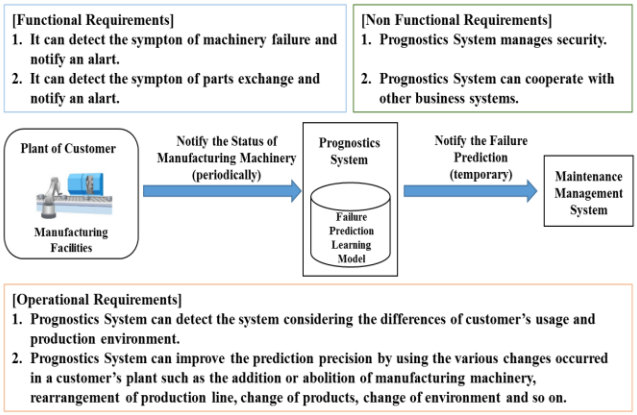

Figure 2. Basic Requirements

3.2. Functional, Non-functional and Operational Requirements

In this section, we show the requirements fulfilled by a prognostics system to provide a maintenance service described in chapter 2 (See Figure 2).

[Functional Requirements]

1. It can detect a sign of machinery failure and notify an alarm message.
2. It can detect a sign of parts exchange and notify an alarm message.

We monitor a machinery from a remote site all days and we need to detect a sign with a margin that we can prepare for parts and assign a field engineer. Prognostics system can notify an alarm message to not only the displays provided by itself but also the other business system such as maintenance management system, parts management system and so on.

[Operational Requirements]

1. Prognostics system can detect the system considering the differences of customer's usage and production environment.
2. Prognostics system can improve the prediction precision by using the various changes occurred in a customer's plant, such as the addition or abolition of manufacturing machinery, rearrangement of production line, change of products, changes of environments and so on.

Prognostics system manages "Failure Prediction Learning Model (FPLM)" for each machinery of failure prediction target and has to relearn if the affected change has happened. As for the above 1, if the way of customer's usage and the difference of environments affect the failure prediction precision, we need to reconstruct the FPLM.

Also as for the above 2, if we can make clear a changed factor according to the time course that is useful to a machinery health condition, we need to reconstruct the FPLM when the factor changes.

[Non-Functional Requirements]

We finally show the non-functional requirements.

1. Failure Prediction System (FPS) manages security.
2. FPS can cooperate with other business systems.

As for 1 in minimum level, a prognostics system needs a mechanism to prevent the leakage of data such that it ciphers data for communication. As for 2, in order to cooperate other business systems easily, a prognostics system can open API publicly and access to API by an open protocol. A prognostics system can also interact with other systems by push / pull type communication.

4. CONCLUSION

In this paper, we have proposed the basic requirements for a prognostics system that supports the decreasing of sudden failures and systematic maintenances. We currently develop the system based on the proposed requirements and have a plan to evaluate it at the real production line in near future.

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BIOGRAPHIES

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