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The two stage assigning and scheduling algorithm for 2-stroke engine assembly shop

Authors

Seung-Jin Ha*, Tae-Hoon Choi**, Soon-Ik Hong**, Ji-On Kim**

* : Chief Researcher

Tel: 82-52-202-3202   Fax: 82-52-250-9587   E-mail : haie@hhi.co.kr

*, ** : Hyundai Industrial Research Institute, Hyundai Heavy Industries Co., Ltd.

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Abstract

In this study, the optimization algorithms are proposed for 2-stroke engine assembly shop. 2-stroke engine is mainly used to turn a propeller in a ship. Engines are manufactured through the various processes and the final process is an assembly process at the engine assembly shop. The schedule of engine assembly process is very important, because it is the basis of the production schedule of other processes, and the due date of raw material and components. The manual scheduling is very difficult to change production schedules, to improve the balance of workload and the efficiency of stage usage, which would be paid also another cost for storage of engine.

Therefore, in this paper two stage scheduling algorithms are proposed. In the first stage, engines are assigned and scheduled to assembly shops on the due date by the initial algorithm. In the second stage, three algorithms are proposed which improve the balance of workload, the efficiency of stage usage, and the reduction of storage period respectively. Also the efficiency of the algorithms is compared with the manual result.

1. Introduction & Analysis

The 2-stroke engine is mainly used to turn a propeller in a ship. Engines are manufactured through the various processes and the final process is an assembly process at the engine assembly shop. The schedule of engine assembly process is very important, because it is the basis of the production schedule of other processes, and the due date of raw material and components.

Our company is the largest engine manufacturer of the world. About 450~600 2-stroke engines are manufactured in a year. So a manual scheduling is very difficult. And if engine buyer changed the due-date of engine, the production schedules must be changed. But the manual scheduling cannot provide proper result. And it cannot improve the balance of workload and the efficiency of stage usage, which would be paid also another cost for storage of engine.

Therefore, in this paper two stage scheduling algorithms are proposed. In the first stage, engines are assigned and scheduled to assembly shops on the due date by the initial algorithm. In the second stage, three algorithms are proposed which improve the balance of workload, the efficiency of stage usage, and the reduction of storage period respectively. Also the efficiency of the algorithms is compared with the manual result.

Fig. 1 The 2-stroke engine and assembly shop

2. Design

2.1 Design of scheduling process

The scheduling algorithm is proposed by analyzing existing scheduling process, problems and requirements. Fig 2 shows the improved scheduling process. The scheduler can establish schedule immediately from using the two stage algorithms. Work efficiency can be improved by dealing with establishing, modifying, confirming and distributing the schedule in this algorithm. Also scheduler can analyze the schedule that he makes by using analyzing module in this algorithm.
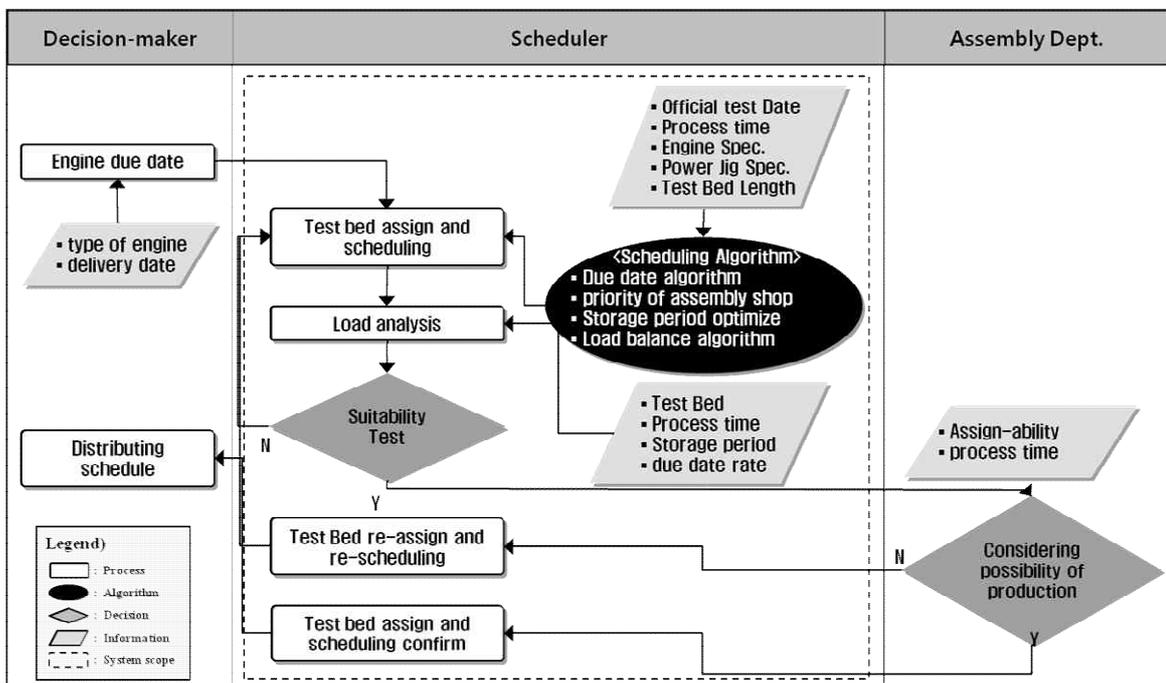

Fig. 2 The improved scheduling process

The scheduling result is tested by shop worker of assembly department. Because working shop condition is frequently changed. And then scheduling result is confirmed and distributed by decision maker of production planning department.
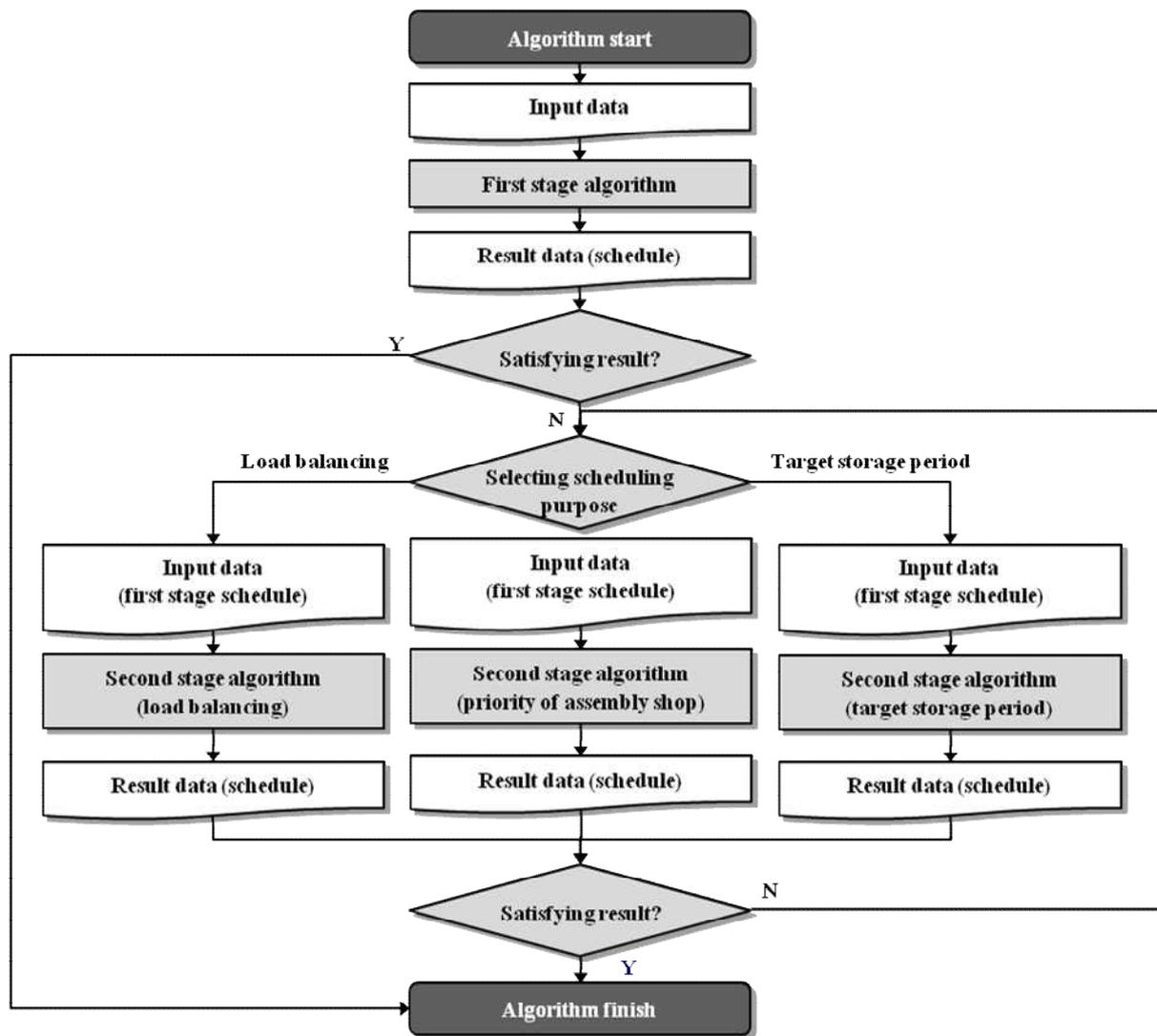
2.2 Algorithm

Fig 3. Two stage algorithm

From Fig 3, the algorithm has two stages. In the first stage, the algorithm issued initial scheduling that is used input of second stage. It considers assembly shop by engine type and due date. In the second stage, it has three purposes, load balancing, target storage period and priority of assembly shop. Load balancing is focusing on balancing the work load. Target storage period is managing the storage period of engines. And priority of assembly shop algorithm is managing the productivity of engine assembly shop. Because of suitable assign

of working shop can increase the assembly productivity.

First of all, scheduler selects the purpose with considering total number of engines and market condition. After selecting purpose, the algorithm inputs data such as type, delivery date of engines and so on. The algorithm makes schedules reflecting the purpose and the schedules are generated as result data. The schedule is evaluated by three criteria, delivery meeting ratio, load balancing ratio and average storage period.

2.2.1 Load balancing algorithm

Balancing work load is one of the most important purposes in engine assembly schedule. If there is no work load balance then work load may be concentrated at certain time. And this will cause overtime works, problems of quality and safety. On the other hand, if there is no work load, there comes problem about surplus labor. Therefore, it is significant issue to balance work load in order to solve these problems.

Fig 4 shows conceptual diagram of load balancing algorithm. There are four steps to perform the algorithm. In step 1, initial scheduling data is inputted. The data include type, delivery date, total number of engines and official test dates. The algorithm searches month that is the largest deviation of official test number. In step 2, the algorithm searches moveable engine. In step 3, the selected engine is moved prior or posterior month. And the step 1 to 3 are repeated during moveable engine empted. In step 4, the algorithm generates schedule as result information. Fig 5 shows flow chart of load balancing algorithm.
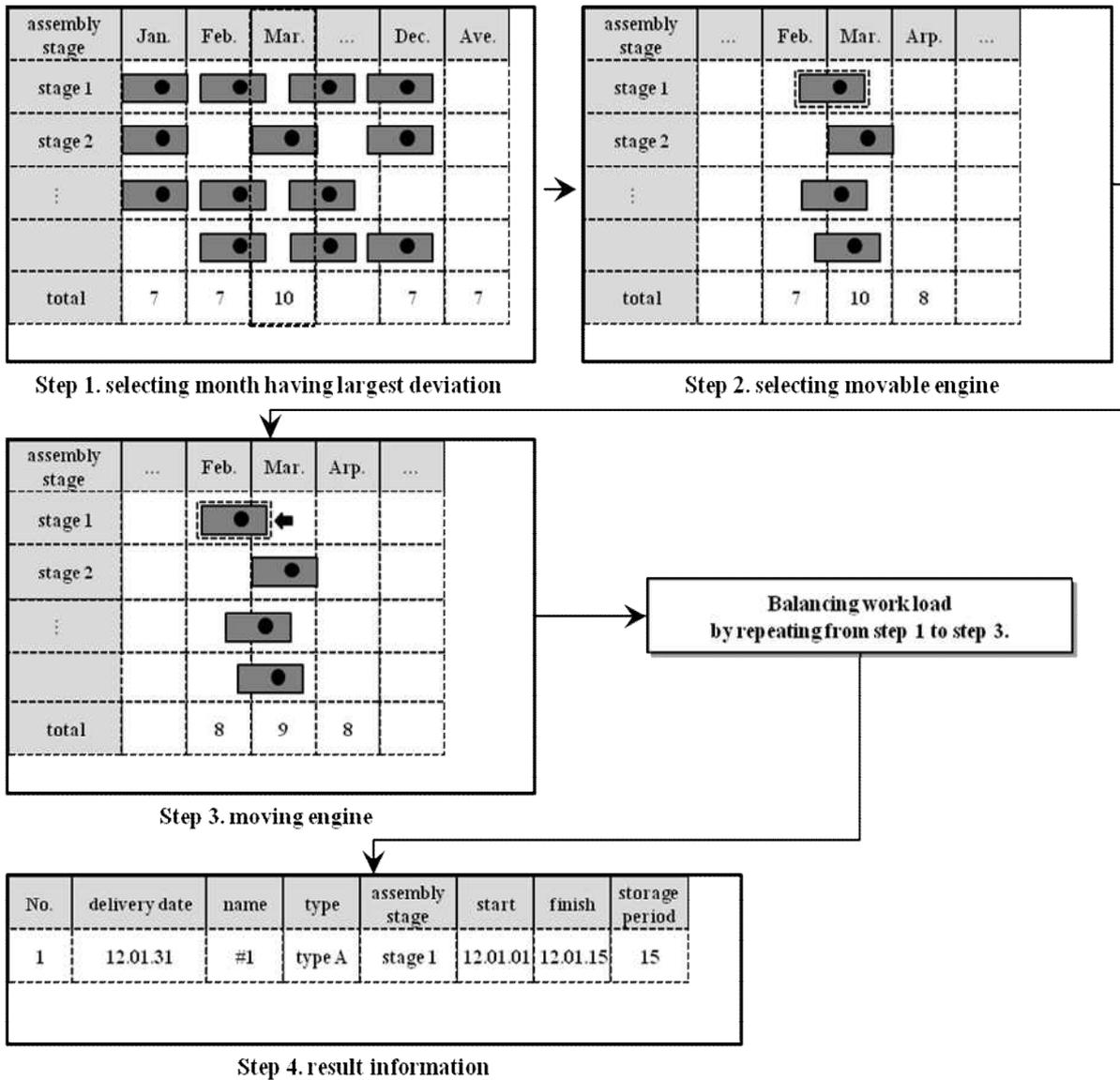
Step 1. selecting month having largest deviation

assembly stage	Jan.	Feb.	Mar.	...	Dec.	Ave.
stage 1	●	●	●	●		
stage 2	●		●		●	
⋮	●	●	●			
		●	●		●	
total	7	7	10		7	7

Step 2. selecting movable engine

assembly stage	...	Feb.	Mar.	Arp.	...
stage 1			●		
stage 2			●		
⋮			●		
			●		
total		7	10	8	

Step 3. moving engine

assembly stage	...	Feb.	Mar.	Arp.	...
stage 1		●			
stage 2			●		
⋮			●		
			●		
total		8	9	8	

Balancing work load
by repeating from step 1 to step 3.

Step 4. result information

No.	delivery date	name	type	assembly stage	start	finish	storage period
1	12.01.31	#1	type A	stage 1	12.01.01	12.01.15	15

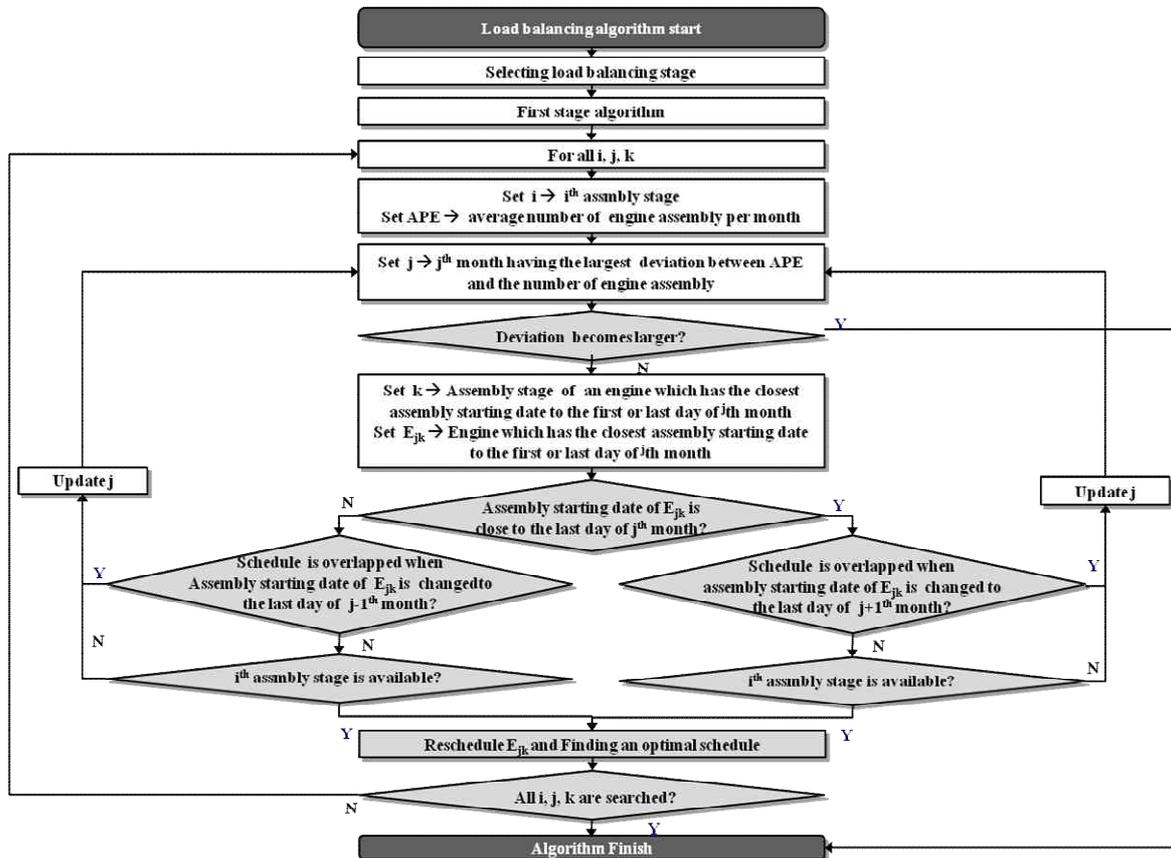Fig 4. Conceptual diagram of load balancing algorithm

Fig 5. Flow chart of load balancing algorithm

2.2.2 Target storage period algorithm

Managing the target storage period is also important purpose in engine assembly schedule. After assembling the engines, the storage period occurs because of daily gap between finish day of assembling engine and delivery. As storage period occurs, there arises management cost for storing engines. Therefore, it is significant issue to manage the target storage period in order to reduce the management cost for storing engines.
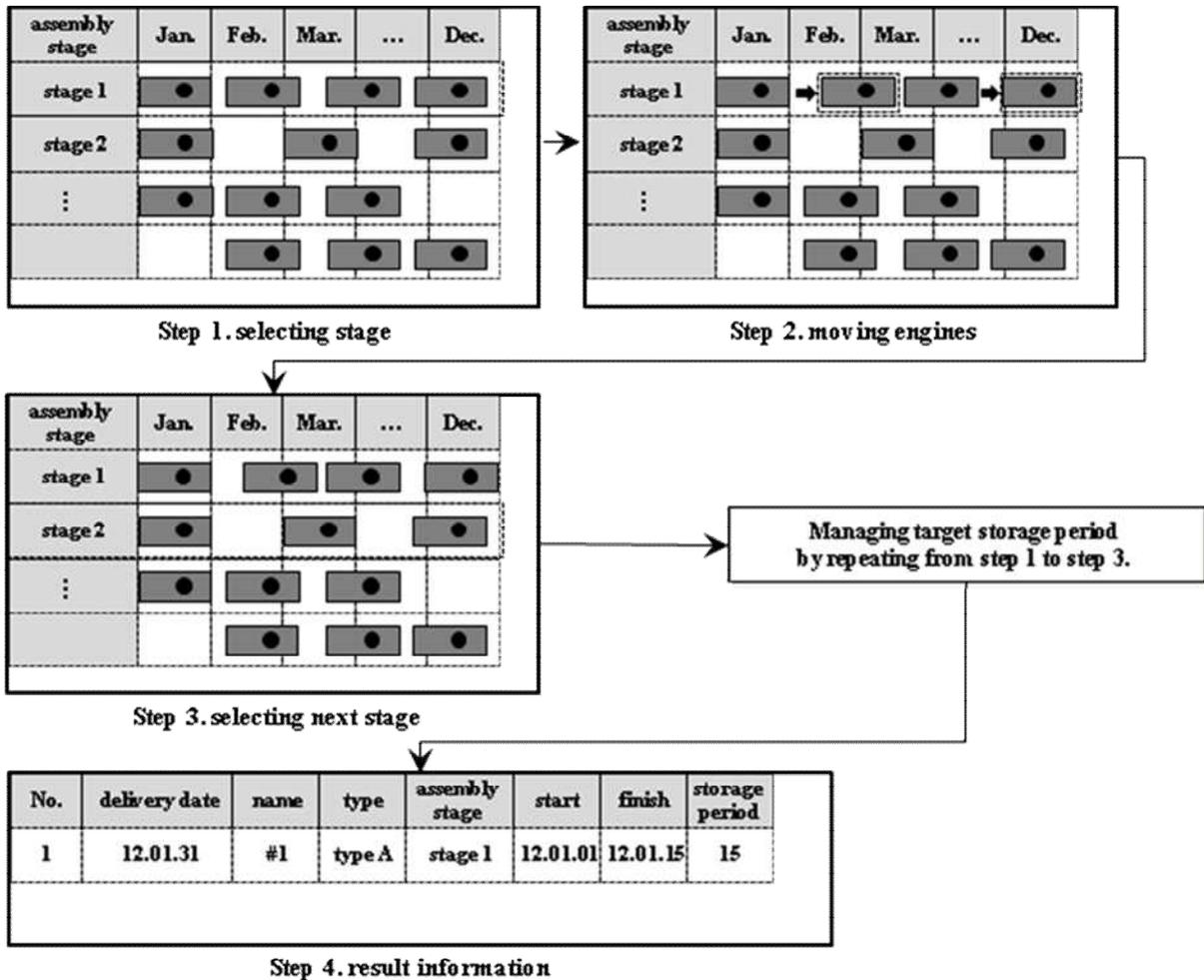
Fig. 6. Conceptual diagram of target storage period algorithm

Fig. 6 shows conceptual diagram of target storage period algorithm. There are four steps to perform the algorithm. In step 1, the algorithm searches assembly stages that can produce engines and selects the moving engine. In step 2, the selected engine moves until target date. In step 3, the next stage is considering. And the step 1 to 3 are repeated. In step 4, the algorithm generates schedule as result information. Fig. 7 shows flow chart of target storage period algorithm.
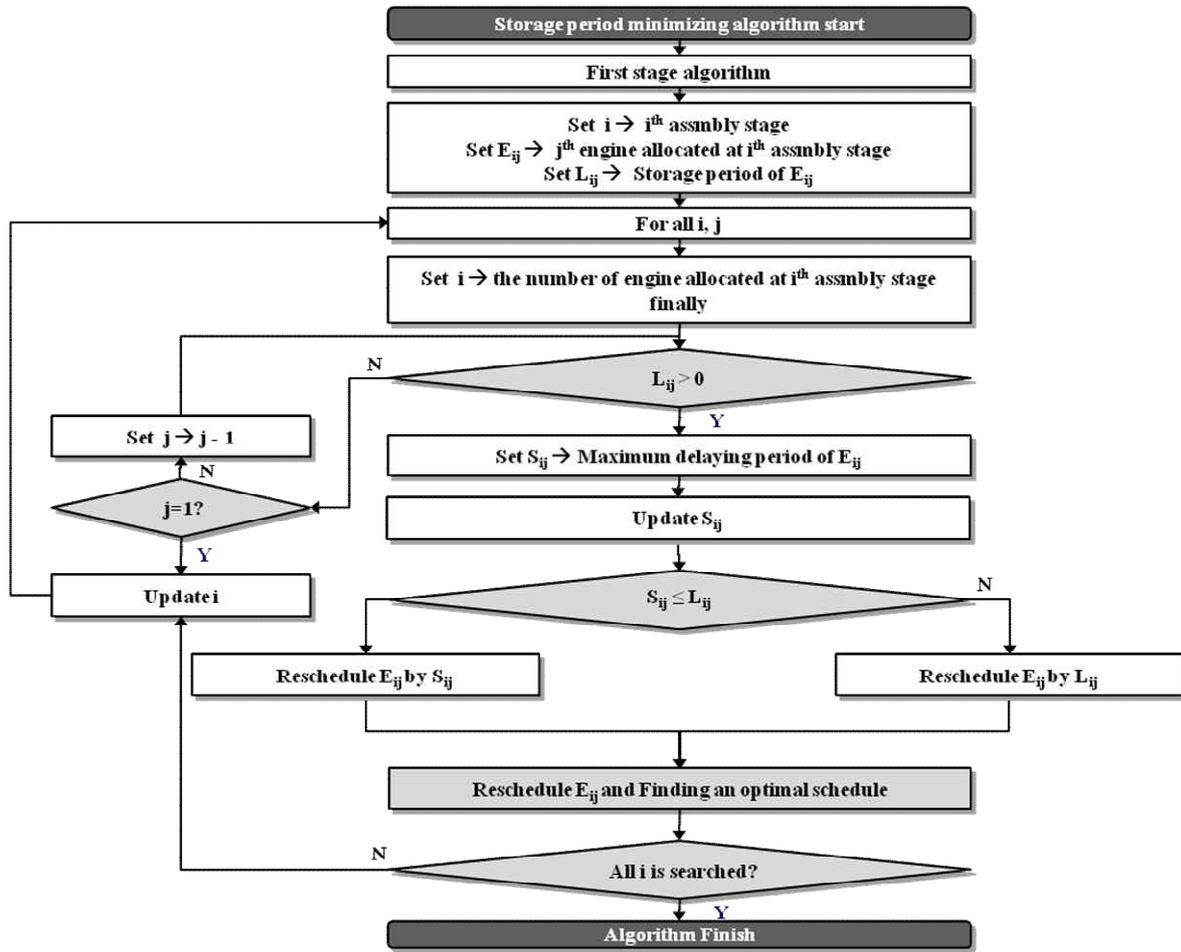
Fig. 7. Flow chart of target storage period algorithm

3. Result

In this paper, the two stage algorithm makes current routine works more comfortable and effectively. Also the schedule of this algorithm is better than that of manual from three criteria, delivery meeting ratio, load balancing ratio and average storage period. Table 1, table 2 and table 3 show results of schedules by using algorithm and manual. Fig. 8 shows the definitions of three criteria.

Table 1. The results of schedules (Case 1 – target storage period)

Schedules	Delivery meeting ratio	Priority of shop	Load balancing ratio	Ave. storage period
Manual schedule	Standard value (a%)	Standard value (b%)	Standard value (c%)	Standard value (d days)
Two stage schedule	a + 7.1%	b + 8.1%	c - 22.7%	d - 25 days

Table 2. The results of schedules (Case 2 – load balance)

Schedules	Delivery meeting ratio	Priority of shop	Load balancing ratio	Ave. storage period
Manual schedule	Standard value (a%)	Standard value (b%)	Standard value (c%)	Standard value (d days)
Two stage schedule	a + 7.1%	b + 8.1%	c + 11.4%	d + 6 days

Table 3. The results of schedules (Case 3 – priority of assembly shop)

Schedules	Delivery meeting ratio	Priority of shop	Load balancing ratio	Ave. storage period
Manual schedule	Standard value (a%)	Standard value (b%)	Standard value (c%)	Standard value (d days)
Two stage schedule	a + 7.1%	b +18.1%	c + 4.5%	d - 25 days

* Delivery meeting ratio : ratio of engines meeting the delivery date

$$* \text{Load balancing ratio} = \left(1 - \frac{\text{Standard deviation of monthly engine production}}{\text{Average of monthly engine production}}\right) \times 100\%$$

$$* \text{Average storage period} = \frac{\sum_i(\text{delivery date of engine } i - \text{finish date of assembling engine } i)}{\text{Total number of engines}}$$

Fig. 8. The definitions of three criteria

From table 1 to table 3, three cases have different production purpose. In case 1, the purpose of scheduling is managing target storage period. However, in case 2, the scheduling focuses on balancing work load. And in case 3, priority of assembly shop is considered factor. From these results, the performance of three algorithms, load balancing algorithm, target storage period and priority of assembly shop algorithm, are proved in three criteria. First of all, delivery meeting ratios of algorithms are better than those of manual schedules in three cases. In case 1, target storage period algorithm makes less average storage period than manual schedule. In case 2, load balancing ratio can be improved by using load balancing algorithm. In case 3, the priority of assembly shop is most improved.

From these results, algorithms make better schedule in criterion that each algorithm aims to. Also the algorithm is designed to deal with various production purposes like case 1 to case 3. Therefore, the algorithm makes better result than manual schedule and the performance of algorithm are proved.
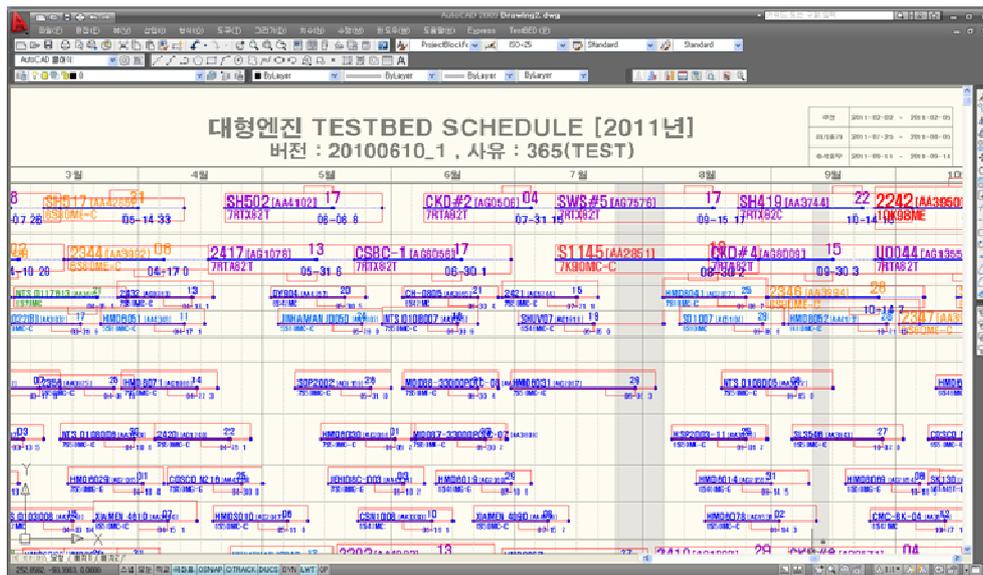

Fig. 9. The sample screen shot of development system

4. Conclusion

As a result of applying algorithm, it is possible to make an advanced schedule easily and the productivity of the engine assembly shop is improved. Also the algorithm can deal with various situations of the engine assembly shop, such as work delay of engine and temporary stops of work processes, and provide modified schedule immediately. Moreover, we analyze load balance in engine assembly shop and make efficient operation strategies not to exceed capacity of the engine assembly shop but to be even with algorithm.

Reference

Hong, S. I., T. H. Choi, T. H. Baek, S. J. Ha and J. O. Kim "Development of the Advanced Work Order Scheduling System for the Panel Welding Line of Panel Fabrication Shop in Shipbuilding", Proc. POM 2009, Orlando.

Choi, T. H., S. J. Ha, and T. H. Baek "A study on the design of a continuous flow production system and process innovation methodology in panel assembly lines of shipbuilding", Proc. POM 2008, La Jolla.

Baek, T. H., J. O. Kim, and C. K. Park "A study on improvement of material flow of assembly block and rationalization of lot number management in shipbuilding", Proc. POM 2006, Boston, pp. 120-123.

Morton T. E., Pentico D.W., Heuristic Scheduling Systems, John Wiley & Sons, Inc.