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**An Operating and Monitoring System Design for Safety Control of
the Blasting Cells in Shipbuilding**

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Abstract

In this paper, we design an operating and monitoring system for safety control of the blasting cells in shipbuilding, called HYMOS(HYundai heavy industry Monitoring and Operating System for the blasting cells). The blasting cells operations are currently scheduled manually by human experts. Manual scheduling is a serious time consuming job and generally can not guarantee a full optimality. Building a traditional scheduling system for this problem, however, is not promising because there are various kinds of constraints to be satisfied including space allocation of blocks in the blasting cells. Also, the blasting work is a very dangerous because workers have to carry and operate with the heavy working tools and it requires a long time to perform a duty at the inner part of block. We, therefore, develop an optimal work order approach and a real-time location algorithm based on wireless network technology. And through simulation experiments for various situations of the blasting cells, this study demonstrates the usefulness of the workers location compensating algorithm.

1. Introduction

Shipbuilding is industry that produces a various types of ship through processes which are consist of hull construction, outfitting and blasting/painting. The hull construction forms the structural body of ship through the series of production stages such as parts fabrication, block assembly and hull erection, while the outfitting handles all the parts of a ship that are not structural in natural. Next, the blasting is to make shots at the block with grit or small steel balls to clear rust, which is followed by the painting job to spray paints upon the blasted block several times. To prevent rusting blocks are painted immediately after finishing the blasting. The blasting work is a very dangerous because workers have to carry and operate with the heavy working tools and it requires a long time to carry out in enclosed spaces (i.e., the blasting cells) in order to comply with environmental standards and to permit grit recycling.

This study focuses on the blasting, especially the blasting process and describes the 'HYMOS (HYundai heavy industry Monitoring and Operating System for the blasting cells)' which has been performed at the blasting cells in Hyundai Heavy Industries, one of the largest shipbuilding companies in the world, with intent to achieve high productivity and the safety of workers. The blasting process is placed the initial stage of painting process and between outfitting and pre-erection processes, which are on the critical path of shipbuilding process. The performance of blasting process influences the whole shipbuilding processes such that its low performance directly results in process delays and late delivery of a ship.

The blasting cell operations are currently scheduled manually by human experts. Manual scheduling is a serious time consuming job and generally can not guarantee a full optimality. Building a traditional scheduling system for this problem, however, is not promising because there are various kinds of constraints to be satisfied including the limited workspace allocation of blocks in the blasting cells.

This paper describes an optimal work order approach, a real-time location algorithm based on wireless network technology and a monitoring system for safety control in the blasting cells. And through simulation experiments for various situations of the blasting cells, this study demonstrates the usefulness of the workers location compensating algorithm.

2. The optimal work order approach

The blasting operations are conducted in the blasting cells confined by walls and roof, where several blocks are blasted after arranged. Blocks generally stay one day in the blasting cells and then they are moved to next stage (painting process).

To build the schedule of blasting process is so complicated because it needs to consider the traditional scheduling problem as well as the spatial allocation of blocks within the limited workspace. For solving the problem, we adopt the optimal work order approach to maximize the space utilization of the blasting cells by efficiently arranged blocks and keep the workload balance uniform.

As shown in *Figure 1*, the optimal arrangement searches for the best layout at the blasting cells and the appropriate assignment of working teams by the most efficient method.

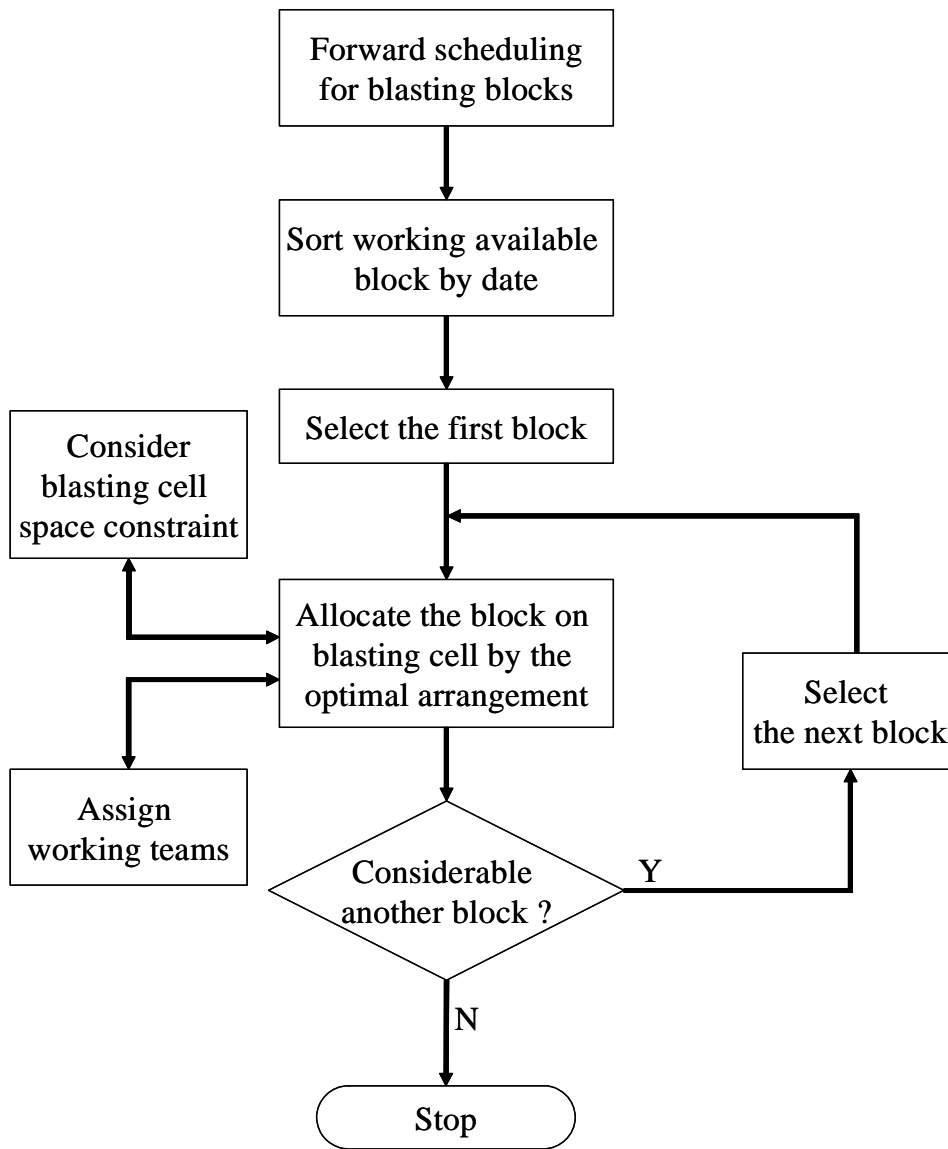


Figure 1. The logic of optimal work order approach for the blasting cells

Figure 2 shows the result of optimal arrangement at the blasting cells.

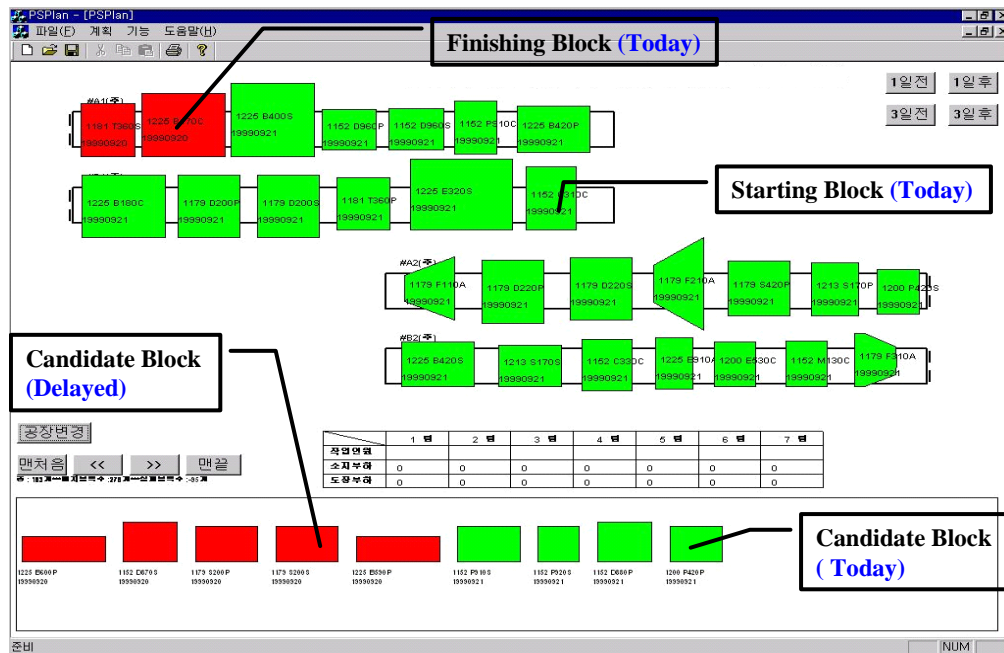


Figure 2. The result of block arrangement at the blasting cells

To evaluate the performance of optimal work order approach for the blasting cells, the experiments to the performance of space utilization and workload balance are conducted as comparing work order approach with manual operation. *Table 1* shows the comparison of results obtained by system.

Table 1. Comparison of space utilization and workload balance

Performance of blasting cells	Manual	Work order approach	Improvements (%)
Space utilization	70.58 %	80.79 %	14.5
Workload balance	71.34 %	89.25 %	25.1

3. The monitoring system for safety control

In order to check the safety of workers in the blasting cells, we develop the real-time monitoring system based on wireless network technology. After analyzing the process flows of the blasting cells and requirements of workers we design the monitoring system for safety control of the blasting cells as *Figure 3*.

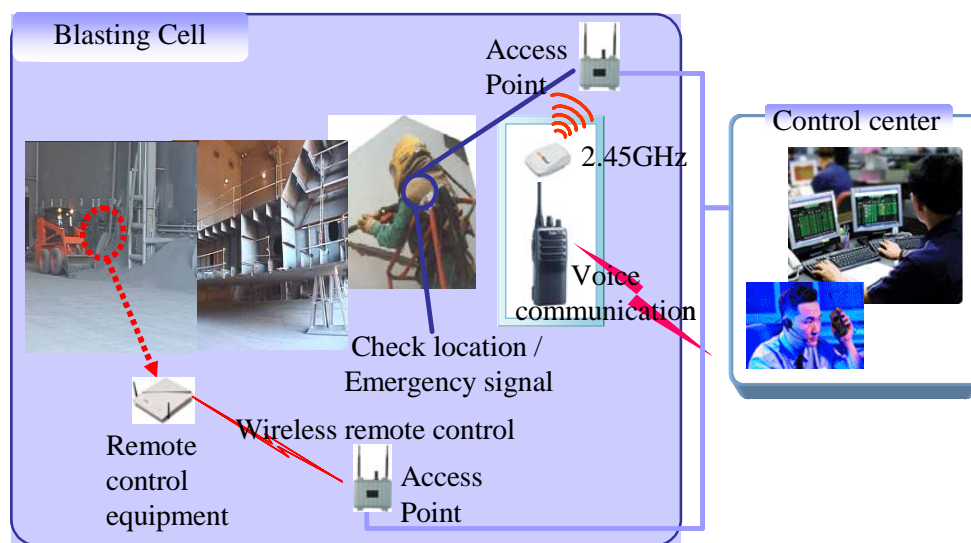


Figure 3. The design of monitoring system for safety control

To decide a proper type, quantity and location of AP for a blasting cell (30m x 25m x 15m) and the range of radio frequency for communicating between control center and workers the experiments for various situations of the blasting cells have executed for about 3 months. There are lots of difficulties in gathering the data at the beginning of test because the shape of tested blocks is different day by day. *Figure 4* shows the result of measuring the location values (x, y point) of workers in the blasting cell by RTLS engine (Aeroscout).

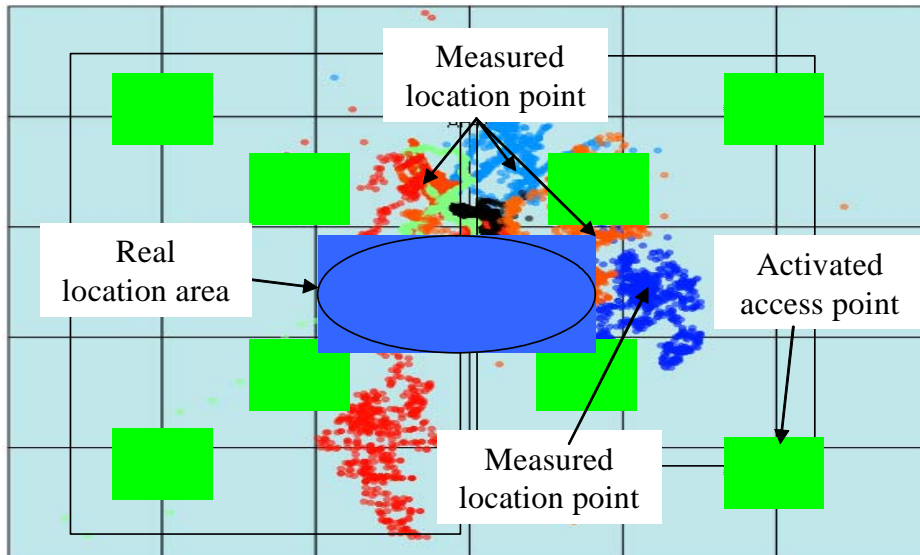


Figure 4. The screen of measuring the location value of workers in a blasting cell

It can be checked the differences between the real location values and the measured through tested results as *Table 2*.

Table 2. The result of tests by the various conditions changed

Quantity of access point	No. of division area (by RTLS engine)	Deviation of location point	Receipt condition of radio signal
12	1	10m more	Good
	4	10m more	Interruption (10~20sec./min.)
8	1	10m more	Good

To acquire the exact location values of workers in the blasting cells is so hard because of reverberation and collision of radio signal to the blocks assembled by the steel plates. For solving the problem, the location compensating algorithm is developed and demonstrated the usefulness as shown in *Figure 5* and *Figure 6*.

Figure 5 shows the logic of location compensating algorithm for the safety of workers.

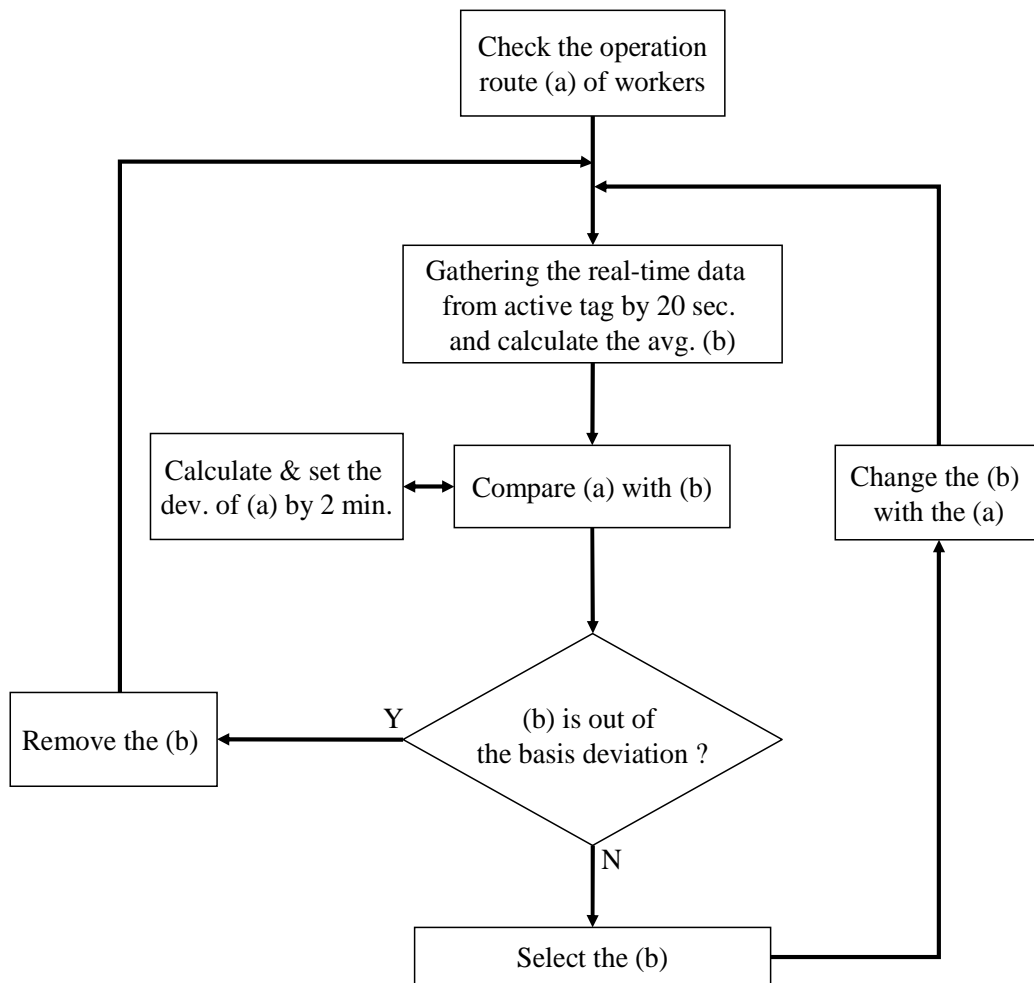


Figure 5. The logic of location compensating algorithm

Figure 6 shows the result of demonstration to check the usefulness of location compensating algorithm.

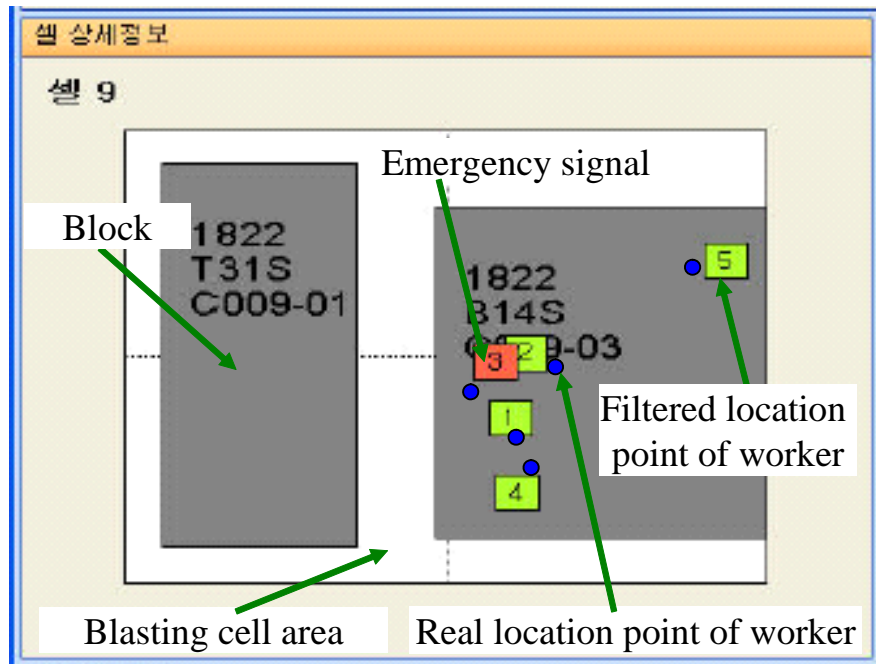


Figure 6. The screen of real-time workers location by location compensating algorithm

4. Conclusion

In order to contribute to improve productivity as space utilization and workload balance and check the safety of workers in the blasting cells, the optimal work order approach and the real-time monitoring system based on wireless network technology are developed. The usefulness of optimal work order approach is proved by the experiments that compare scheduling by the system with manual operation. And to resolve the difficulties in getting exact location data because of reverberation and collision of radio signal to the blocks fabricated by the metal materials the location compensating algorithm is proposed and demonstrated.

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