A supporting tool for innovative maintenance strategies

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Abstract

Today the maintenance activity oriented to industrial assets is considered one of the most important business opportunities. Small and medium enterprises are often in trouble facing these issues so they need dedicated tools in order to offer a maintenance service aligned to the costumer requirements. Tuscany Region with the partnership of Florence University, by the EU funds, has financed a project, called eMeccanica (www.e-meccanica.org), in order to aid the birth of a Virtual Enterprise Network, formed by SMEs, able to offer maintenance service in the field of industrial plants (power generation, manufacturing, ecc). In this paper we describe the second step of the eMeccanica project and in particular the development of a prototype application that could be useful for the growth of the CBM tool.

Keywords: supporting tool, data collection and treatment, condition based maintenance, virtual enterprise.

1. Introduction

Today the maintenance activity oriented to industrial assets is considered one of the most important business opportunities. The maintenance suppliers operate in a very competitive market. First of all from the final users of the assets, there is a growing request in terms of reliability, availability and productivity; on the other hand industrial goods are often provided with complex systems and advanced technologies, not easily manageable.

Small and medium enterprises are often in trouble facing these issues so they need dedicated resources in order to offer a maintenance service compliant to the costumer requirements. The same problem, but from a different point of view, affects the final users of the asset that would like to monitor and check the performance of the maintenance service, often managed by an outsourced service.

Tuscany Region with the partnership of Florence University, by the EU funds, has financed a project, called e-Meccanica (www.e-meccanica.org), in order to aid the birth of a Virtual Enterprise Network, formed by SMEs, able to offer maintenance service in the field of industrial plants (power generation, manufacturing, ecc). The project has been developed following different steps.

In this paper we describe the second step of the eMeccanica project and in particularly the development of a prototype application that could be useful for the growth of the CBM tool. The availability of prototype represents an important element for the test&validation steps of the software tools development process.

2. E-meccanica project

The E-Meccanica project was created by a group of small size enterprises linked with Piombino territory. An area where you can feel the changes due to renovation and downsizing of heavy industries, i.e. Lucchini and the associated corporations. One of the most attractive businesses in such a field is associated with Maintenance, as an outsourcing activity. The basic needs for routine interventions do not require particular skills, but mostly man power with low margin of profit. Competition among suppliers of labour is constantly growing together with decay of qualified operators demand; at the same time prices for services are decreasing. In such a scenario the group of e-Meccanica decided to merge on team project aiming to improve the quality of the potential proposals to the market.

Trough an enquiry in the area there was the feeling of the need for innovation in Maintenance procedures. The possibility to offer some kind of revamping of major assets, trough online sensors and a platform that trough web channels may create an interface able to communicate the most part of operational parameters to a data management system was very much appreciated. Local industries are mostly based on machineries and technologies (if not obsolete definitely without any real time control systems) belonging to “last generation” kind of equipments. The possibility to update them, in order to develop some kind of Conditions’ monitoring prospect, with same internal management manpower seems a very attractive task. The option that E-meccanica group (and the associated) can deliver to the plant the skills and knowledge, by several experts in different Predictive tasks, with a form of virtual outsourcing and remotely operated procedures could be a winning tool. In order to demonstrate the feasibility of the project was created a demo unit of a basic type of machine; a chiller installed on a small skid with all the dynamic parts, linked to a data logger custom developed for the task. All together the package was easily transportable and could be delivered to different sites for demo purposes. Among the suggested improvements to make an easier procedure we are considering to apply a webcam near to the unit and downloading video files together with operational parameters. The concept of online monitoring only the out of range evidences was our target.

3. Project steps

The project has been developed to reach a business opportunity in the maintenance activity of the industrial plants. So at the beginning has been carried out a market analysis in order to identify and codify the needs of the plants' users. The study considered the medium and big size enterprises which assets are typical of the process industry like chemical, oil&gas and energy.

Most of the analysis has been carried by some meetings with the potential customers to meet their specific requirements in terms of reliability, availability and safety performances. Then was investigated the better solution for the VEN structure that could regulate the partners relationships, communication, roles and responsibility. In this step has been developed the reference business model that guided the next part of the project phases. The last efforts were concentrated in the development of an integrated tool for condition based maintenance (CBM) that was able to support maintenance service of the VEN.

The reference business model definition allowed to define the technical specification of the expert system platform, opening the design step of the support tool. As further mentioned the structure of the software tool is composed by a database where are stored the data and information and some different intelligent modules, that represent the interpretation tools of the plant conditions.

At the same time, the commercial partner of the VEN tried to find a case study that could represent a first industrial application but also could be an opportunity to develop and testing the expert system. The support system development required a case study but there wasn't any prompt chance so bore the idea to create a prototype plant that would be able for the test and validation step.

This paper reports the main activities of the prototype development, starting from the thermotechnics design until the reliability analysis that has been performed to carry out an adequate test bench. At the moment, the last step of the project is still in progress and the development of the decision support system is going on but the benefits of the prototype availability are evident and it will guarantee a reliable product.

4. The prototype

The development of the platform called for the need to have a dedicated test case. That is why the VE was activated to search an actual case that could serve as a pilot project.

As expected, the critical application scope of the project (maintenance of facilities) and its innovative approach generated mistrust in potential customers and hence the marketing activities has been very difficult and with little results.

In this way, the VE, which had to submit as a team of effective and concrete companies, has risked not find a case application on which develop its potential. This reason has been the main stimulus for the birth of the idea of developing a prototype

that could testify and highlight the added value of the service that the VE is able to provide to its customers.

Furthermore, the implementation of a prototype plant in a laboratory environment ensures a place of environment much simpler and a suitable for an expert system platform compliant with a maintenance support service.

The choice of the type of plant fell upon a water chilling group, for the following reasons:

- Compact and easily transportable;
- Widespread and common application;
- It works easily and technological knowledge consolidated;
- The maintenance activities include a broad spectrum of expertise.
- All the features listed above will encourage the possible future marketing activities

The following details of the machine (Fig. 2)

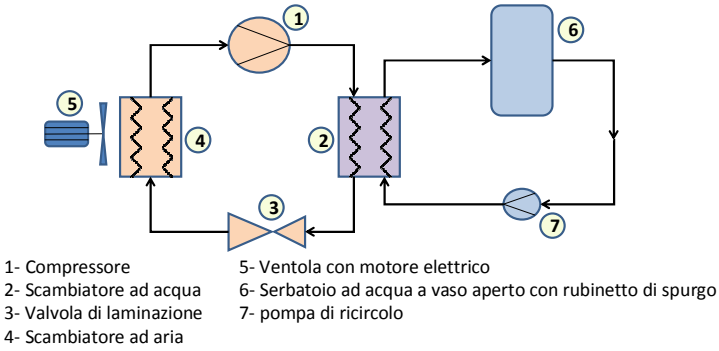

Figure 2: prototype scheme:

The development of the prototype was supported by an FMEA and an FTA analysis with the aim of:

- Avoiding mistakes during fault simulation, in particular it was necessary to preserve the permanent machine failures that could permanently stop the functioning;
- Defining those measurements to be acquired and all the sensors to be used for feeding with data the expert platform;
- Ensuring a design phase supported by a reliability assessment, as suggested by constructive good practices.

At the same time the integrated tool for the CBM was carried out and it is composed by an Online Machine Tool for the data acquisition and treatment (called OMT, developed by Mecoil S.r.l.), database for data storage and management and an expert system for data interpretation. This tool represents an expert platform able to be a decision aiding system for the support of the VEN maintenance service.

The issue of this expert platform is the continuous online remote monitoring and the automatic and autonomous decision taking in terms of maintenance activities for industrial machines as compressors, boilers, and so on.

The project is still in progress and soon will be available interesting development and application.

5. The design

The FMEA like reverse analysis (Failure Mode and Effect Analysis), shown in Table 1, performed exclusively for the stage of normal operation, had a dual purpose:

- Definition of the possible failure modes of the prototype, found during the simulation;
- Identification of the type and placement of sensors required for data acquisition (Figure 3).

Table 1: FMEA like analysis

End Effect	Local Effect	Simulation	Measurement	Cause
Water in circuit 2 doesn't decrease temperature	High pressure in circuit 1	Cover the gas/air heat exchanger	P2	Dirty radiator
		Power off the fan	P2+V2	Broken Fan
	Low pressure circuit 1	Partial closing of interception valve circuit 1	P2	Leakage circuit 1
		Power off the fan	P2+V1	Broken compressor
	Little flow in heat exchanger circuit 2	Partial closing of interception valve circuit 2	P3+ΔT3	Bad working of water pump
	No flow circuit 2	Power off the water pump	P3+ΔT3+V3	Broken water pump
Non water in circuit 2	Water level in tank of circuit 2 goes down	Open the tap of circuit 2 tank	L	

The FTA analysis (Fault Tree Analysis), however, has allowed the setting of the expert system for the processing and interpretation of data from sensors.

Following the analysis described above, the final draft of the prototype was delivered. The building step was thus initiated. The chiller was built by MP Refrigeration S.n.c. on behalf of Mecoil S.r.l.. Once delivered, it was completed with sensors, by the insertion of some probes that had not been mounted under the previous step.

The second phase of development was to install a prototype of the component called OMT (Online Machine Tutor). The OMT was developed following the idea to create an integration trough procedures, with all the principal feedbacks and functions from machineries that are strategic for the plants, in one single data manager, capable to take real time decisions on how and when an intervention by the supervisors is really needed. On a perspective of Lean organization, the maintenance is carried out,

depending on actual conditions; real time on real demand. The sensors were connected to the data acquisition card. Then there was the check of the correct interaction between machine and monitoring system.

The prototype has been installed inside the laboratories of the University of Florence (Department of Energy, Plants and Industrial Technologies Section). It has been linked to a computer on which the expert platform had been previously installed, developed in Microsoft Visual Basic 6.0. The verification of the proper functioning of the whole apparatus, through a series of tests and trials, was the last step necessary for the completion of the prototype.

Then began the real testing phase, which has, as its goal, the development of an expert platform for the support to maintenance operators. All this should be made in order to implement a "predict and prevent" maintenance strategy.

This activity is still in progress and it is difficult to determine its duration as such as the possibilities for growth and improvement: everything will be based on future stimuli and features that you will want to implement.

7. Developments

The platform MONITO was born thanks to a development programme basing on a prototype plant.

Its potentialities can be very wide and they depend on the application within which you decide to enter. Regarding the "e-meccanica" project, it is able to support a virtual enterprise in the implementation of a maintenance strategy like "predict and prevent". In particular, it can acquire signals, data and information from the field, both online and offline, and then to update the knowledge base. All this in order to define, moment to moment, the health status of a machine or a plant. Furthermore it may indicate maintenance operations necessary for its preservation in a state of proper functioning. Finally, thanks to the communication technologies adopted, the expert platform and the maintenance organization could be in a remote location compared to the machine itself.

The opportunities for the application of an instrument of this type are very wide and varied.

Surely all machines critical to the operation of a facility, with not recent technologies, would gain an great benefit in adopting this kind of systems. If we also consider, as is often the case, a context where maintenance activities are handled by a network of operators who have complementary skills, it would find its ideal application and it would be able to generate a significant added value in effectiveness and efficiency of the service provided

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