Virtual Input Parts Decision System of Job-Shop Production Line by using GA with ON / OFF Gene

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Abstract

In this laboratory, priority allocation method to the machine tool that has the minimum machining time was developed. Moreover, to solve the problem of this system, to make better solutions .we have developed the determination system of parts using GA. If we apply GA to job shop production line, lethal gene and loss time of the problem occur. The problem of the lethal gene is a thing to use the concept of the ON/OFF gene, and the problem at loss time is solved by devising the order of turning on parts to begin the next cycle even if one cycle does not end to the last.

Keywords: Virtual Input Parts Decision System, GA, Job Shop Production, Loss time,

1. Introduction

In this study, the research aims to improve a production efficiency of a job-shop production line where one person carries parts, and to make the visualization of the production results. We already developed the existing priority allocation method to allocate parts to the machine tools. The method has the special characteristic that a part is allocated to the machine tool whose machining time is the shortest. To make better solutions, we develop the new system to find the input parts order using Genetic Algorithm (GA)

2. Virtual Input Parts Decision System

If we apply the conventional GA to find the order to put the parts into the machine tools in a job shop production line, a lethal gene problem occurs because of different production conditions such that different types of parts need different manufacturing processes. Real genes have a directive information that sends the order to work when it is necessary and to stop when it isn't necessary. We express this directive information as the concept of ON / OFF (activation / deactivation) of the gene. This expression solves the lethal gene problem when it happens by inserting the concept of ON / OFF genes for switching the directive information into a chromosome. In this study, by using the concept of ON / OFF genes, we propose the simulator to decide the best parts input order. We call this simulator as Virtual Input Parts Decision by ON/OFF Genes (VIPDOG).

VIPDOG has 2 configuration systems as follows:
1) The parts order decision system to indicate the parts input and processing orders of a job shop production line.
2) The virtual production system that performs the visualization of the working environments acquired by

VIPDOG. The virtual production system can check what will happen in the future and some experienced engineers can discuss the problems to solve them.

2. 1 *VIPDOG*

Locus gene used in the GA of the VIPDOG is represented by three elements.

ⅰ) Part name

ⅱ) Process name

ⅲ) Machine tool

The respective numerical value of the element in the locus gene shows the part and the necessary process and each machine tool specifically. In addition, Element numerical value of the process name shows the worker's work information ① and ②at the same time.

①The operator turns on the parts to machine tools

②The operator takes out the parts from the machine tool

Fig.1 shows an example of one of the locus gene.

[A,K(1),M(1)]

Fig.1 one of the locus gene

A of this locus indicates the part name. K (1) shows the process name. M (1) shows the machine tool. Numerical value of K () and M () to enter a positive integer. K (1) shows the process 1. M (1) shows the machine tool 1. If the number of K () is a positive integer, the gene show the work information ① at the same time.

As an example of the work information ②, it show the Fig.2.

[B,K(0),M(2)]

Fig.2 one of the locus gene

Only for K shown a process name, Numeric value of () exists that become zero. At this time, it show the work information ②.

2. 2 *ON /OFF gene*

Genes representing the work information ② in a gene used for GA in this study is expressed by ON / OFF gene wake up when needed.

The advantage of the ON / OFF gene prevents the occurrence of a lethal gene. ON / OFF gene is located between the normal genes that represent the working information ① as shown in Fig.3. As shown in fig.4 the switching ON / OFF is operated before and after the evaluation of fitness.

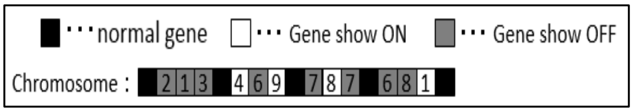

Fig3 ON / OFF genes sandwiched between normal genes

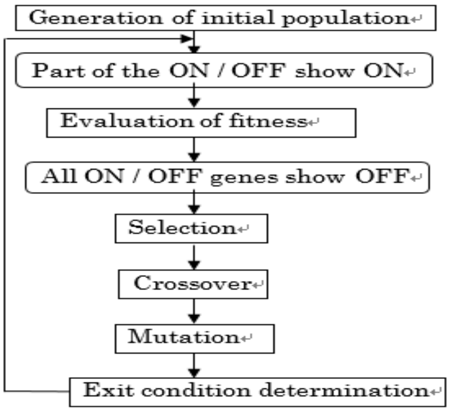

Fig4 Algorithm of ON / OFF switch

2. 3 *ON / OFF gene not to occur lethal gene*

The chromosomes of the parents that produce a lethal gene by crossover are shown in Fig5

Parent 1

[A,K(1),M(1)] [A,K(0),M(1)] [B,K(2),M(1)] [C,K(1),M(2)]

Parent 2

[B,K(2),M(1)] [B,K(0),M(1)] [A,K(1),M(1)] [D,K(1),M(3)]

Fig.5 Chromosome to be parents

The chromosomes of the children after circulation crossover are shown in Fig6.

Child 1

[A,K(1),M(1)] [B,K(0),M(1)] [B,K(2),M(1)] [D,K(1),M(3)]

Child 2

[B,K(2),M(1)] [A,K(0),M(1)] [A,K(1),M(1)] [C,K(1),M(2)]

Fig.6 Chromosome of children

To summarize the information of child 1 chromosome is as follows.

1. Put the part A to machine tool 1
2. Take out the part B from the machine tool 1
3. Put the part B to the machine tool 1
4. Put the part D to the machine tool 3

In the case of 2, there is a conflict when the operator wants to take the part B which has not being introduced into the machine tool 1. This is the occurrence of a lethal gene. The lethal gene problems can be solved by using the ON / OFF genes. ON / OFF gene is the gene that has a work information ②.That is, it was the gene with K a (0) in the locus. Inside the chromosomes, we use the ON/OFF gene and if we turn it OFF, the gene of the chromosome is not used. It is shown in Fig.7

Parent 1

[A,K(1),M(1)] [B,K(2),M(1)] [C,K(1),M(2)]

Parent 2

[B,K(2),M(1)] [A,K(1),M(1)] [D,K(1),M(3)]

Fig.7 OFF chromosome to be parents

Fig.8 shows the chromosomes of the children after circulation crossover.

Child 1

[A,K(1),M(1)] [B,K(2),M(1)] [D,K(1),M(3)]

Child 2

[B,K(2),M(1)] [A,K(1),M(1)] [C,K(1),M(2)]

Fig.8 OFF chromosome of children

The next three cases indicate to summarize the information of child 1 chromosome

1. Put the part A to machine tool 1
2. Put the part B to the machine tool 1
3. Put the part D to the machine tool 3

In the second case, the operator trying to put the part B into the machine tool. The machine tool already has the part A. The contradiction of work that putting part B is impossible occurs. This is the occurrence of a lethal gene. In order to avoid the lethal gene, we adopt to watch the lethal gene and all genes before the lethal gene, and change necessary and sleeping off gene to ON. The above example shows in fig.8 and fig.9. We watch [B,K(2),M(1)] corresponding to a child1 lethal gene and [A,K(1),M(1)] of fig.8. If the gene that has the information of taking out the part A from the machine tool 1 is between [A,K(1),M(1)] and [B,K(2),M(1)], the contradiction of work does not occur. [A,K(0),M(1)] of fig.9 change ON from an off gene.

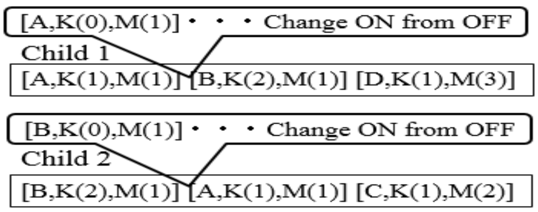

Fig. 9 ON chromosome of child

The next four works indicate the meaning of child1 of Fig.9.

1. Put the part A to machine tool 1
2. Take out the part A from the machine tool 1
3. Put the part B to the machine tool 1
4. Put the part D to the machine tool 2

The four works has no contradiction and lethal genes do not occur. By utilizing the ON / OFF gene, even after the crossover, it is possible to prevent the occurrence of lethal genes and to determine the best input order.

2. 4 *Elimination of loss time between cycles*

When determining the parts input order under the conditions that the target production ratio of parts is adopted as one cycle, the loss time corresponding that an operator can't work occurs. This is because an operator stays for a long time till the next input cycle starts. To solve this problem, we adopt the different two machine tools, the last machine tool of a cycle and the first machine tool of the next cycle. Even if one cycle is not finished until the cycle last, the next cycle can start. Fig.10 shows the example of reducing the loss time.

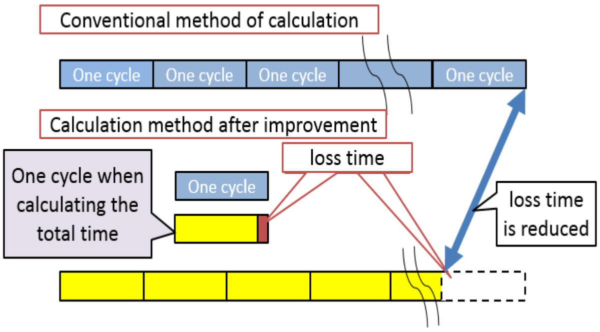

Fig.10 Example of reducing loss time

3. Simulation Applications

We applied VIPDOG to the job-shop production line as show in Fig.11 and simulated production results. The production conditions are shown below.

1 Operator's number : One person
2 Process : 15 types
3 Parts : 5 types
4 Ratio of the target production volume : 5 types
5 The number of machine tools : four

In addition, the ratio of the target production is shown in Table 1.

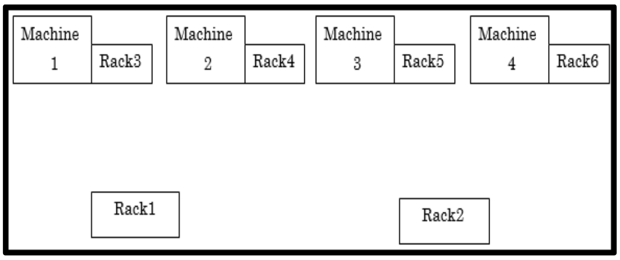

Fig.11 Layout of job shop production line

Table 1 The ratio of target production

		Type A	Type B	Type C	Type D	Type E
Target production ratio	P1	1	1	1	1	1
	P2	2	3	2	1	1
	P3	1	2	2	2	1
	P4	2	1	4	1	1
	P5	1	1	3	2	1

The conditions of GA are as follows
1 Population size: 100 individuals.
2 The number of generations: 500 generations.
3 Use a roulette selection and elite preservation strategy.
4 Use a circular crossover.
5 The probability of a mutation: 1%.

Using the above described various production conditions and the GA conditions, production simulation of 8 hours, 40 hours and 160 hours were carried out. We adopted two types of VIPDOG, one includes the loss time and the other doesn't. The former calls VIPDOG1 and the latter calls VIPDOG2. The production simulation results of VIPDOG2 are shown in Table2. The production simulation results of VIPDOG1 are shown in Table3. The results of the production simulator that do not use the GA compared to VIPDOG are shown in Table4. The number of occurrence of the lethal gene shows in Table5.

Table 2 Production simulation results of VIPDOG2

Production volume (the number)	8 hours	40 hours	160 hours
P1	21.81818	109.0909	436.3636
P2	12.11104	60.55519	242.2208
P3	13.89243	69.46217	277.8487
P4	13.02225	65.11124	260.445
P5	14.66395	73.31976	293.2791

Table 3 Production simulation results of VIPDOG1 (No loss time reduction)

Production volume (the number)	8 hours	40 hours	160 hours
P1	21.62487	108.1243	432.4974
P2	12.06257	60.31287	241.2515
P3	13.71723	68.58613	274.3445
P4	12.32191	61.60955	246.4382
P5	13.8367	69.1835	276.734

Table 4 Results of previous simulator without GA

Production volume (the number)	8 hours	40 hours	160 hours
P1	19.72603	98.63014	394.5205
P2	10.95057	54.75285	219.0114
P3	11.65992	58.2996	233.1984
P4	10.82707	54.13534	216.5414
P5	12	60	240

Table 5 The number of lethal gene

	Lethal gene
P1	0
P2	0
P3	0
P4	0
P5	0

Table 5 shows no occurrence of the lethal gene. VIPDOG can prevent the occurrence of lethal genes. As a result, we can have better result to use VIPDOG2. This is because we got the optimal solution by the GA and we reduced loss time. One shot example of visualized production results are shown in Fig.12.

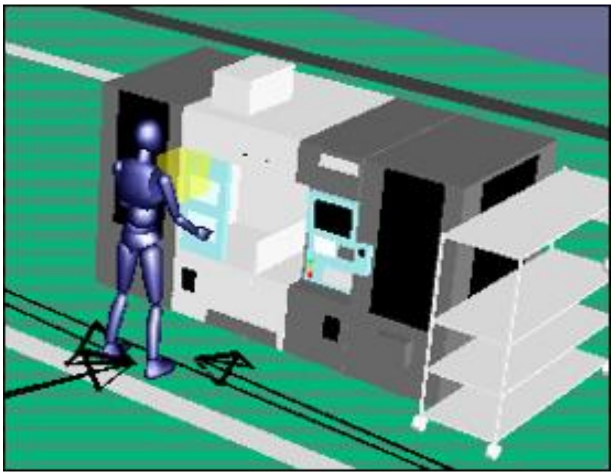

Fig.12 Visualization of VIPDOG

4. Conclusions

It is ascertained that VIPDOG including ON/OFF gene and not including the loss time can have good production results. In addition, we developed the visualized production results. The visualized system can check what will happen in the future and experienced engineers can discuss the problems to solve them.

References

[1] Hidehiko Yamamoto, Takayoshi Yamada and Masanori Nakamura, Parts Layout Decision for Assembly Cell-Production by GA and Virtual Factory System, Transactions of Japan Society of Mechanical Engineers, Vol. 76, No.764, pp.210 -215, 2010