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Development of the Optimized Algorithm for Scheduling the 4-Stroke Diesel Engine in the Engine Assembly Shop

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Abstract

In this paper, the optimized production scheduling algorithm for the 4-stroke diesel engine was studied. Because other processes of producing engines are determined on the basis of the engine assembly schedule, it is very important to decide the schedule of the engine assembly process efficiently. A heuristic algorithm deciding an optimized schedule to produce engines is proposed for improving efficiency and productivity of the engine assembly shop. The result of the proposed algorithm provides a solution for the best location of the assembly stage and the best moment of start time for the production. The algorithm considers the delivery date of each engine, the work constraints of the assembly shop, and the workload balance. With the algorithm, an optimized schedule can be made easily and the productivity of the engines can be improved. The algorithm can deal with various situations of the shop such as work delay of engines and a temporary stop on processes, and can provide other modified schedules immediately. Moreover, load balance in the assembly shop can be analyzed and efficient operation strategies also can be made from the algorithm.

1. Introduction & Analysis

The 4-stroke diesel engine is produced through various processes such as forging, machining, assembling and painting process. The solution for the best location of the assembly stage and the best moment of start time for the production is determined by scheduling the engine assembly process. The engine assembly schedule is very important because other schedules of engine production processes are affected by engine assembly schedule.

The engine is classified as various types based on weight and length. And there exist various assembly stages in the assembly shop to produce the engines. These assembly stages are set to produce their own specific type of engine. Also storage period of engine is determined from daily gap between finish time of assembling engine and delivery time. For reducing storage cost, there arise the needs for managing storage period of engines.

However, there are many problems about scheduling the engine assembly process. Because there is no system for scheduling, it spends much time and efforts to make schedule and deal with various situations of assembly shop such as work delay of engines and a temporary stop on processes. Also balancing the workload and managing storage period of engines are important issues. The algorithm can deal with these various situations of the shop and can provide other modified schedules immediately. Moreover, load balance in the assembly shop can be analyzed and efficient operation strategies also can be made from the algorithm.

2. Design

2.1 Design of scheduling process

The advanced scheduling process using algorithm is proposed by analyzing existing scheduling process, problems and requirements. Figure 1 shows the advanced scheduling process. The scheduler can establish schedule immediately from using knowledge-based algorithm. 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.

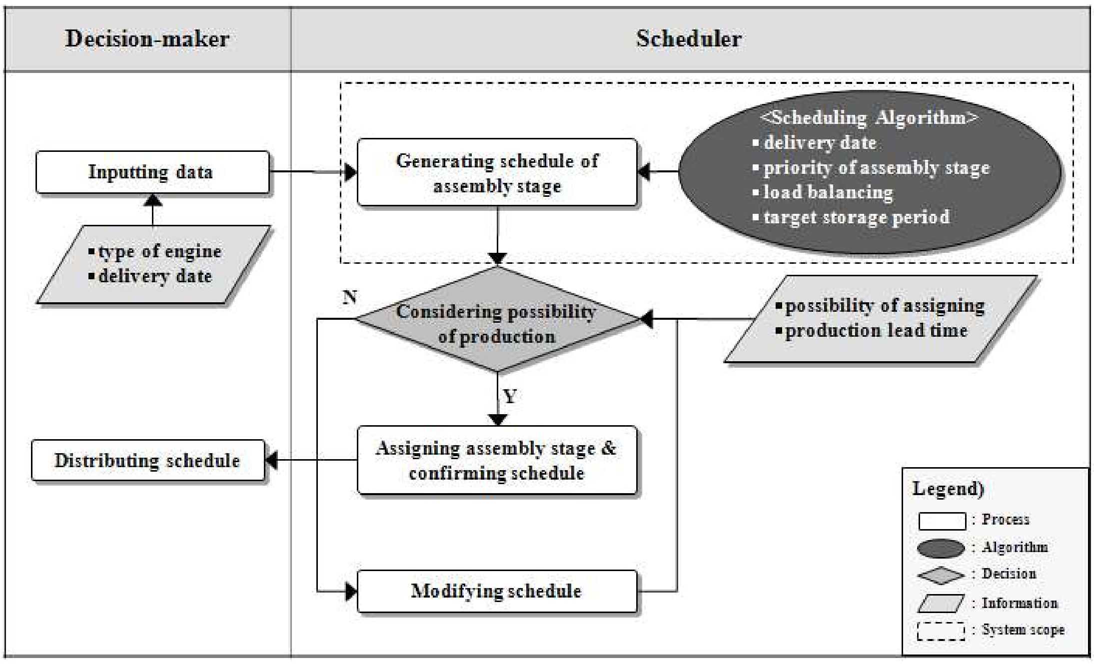

Figure 1. The advanced scheduling process

2.2 Algorithm

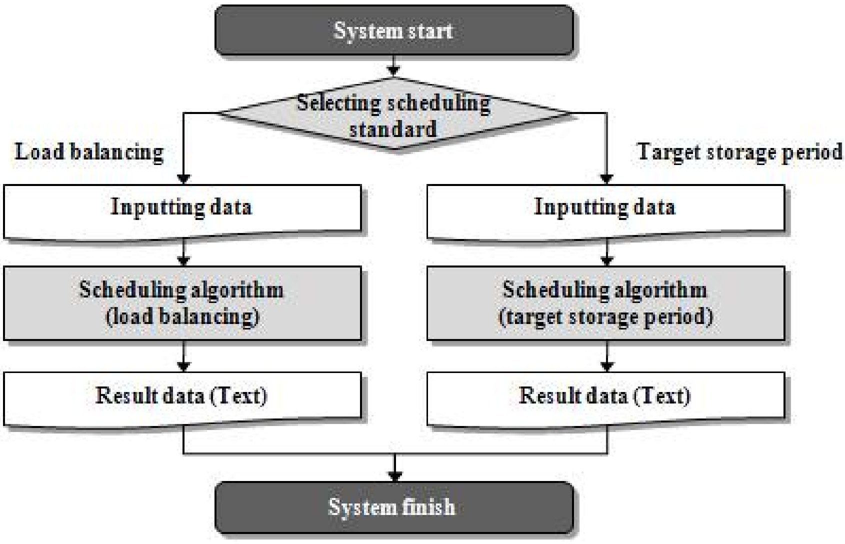

Figure 2. Two purposes of algorithm

From figure 2, the algorithm has mainly two purposes, load balancing and target storage period. Load balancing is focusing on balancing the work load. Target storage period is managing the storage period of engines.

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.

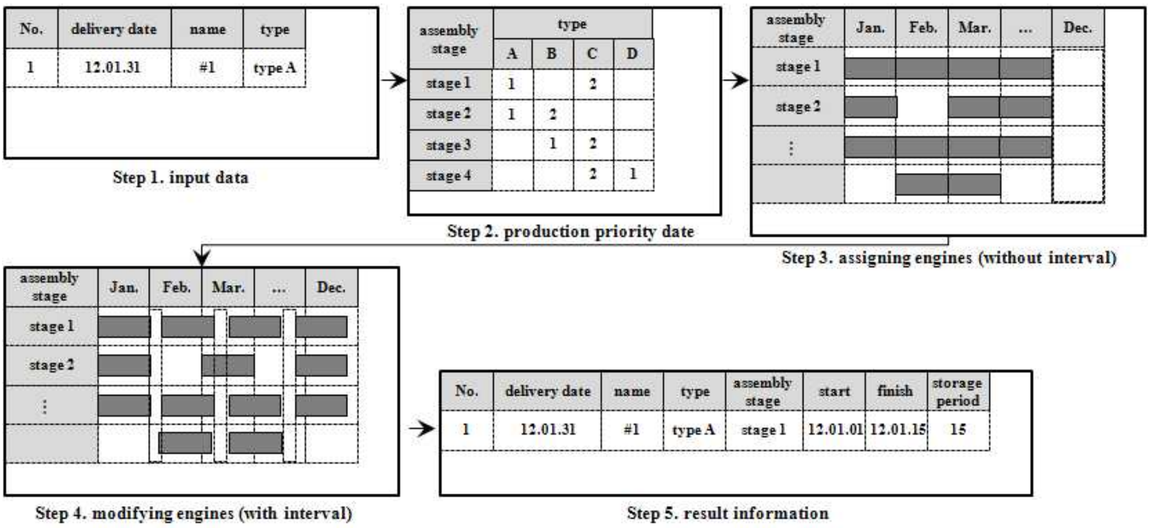

Figure 3. Conceptual diagram of load balancing algorithm

Figure 3 shows conceptual diagram of load balancing algorithm. There are five steps to perform the algorithm. In step 1, engine data is inputted. The data include type, delivery date and total number of engines. In step 2, the algorithm searches assembly stages that can produce engines and memories the production priority of all assignable stages. In step 3, the algorithm assigns every engine to appropriate stage with considering the production priority of stage. When assigning engines, the algorithm assigns each engine to stage as early as possible. After assigning engines without interval, the algorithm calculates dates when the engines don’t be assigned to assembly stages. And in step 4, the calculated dates are distributed to all engines equally. At this step, algorithm also considers delivery dates of engines. In step 5, the algorithm generates schedule as result information. Figure 4 shows flow chart of load balancing algorithm.

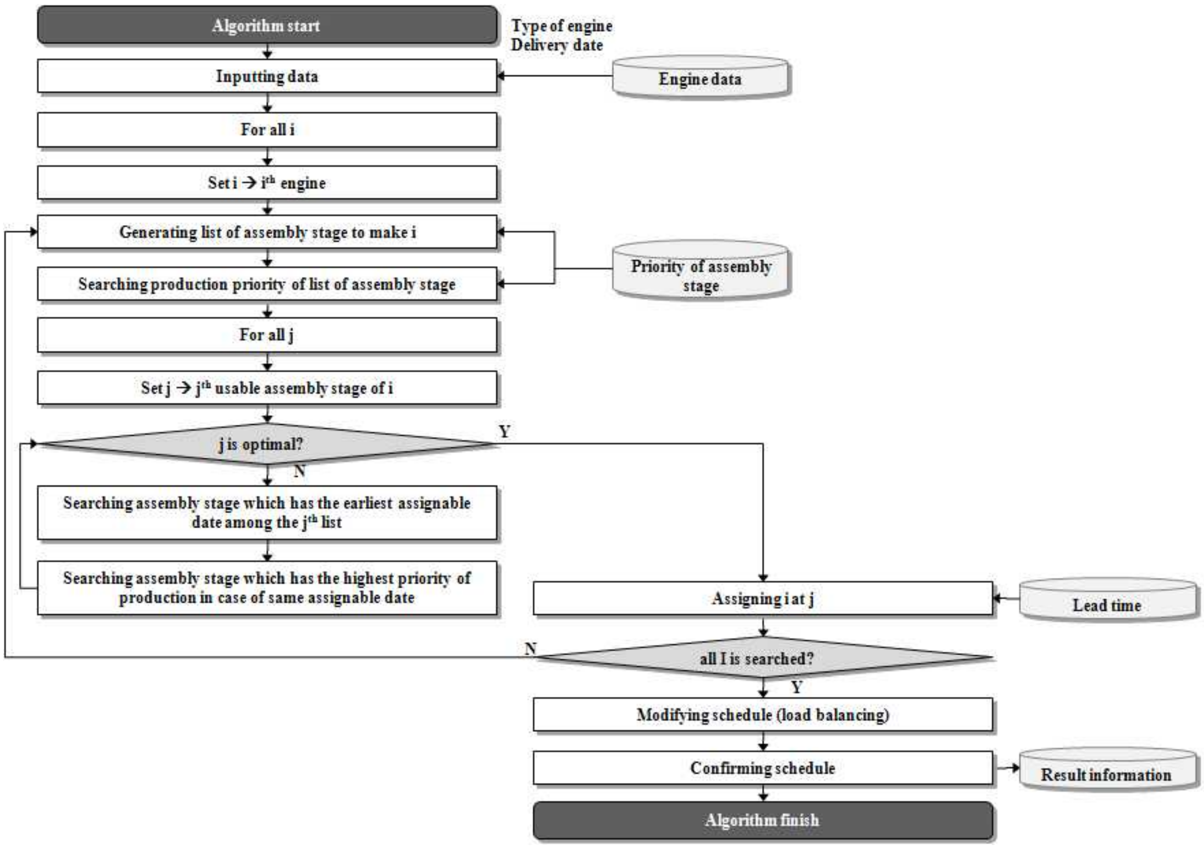

Figure 4. Flow chart of load balancing algorithm

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 time of assembling engine and delivery time. 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.

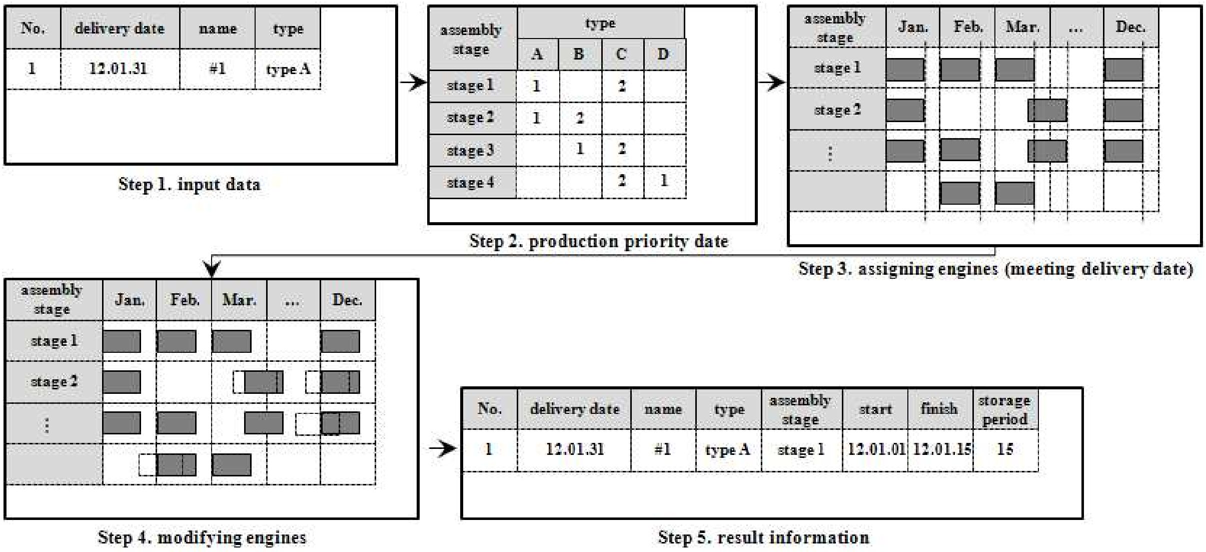

Figure 5. Conceptual diagram of target storage period algorithm

Figure 5 shows conceptual diagram of target storage period algorithm. There are five steps to perform the algorithm. In step 1, engine data is inputted. The data include type, delivery date and total number of engines. In step 2, the algorithm searches assembly stages that can produce engines and memories the production priority of all assignable stages. In step 3, the algorithm assigns every engine to appropriate stage with considering the production priority of stage. When assigning engines, the algorithm assigns each engine to stage reflecting the target storage period. In step 4, the algorithm modifies the schedule in case of overlap schedule of engines. In step 5, the algorithm generates schedule as result information. Figure 6 shows flow chart of target storage period algorithm.

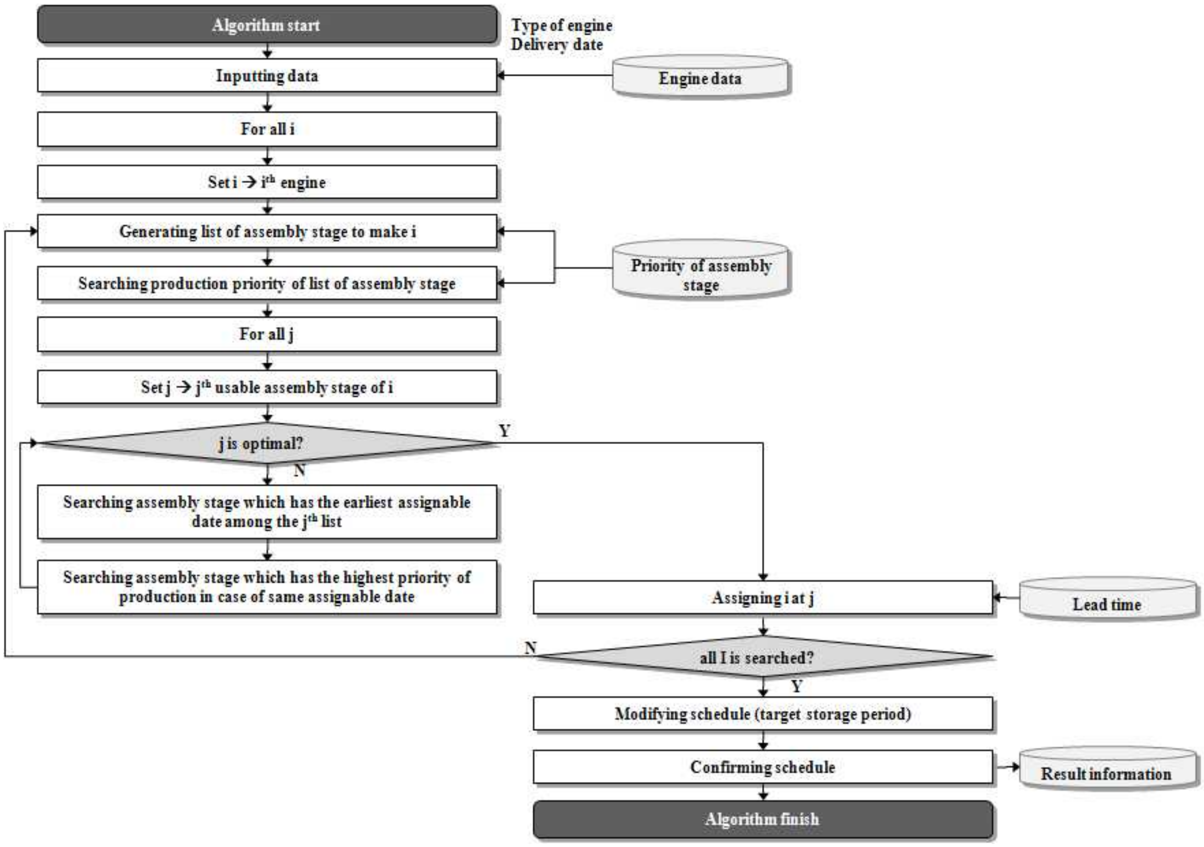

Figure 6. Flow chart of target storage period algorithm

3. Result

In this paper, knowledge-based algorithm makes current routine works more comfortable. 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 and table 2 show results of schedules by using algorithm and manual. Figure 7 shows the definitions of three criteria.

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

Schedules	Delivery meeting ratio	Load balancing ratio	Ave. storage period
Manual schedule	Standard value (a%)	Standard value (b%)	Standard value (c days)
Advanced schedule (Target storage period)	**a + 3.0%**	**b - 6.2%**	**c - 3 days**

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

Schedules	Delivery meeting ratio	Load balancing ratio	Ave. storage period
Manual schedule	Standard value (x%)	Standard value (y%)	Standard value (z days)
Advanced schedule (Load balancing)	**x + 1.8%**	**y + 4.5%**	**z - 6 days**

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

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

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

Figure 7. The definitions of three criteria

From table 1 and table 2, two cases have different production purpose. In case 1, the production purpose is managing target storage period. However, in case 2, schedule focuses on balancing work load. From these results, the performance of two algorithms, load balancing algorithm and target storage period algorithm, are proved in three criteria. First of all, delivery meeting ratios of both algorithms are better than those of manual schedules in both 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.

From these results, both 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 and case 2. Therefore, the algorithm makes better result than manual schedule and the performance of algorithm are proved.

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.

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