METALLURGICAL SYSTEMS CONTROL WITH LOCALIZATION INSTRUMENTATION SUPPORT

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Abstract

This paper is focused on problems with operative control support with usage of object localization in heterogeneous industrial environments. There is presented usage of specialized localization and identification electronic systems and logistic methods, development of own localization units with usage of standard GPS and GSM systems, including device testing in various industrial environment. The application is aimed on optimization of maintenance teams in metallurgical company. These companies are territorially large, with high share of metallic structures. These structures complicate standard localization methods. Optimization of maintenance teams is very desirable, because of economical savings regarding to maintenance it selves and treatment speed.

Keywords: Metallurgical company, localization, maintenance, GSM, GPS, optimization

1. INTRODUCTION

The problem definition. There is an issue, when optimizing maintenance teams in large premises. The maintenance teams has usually a daily schedule which means, that they are working in several specific problems. If there is a sudden failure, there has to be at least one backup team, which will deal the issue. This is similar when comparing any other service maintenance teams, working large area, such as a city, or state. To better utilization of maintenance teams is suitable to use an operator, which has absolute knowledge about team's positions and theirs schedule plan. We have focused on large company premises such as Arcellor Mittal or Třinecké železárny a.s. These premises has very similar environment. A many huge metallic structures with concrete basis. In this environment, it is very difficult to find out the precise position of maintenance team, especially if its work is inside of the structures. So, this article is focused on maintenance efficiency increase in huge metallurgical premises. We are describing a tool, which can allow more precisely control and manage maintenance tasks in big metallurgical company.

1.1. Maintenance in metallurgical environment

Very important, but also usually neglect support instrument of production is maintenance. It is commonly understand as a mandatory ballast, because, in essential, the maintenance is not providing profit. Because of economization of production and increasing process clarity is usually maintenance outsourcing. This step solving operation costs, but unfortunately not an optimization of maintenance from the point of view of maintenance flexibility. To be more effective, the maintenance teams have to be interconnect to MES systems in both directions. This step can significantly increase maintenance efficiency and flexibility.

The functional area of *Maintenance Management* follow and control an activities performed for keep production resources in such state, which will precede unplanned production interruptions. Maintenance Management can offer schedules of preventive and periodic maintenance actions. If the production device is properly equipped, the maintenance can be driven according to the actual device's state. It also react to alarms, common issues and for future diagnostics store actions history. [1], [2]

The specificity of maintenance management on metallurgical plants is given above all by character of production process it selves and further by followed facts:

- Most of monitored nodes or device's parts has repairable capability, whereas repairable level is given by cause of failure;
- If there is higher number of monitored elements in repairable system, there is usually not known precise time of failure of each single element;
- Failure removing process, with has minor operational consequences, is usually done after a accumulation of more minor failures, commonly during regular maintenance;
- It is almost impossible, from operational, economical or organizational reasons, to ensure monitoring of middle complex and complex systems on homogenous files, huge enough from the statistical point of view;
- Actual monitoring device's state evaluation is far more different than in other branches;
- There is also different experimental determination, or verification, of reliability indicators than in other branches;

In maintenance of metallurgical machines and equipment can be defined four maintenance approaches, which are now implemented in main metallurgical companies with different level of importance. The primary purpose is optimization of economic and technical targets of maintenance:

- corrective (repair) maintenance,
- preventive maintenance,
- maintenance based on knowledge of actual state of the device,
- casual maintenance - the title implicate a fact that it is provided in case of shut down of the device.

1.2. Computer support for maintenance control

Above mentioned aspects and more, less important ones can lead to significant complications when implementing computer support control of maintenance in metallurgical plants. What are the main reasons and contributions of implementing computer technics into the maintenance activities? These are the data and so on increasing of control effectivity on the basis of adequate data and information. Modern maintenance control on the data basis mean monitoring production metallurgical devices, planning and control theirs preventive maintenance including concurrence on storage control and an administrative of spare parts purchasing with interlacing on company's information and economic system.

The present day trend in metallurgical maintenance environment is usage of electronic elements for labor unit control (*Labor Management*). A workers surveillance is functional area which offer at first place an information about a crew, which is in given time at the disposal.

Labor management keep records and inform about crew competence (education, certificates, special knowledge and skills). It monitor also indirect activities when preparing materials, machines and instruments as a basis for cost calculation according to activities. In Interaction with assigning a sources it help to choose workers for specific task optimally.

An electronization of working crew control ends in many companies at electronic attendance system. This is a good start, but also insufficient. Workers equipped with electronic identifying instruments could be the first step to real labor control system. Monitoring if someone is in the workplace, or just leave has more likely security and evidence meaning. For production control it has minor significance and in the case, that this system is not interconnected with operative planning sub-system, even unavailing. If it is in place usage of electronic identification of workers for monitoring on tasks participation and interconnection with operative planning is done, it can be much more improvement in labor usage.

2. ELECTRONIC INSTRUMENTS FOR MAINTENANCE CONTROL SUPPORT

The labor management in term of maintenance management is in place in one of the largest metallurgical company in Czech Republic. We are not allowed to name the company because of mutual agreement, but it is not important. To improve efficiency of maintenance process it selves, the personal localization device was developed.

The first version was dependent on RFID wireless identification, which is very precise, but on the other hand, very expensive and it can't be applied across the company buildings. The reason is only the price. One stationary gate equipped with RFID transmitter working on 860 MHz costs more than 3 000 EUR. Reading distance is more than 6 m, so maintenance teams could be uniquely identified with preciseness better than 10 m. Knowing this, the GPS localization sub-system was added. This improvement significantly increase knowledge about team's position, but it is useless when inside of buildings. Most of the building in metallurgical premises has metallic core, with concrete basis. This combination is virtually impermeable for radio waves, on which GPS system operates. On the other hand, this technology gives the operator great vision, where the given maintenance team is in real time. The main drawback is, that in case of the team gets inside building, GPS signal is lost and the operator doesn't know specific location of the team. In addition, if the GPS localization system should be online, must to contain any version of data communication. The first in mind is standard, ubiquitous WiFi. But metallurgical companies used to be vast in range, so external WiFi transponders is not an option, because of small communication radius. Also metallic structures make it impossible to penetrate signal inside of these structures. As a data communication instrument was then choose a GSM. As a modern technologies are more common, there are several localization methods relative to GSM communication modules. Due to better sensitivity and mainly lower working frequency than WiFi or GPS it is able to penetrate inside the buildings and makes data connection possible. So a combination of RFID, GPS and GSM originate and then was tested under operation condition, respectively in metallurgical premises. [3], [4]

It was made a case study, if there is a similar system, which can monitor objects online in large area. Usually are these support instruments used when monitoring wild animals in nature environment, but they has one thing common. The GPS/GSM system. One is for the data communication, the other for localization. In [5], [6] and [7] the authors deal with usage of wireless network based on WiFi and difficulties with transmission. Very close results was obtained, when testing wireless signal transmissivity in structure when continuous casting device operate. Hi share of metallic parts and vast peak current flows through the conductors almost suppress wireless signal working on 2.4 GHz. Large alternating current is in metallurgy usually used to heat up the melting charge. In our case, when large arc furnace works, an addition radio frequency (RF) emissions occurred. Only high power RFID stationary gate can operate at this hard type environment.

3. OPERATIONAL TESTS

The operational tests was made in two levels. The first one was for comparison in open area if the overall accuracy is sufficient and can be used. It means, that GSM localization was compared to much more accurate GPS system. The visualized data are presented in (**Figure 1)** The system accuracy was determined by simple algorithm presented in (1).

$$|\sigma| = GPS_{x,y} - GSM_{x,y} \,, \tag{1}$$

where σ is absolute deviation between GPS and GSM positions, $GPS_{x,y}$ and $GSM_{x,y}$ are actual absolute position represented by two dimensional coordinates. Total mean deviation of position then can be represented by (2).

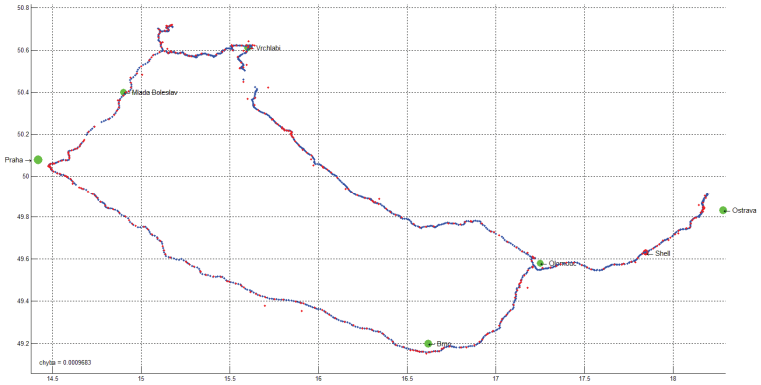

Figure 1 Testing GPS/GSM localization system in open space to evaluate accuracy

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}\left(GPS(i)_{x,y} - GSM(i)_{x,y}\right)^2, \quad (2)$$

where *n* is total number of measured data. As can be seen, this is a modified equation for mean square deviation, which is calculated with usage of mean error.

The second level of testing proceed in metallurgical premises, under operational conditions. This means, that all systems was in normal operational mode. Position of maintenance team is illustrated as a red dots in (**Figure 2)**. The final position is combination of GSM and GPS system, according to which one actually supply readable data. There can be seen the whole trip originating in Ostrava city with the trip end in Company XX. Lower part of the figure then visualize detailed picture with highlighted red dots.

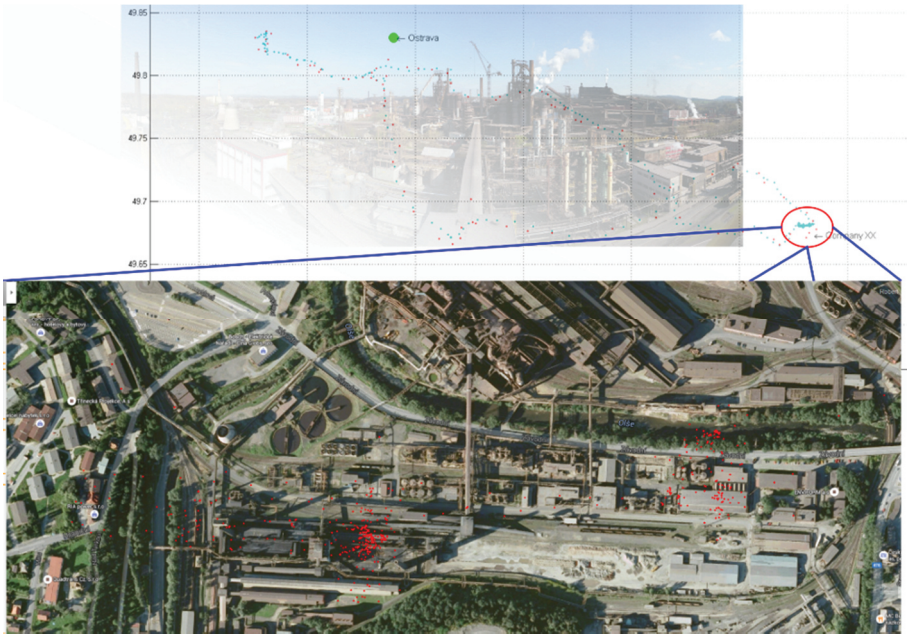

Figure 2 Testing GPS/GSM localization system in operation condition inside metallurgical company's premises

In operational condition, there is a significant difference between open area conditions and conditions inside metallurgical premises. A position resolution drop below 20 m, in other words, precise position in 3D space were somewhere in circle with 20 m radius. The previously developed device was for that reasons equipped with better GPS and GSM antenna (**Figure 3**).

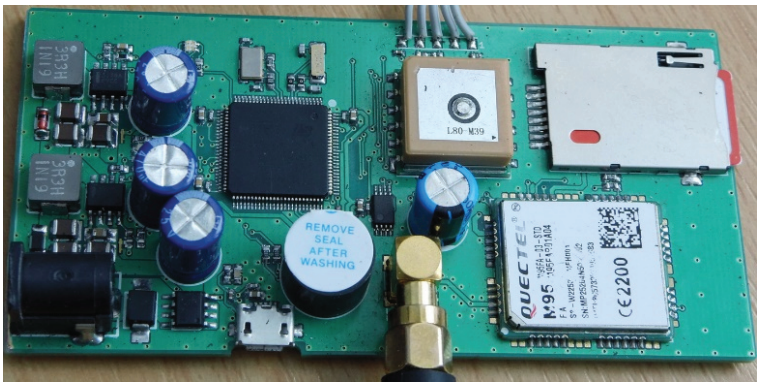

Figure 3 Improved personal GPS/GSM/RFID localization device for usage in large metallurgical premises

There is a power supply on the left side of the picture, central processing unit and external GSM antenna in the middle and GSM/GPS/SIM card slot on the right of the picture. The maintenance team's position is immediately send to central database, where the operator can see team's position. Even if the position is not known precisely, 20 m uncertainty is sufficient for the operator to determine exact location, because the operational complexes has large distances between each other. So if there is a sudden failure somewhere, and the operator evaluate its threat level as high, the closest maintenance team with threat level lower failure, can immediately react. [8]

4. CONCLUSION

The scope of the paper is into optimization of maintenance management as a part of labor management in large metallurgical premises. The maintenance management is very important because of great complexity of production chain, which consist of many "smaller" sub systems dependent on each other. For optimization of maintenance process was developed small, wearable localization device, which helps operator evaluate maintenance team's position and can quickly react on immediately threat. The article brings first operational data from use the device inside the metallurgical company with all restrictions takes into account. Metallurgical premises is very distinct from standard, open space environment, which was proved from measurements. We believe, that proper maintenance management with good labor management can significantly decrease failure removing time and precede another additional costs.

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