Memoirs of the Faculty of Engineering, Okayama University, Vol.29, No. 2, pp.23-27, March 1995

An Expert System for Reducing the Variety of Parts in Multi-item Production

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(Received January 27 , 1995)

A method for reducing the variety of parts is proposed. The variety of parts in a product and the variety of parts among products are evaluated in consideration of some factors that influence the production cost. Rules are formulated for selecting parts which should be eliminated or whose designs should be changed to reduce these varieties. An expert system is developed based on this method for reducing the variety of parts.

1. INTRODUCTION

The variety of parts is increasing to cope with the consumer demands or the consumer preference. That has resulted in increasing the inventory cost of parts, the variety of JIGs, Fixtures and the production cost. [1] If we reduce the variety of parts, then we can reduce the production costs and improve our competitive power.
In this paper, a rule based method is proposed for reducing the variety of parts. In this method, we try to reduce the assembly cost, because few people have made researches into the reduction of the variety of the parts from the view point of the assembly. The variety of parts is reduced in the following procedure. First, the two kinds of variety of parts are clarified. One is a variety of parts in a product. The other is the variety of the same kind of parts among products. [2] Secondly, we identify parts that should be redesigned for reducing each variety. Finally, the new specification of the selected parts are determined.

2. A METHOD FOR REDUCING THE VARIETY OF PARTS

(1) The variety of parts

A product is made up of parts. The variety of parts in a product is shown in Fig.1(a), and it is named the vertical variety. There is a case where the same kind of parts are used in several products. The variety of the same kind of parts among products is shown in Fig.1(b). This variety is named the horizontal variety.

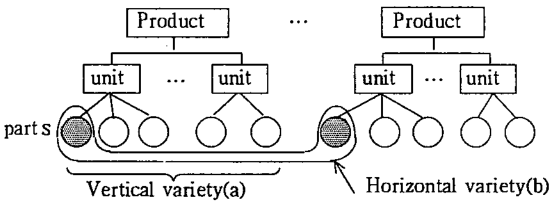
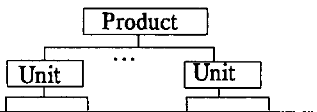


Fig.1 Variety of parts

(2) Vertical variety analysis

The procedure to clarify the vertical variety is shown in Fig.2. The vertical variety is evaluated by five factors that influence the inventory cost and the diversity of robots and JIGs. Five factors of the parts are (i)the fastening method, (ii)function, (iii)material, (iv)interval for replacement and (v)the number of parts. These factors are used to evaluate the variety of parts and select parts that should be eliminated or whose designs should be changed to reduce the variety.



Factors \ Parts	P_{i1}	P_{i2}	...	P_{in}
Function	S_{i11}	S_{i21}	...	S_{in1}
Fastening method	S_{i12}	S_{i22}	...	S_{in2}
Material				
Replacement interval				
Number of parts				

Fig.2 Variety of parts in a product

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(3) Horizontal variety analysis

Even the same kind of parts differ in their specification when they are used in differnt paroducts. Therefore, the horizontal variety of parts is evaluated. (i)The shape, (ii)the fastening method, and (iii)the tightening torque of parts influence the diversity of robots. (iv)The symmetricality, (v)the length and breadth ration, (vi)the dimension and (vii)the weight influence the diversity of both the JIGs and part feeders. These 7 factors are used to evaluate the horizontal variety of parts.

Part group	Products G_1	···	G_m	Kind of parts NV_j	Number of parts NN_j
GP_1	S_{11}	···	S_{1m}	NV_1	NN_1
GP_2	S_{21}	···	S_{2m}	NV_2	NN_2
:					
GP_n	S_{n1}	···	S_{nm}	NV_n	NN_n

GP_i : i th part group

S_{ij} : Type of i th part in the product Gi

Fig.3 The variety of the same kind of parts among products

The cell Sij is the type of parts. The number of parts is shown by the symbol NVj. The variety of the same kind of parts is evaluated by eq.(1), and it is named the commonality index (Q_i).

$$Qi = NNi / NVi \qquad (1)$$

(4) Rules for the vertical variety reduction

After the evaluation of the two kinds of variety is made, some rules are made for selecting parts which should be redesigned to reduce the variety. Four rules are made to reduce the vertical variety. These rules have different objectives; commonization of assembly robots, Reduction of the number of parts, the assembly time and stock parts.

Rule 1 selects the parts which have the same function but different specifications as shown in Fig. 4(a). (commonization of robots)

Rule 2 selects parts which are fastened to a part separately. (miniaturization of products)(Fig. 4(b))

Rule 3 selects parts which are worn out frequently. (reduction of stock parts) (Fig. 4(c))

Rule 4 selects parts which are fastened by the same fastening method to the same part. (reduction of labor time) (Fig. 4(d))

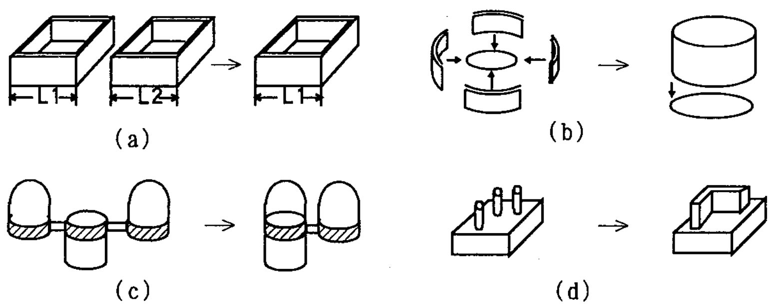


Fig.4 Examples of rules for reducing the vertical variety

The selected parts are recommended to be unified or standardized to other parts. Here, the word "standardization" means that the selected parts are made uniform. The word "unification" means that two parts are put together to one part. If these parts are unified, then the number of parts becomes smaller and the variety in a product is reduced.

(5) Unification index

If more than two parts are selected, we have to determine the order for unifying these parts. As the order of the unification changes, the shapes of the products will change as shown in Fig.5. The unification index is defined for determining the order of unification.

Unification index is determined in consideration of three factors. They are the fastening method, function, and material of the parts. These factors affect the assembly cost.

If all the factors of the parts are the same, then the possibility of unification is high. This case is given 3 points.

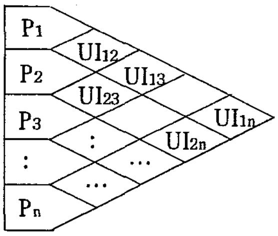
If all the factors of the parts are different, then the possibility of the unification is low. Then, this case is marked 0 point.

The unification index(UIij)

$$UIij = \begin{cases} 3 \text{ (Function, fastening method and the material are the same)} \\ 2 \text{ (Fastening method and function are the same)} \\ 1 \text{ (Fastening method is the same)} \\ 0 \text{ (All the factors are different)} \end{cases}$$

The unification index is evaluated for all the combination of the selected parts and illustrated in the table 1. The parts are unified in the order of the unification index from high to low.

Table 1 Matrix of the Unification index



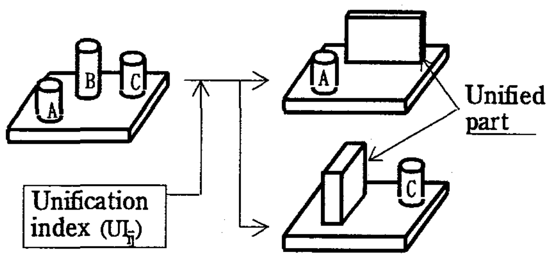


Fig.5 Procedure for reducing the vertical variety

(6) Rules for the horizontal variety reduction

The horizontal variety reduction of parts is intended to facilitate automation of the production system, miniaturization of paroducts, and labor time reduction. Based on these aimes, rules for the variety reduction are set as follows.

Rule 5 selects a kind of parts whose shapes of the fastening place are different.
(commonization of robots) (Fig5.(a))
Rule 6 selects a kind of parts that use different fastening methods. (commonization of robots) (Fig5.(b))
Rule 7 selects bolts whose specifications are different. (commonization of parts feeders) (Fig.5(c))

The selected parts are recommended to be made standardized.

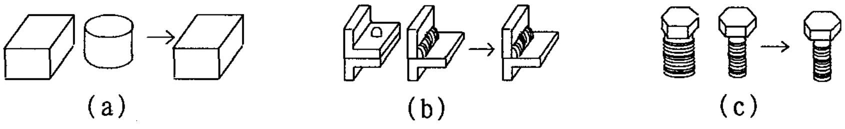


Fig.6 Examples of rules for reducing the horizontal variety

(7) Shape index

The specification of the selected parts should be determined for reducing the horizontal variety. In order to determine the specification of the parts the shape index is defined as shown in table 2. The shape index shows the extent of easiness of assembly. The shape index is determined by 5 factors. They are the step, peaking, symmetry, fastening method and hollownes. We give the points as shown in table 2 depending on whether they are affirmative or negative.

The shape index Eij is the sum of these 5 factors.

$$E_{ij} = \sum_{h=1}^{5} d_{ijh}$$

Table 2 The factors of the shape index

factors	yes	no	d_{ijn}
step	0	1	d_{ij1}
peaking	0	2	d_{ij2}
symmetry	2	0	d_{ij3}
fastening method (insertion)	2	0	d_{ij4}
hollowness	0	1	d_{ij5}

An example of the shape index is shown in Fig.7. Higher the shape index of a part is, easier to manufact-ure the part is. Therefore, we choose the part which has the highest shape index for the standardization.

If some parts have the same shape index, then we choose the part which has the smallest size for miniaturization.

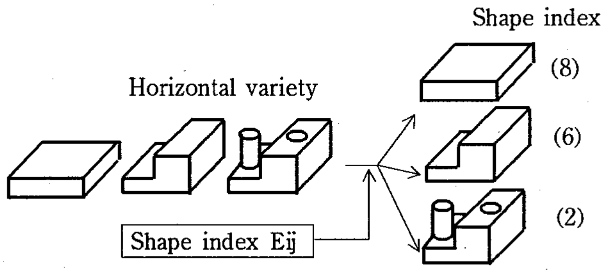


Fig.7 An example of the shape index

(8) Criteria for unification and standardization

After determining how the selected parts should be redesigned, we need to evaluate the feasibility of unification or standardization. The production cost can be estimated from the labor cost, inventory cost and installation cost. If the production cost is reduced by the variety reduction, then we actually unify or standardize the parts. This proposed method is formulated in a predicated logic and an expert system is developed for reducing the variety of parts.

3. APPLICATION EXAMPLE

We tried to reduce the variety of parts in 8 types of motors. The motor type 3 is shown in fig.8. These motors are composed of 26 kinds of parts.

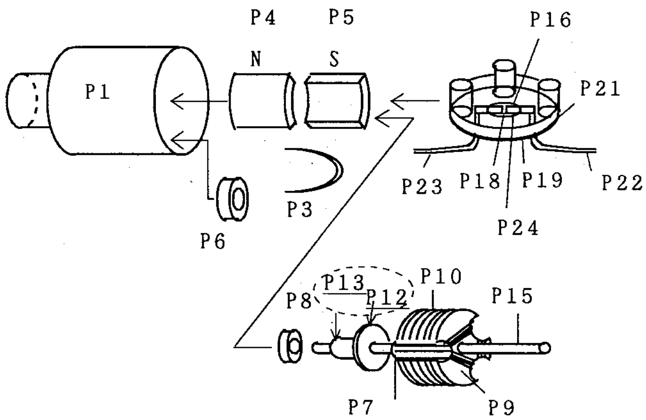


Fig.8 Assembly drawings of the motor G3

(1) Vertical variety

We excluded some parts which relate to the rated horse power of the product. In this case, five parts are excluded because they correspond to the rated horse power of the motor. In the vertical variety reduction, only the part P13 and P12 are recommended to be unified by the rule 4. The unification index of these 2 parts is 3.

Therefore the possibility for unifying them is high.

{ Unification Index of P12 and P13 is 3 because three factors are the same.

Part	Function	Fastening method	Material
P12	holds the commutator	insertion	plastic
P13	holds the commutator	insertion	plastic

(2) Horizontal variety

Ten kinds of parts were chosen to be standardized by the rules for reducing the horizontal variety. The horizontal variety of all parts is shown in Table 3. The actual procedure for reducing the horizontal variety is explained by an example of the part P6 that has the lowest commonality index.

(3) Economical evaluation

The magnet holder P6 is shown in Fig.9. There are 7 kinds. The part P6 has neither a step nor a peaking. It is symmetrical and solid. We fasten the part P6 by insertion. The shape index became 8 for all the seven kinds of the part P6. Therefore, we chose the smallest part E to be standardized for miniaturization. Next, we estimated the production cost. We assume the machining cost (charge) is 70 cents per minute. Inventory cost is 2 cents per year. The assembly robot costs $25,000. By standardizing one kind of part, one robot is saved. If the daily output of each part is 1,000, then 0.3 cents is saved per part.

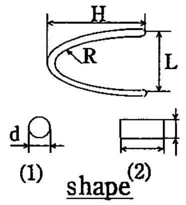
Production cost
Machining cost ± $0
Inventory cost − $0.02
Assembly cost − $25,000 ∕ (1000 × 250 × 3)
= − $0.003
Saving = $ 0.023 (one part)

As a result, 2.3 cents is saved by this standardization.

We estimated that the other nine kinds of the parts should actually be standardized, too because the reduction of their production cost turned out to be possible. These parts are shown in the table 2.

Table 3 Horizontal variety

Part	Number of parts in types							result	
	A	B	C	D	E	F	G	VR	HR
P2 lead wire holder	2	–	–	–	–	–	–		
P3 bearing 1	3	2	1	1	1	–	–		1
P6 magnet holder	2	1	1	1	1	1	1		5
P7 coil	4	3	3	–	–	–	–		
P8 shaft ring	6	2	–	–	–	–	–		
P11 commutator	12	6	3	3	–	–	–		1
P12 commutator base	5	1	1	1	–	–	–		1
P13 commutator holder	5	2	1	–	–	–	–	3	
P14 shaft	4	1	1	1	1	–	–		2
P15 shaft holder	6	1	1	–	–	–	–		1
P16 cap	2	2	1	1	1	1	–		2
P17 cap accessories	1	–	–	–	–	–	–		
P18 bush	4	2	2	4	2	2	–		4
P19 bush connector	8	2	–	–	–	–	–		1
P20 bush stopper	2	–	–	–	–	–	–		
P21 bush contact	2	–	–	–	–	–	–		
P22 lead wire	5	1	1	–	–	–	–		1
P23 lead wire	5	1	1	–	–	–	–		1
P24 bearing 2	2	1	1	1	–	–	–		2
P25 bush holder	3	–	–	–	–	–	–		
P26 condensor	2	–	–	–	–	–	–		



(mm)

type	shape	ϕd	R	L	H
A	1	0.8	4.0	12	14
B	1	0.5	5.0	15	14
C	1	0.5	7.5	15	14
D	1	0.5	5.0	12	15
E	1	0.8	3.5	11	10
F	1	1.0	4.0	12	16
G	2	0.5×2	6.0	14	16

Fig. 9 Horizontal variety of the part Pi6

4. CONCLUSION

We proposed a method for reducing the variety of parts, and developed an expert system. This system supports the reduction of the variety of parts both in an individual product and among products.

REFERENCES

(1) T. HIRANO, JIMA, vol37,No.1, (1986), p.31
(2) JMA Consultants, Method for designing FA system, JMAC, (1985), p.74