

56:166 Production Systems

Case Study 5

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Part I

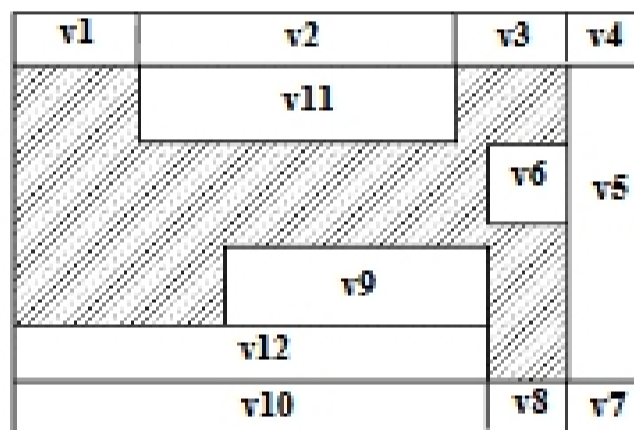
Given:

- Prismatic part
- Four different types of tools are to be used to make features V1 through V13
- Three different types of fixtures are to be used to for features V1 through V13



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Prismatic part with twelve elementary features



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Determine

- (1) Set up an elementary machining feature - machining feature (machinable volume) incidence matrix.
- (2) Assign tools and fixtures to the machining features.



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	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11	v12	v13	Feature
v1	1													t1
v2	1													t2
v3	1		1											t3
v4	1	1												t4
v5		1												t4
v6					1									t2
v7			1				1							t3
v8							1							t3
v9						1								t2
v10							1	1						t2
v11			1						1					t3
v12										1				t3



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Also given:

- The maximum number of tools and fixtures to be selected

3 tools and 3 fixtures

- The cost vector of machining features

Cost Vector [c] = [4, 3, 1, 1, 1, 1, 2, 3, 2, 1, 1, 1, 1]



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(3) Formulate a model for the selection of machining features that minimize the total cost of removing all machining features, the total number of tools and fixtures.

$$\text{MIN } 4X_1 + 3X_2 + X_3 + X_4 + X_5 + X_6 + 2X_7 + 3X_8 + 2X_9 + X_{10} + X_{11} + X_{12} + X_{13} + Y_1 + Y_2 + Y_3 + Y_4 + Z_1 + Z_2 + Z_3$$

SUBJECT TO

$$\begin{aligned} X_1 + X_{10} &= 1 \\ X_1 + 9 &= 1 \\ X_1 + X_3 &= 1 \\ X_1 + X_2 &= 1 \\ X_2 + X_{13} &= 1 \\ X_5 &= 1 \\ X_2 + X_8 &= 1 \\ X_8 + X_{11} &= 1 \end{aligned}$$

Tool	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
v1	1									1			
v2		1											
v3			1										
v4		1		1									
v5		1											1
v6						1							
v7		1					1						
v8							1				1		
v9							1	1					
v10									1				
v11			1							1			
v12							1				1		

$$\begin{aligned} X_6 &= 1 \\ X_7 + X_8 &= 1 \\ X_4 + X_9 &= 1 \\ X_7 + X_{12} &= 1 \end{aligned}$$

$$Y_1 + Y_2 + Y_3 + Y_4 = 3$$

$$\begin{aligned} X_1 + X_8 + X_{12} - 3Y_1 &= 0 \\ X_2 + X_9 + X_{13} - 3Y_2 &= 0 \\ X_3 + X_4 + X_7 + X_{10} + X_{11} - 5Y_3 &= 0 \\ X_5 + X_6 - 2Y_4 &= 0 \end{aligned}$$

$$Z_1 + Z_2 + Z_3 = 3$$

$$X_1 + X_2 + X_7 + X_8 + X_{12} + X_{13} - 6Z_1 = 0$$

$$X_1 + X_3 + X_5 + X_6 + X_{10} - 5Z_2 = 0$$

$$X_4 + X_9 - 2Z_3 = 0$$

END

ITE 20

(4) Solve the model with LINDO.

Solution

The features selected: V2, V3, V5, V6, V7, V9, V10, V11 using tools 2, 3 and 4

From the incidence matrix:

$$\begin{aligned} V_2 &= \{v_4, v_5, v_7\} \\ V_3 &= \{v_3\} \\ V_5 &= \{v_6\} \\ V_6 &= \{v_9\} \\ V_7 &= \{v_{10}, v_{12}\} \\ V_9 &= \{v_2, v_{11}\} \\ V_{10} &= \{v_1\} \\ V_{11} &= \{v_8\} \end{aligned}$$

Tool	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
v1	1									1			
v2		1											
v3			1										
v4		1		1									
v5		1											1
v6					1								
v7		1					1						
v8							1				1		
v9						1							
v10							1	1					
v11			1						1				
v12							1				1		

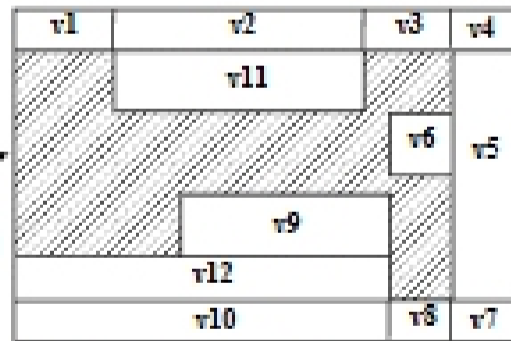
Part II

Sequence the machining features with the topological ordering algorithm so that the total number setups (fixture changes) is minimized.

Assume that the part surface that is not being machined serves as a tolerance base.

$$\begin{aligned} V_2 &= \{v_4, v_5, v_7\} \\ V_3 &= \{v_3\} \\ V_5 &= \{v_6\} \\ V_6 &= \{v_9\} \\ V_7 &= \{v_{10}, v_{12}\} \\ V_9 &= \{v_2, v_{11}\} \\ V_{10} &= \{v_1\} \\ V_{11} &= \{v_8\} \end{aligned}$$

Tol. base



Precedences

$$V_2 = \{v_4, v_5, v_7\} \rightarrow V_5 = \{v_6\} \quad \text{Geometry}$$

$$V_7 = \{v_{10}, v_{12}\} \rightarrow V_6 = \{v_9\} \quad \text{Geometry}$$

Feasible Process Plan: {V9, V3, V10, V11, V7, V2, V5, V6}

Process plan that minimizes the number of fixture changeovers:

$$\{(V_7, t_3, f_1), (V_2, t_2, f_1), (V_5, t_4, f_2), (V_6, t_4, f_2), (V_3, t_3, f_2), (V_{10}, t_3, f_2), (V_{11}, t_3, f_2), (V_9, t_2, f_3)\}$$