Optimal Rotation Planning Method for Gas Turbine Hot Gas Path Parts

Background

Gas turbine hot gas path parts, e.g. blades, vanes, and combustors, are used in severe high temperature conditions, and are inspected, repaired and changed according to a parts rotation schedule. Since the prices of these parts are very expensive, and operation hours between checks differ from unit to unit, a smart rotation schedule, i.e. parts assignment to units that consumes the life of parts efficiently, reduces maintenance costs significantly.

Objectives

CRIEPI has developed a system that supports management of gas turbine hot gas path parts. The objective of the research is to develop a method for planning economical rotation schedules that is incorporated into the developed user support system.

Principal Results

1. Development of an optimal rotation planning method

We have developed a new rotation planning method for gas turbine hot gas parts. In a rotation schedule (Fig. 1) obtained by the method, individual parts are exchanged in consideration of their remaining lifetime in addition to the basic rotation that is done with parts groups (Fig. 2). Thus, the proposed method can plan a rotation schedule that consumes the life of individual parts efficiently and can reduce management costs, compared to existing methods that plan rotation schedule without exchange of individual parts.

It is very hard to plan an economical rotation schedule with exchange of individual parts because the number of parts used in a gas turbine is huge. However, the developed method plans optimal rotation schedule efficiently as follows:

(i) Based on graph theory, the method calculates a required number of parts groups that are indispensable for shortening abort period of gas turbine units.

(ii) Using a hybrid algorithm that is a combination of a heuristic algorithm and a genetic algorithm, the method finds a rotation schedule that minimizes management costs.

2. Verification of effectiveness of the proposed method

In order to evaluate an effectiveness of developed method, we made numerical experiments and compared the developed method with existing methods. In the numerical experiments, as shown in Table 1, we could reduce more than 40% of costs by using the developed method, and ascertained effectiveness of developed method.

Future Developments

We are making the proposed method fit for practical use. Furthermore, we extend the method so that we can plan a rotation schedule in which parts failure is taken into account.

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Reference

Ken-ichi Tokoro, 2004, “Development of management support system for gas turbine hot gas path parts - Optimal parts rotation scheduling method by a combination of a heuristic method and a genetic algorithm -,’’ CRIEPI Report (in Japanese)

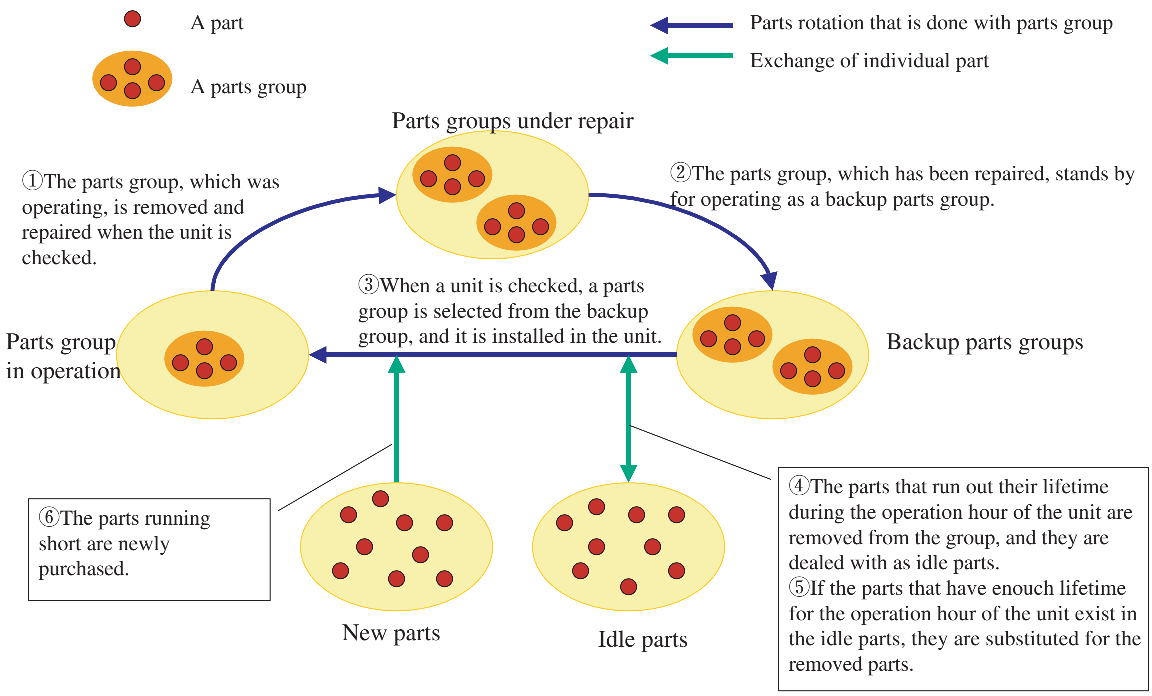

Fig.1 Parts rotation obtained by the proposed method

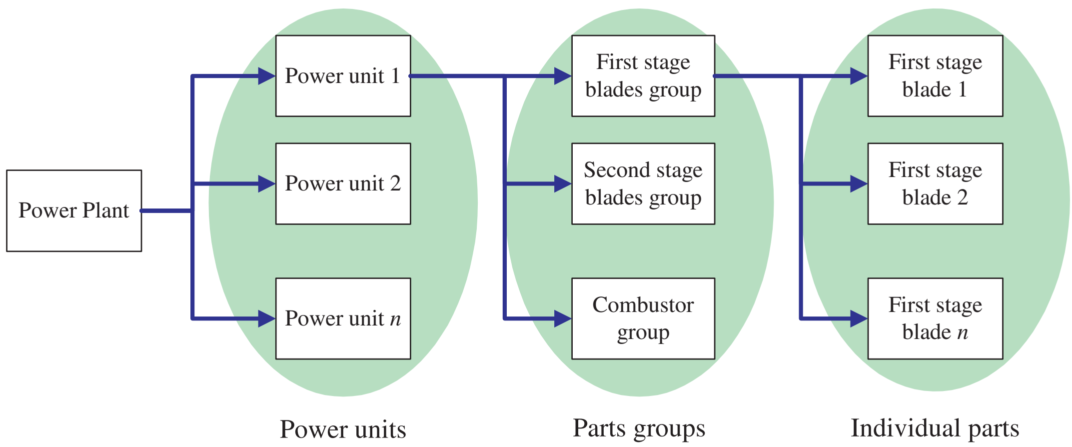

Fig.2 Grouping of parts

Table 1 Comparison of management cost (billion yen)

		Proposed method*1			Existing method	
		(Mean)	(Max)	(Min)	Method 1*2	Method 2*3
Total		47.86	50.03	45.49	95.78	85.46
Break down	Parts purchase costs	36.33	38.99	33.65	86.94	77.28
	Repair costs	10.50	10.29	10.64	7.46	7.03
	Transportation costs	1.03	0.83	1.20	1.38	1.15

*1 The rotation schedule obtained by the genetic algorithm (GA) varies. Thus, we ran the algorithm 10 times, and show the mean, maximum, and minimum value of management costs.
*2 The method installs a parts group in ascending order of their stored time in warehouse.
*3 The method installs a parts group in descending order of their lifetime.