Chapter 3

Operation Analysis

Questions

1. Explain how design simplification can be applied to the manufacturing process.

   Simplicity in product design invariably results in better production. A complex design will usually require more sophisticated processing or at least more complex tooling than a simple design.

2. How is operation analysis related to methods engineering?

   Operation analysis is one technique (by examining nine different aspects of the operation) for accomplishing the goals of methods engineering.

3. How do unnecessary operations develop in an industry?

   Unnecessary operations develop through improper planning when the job was first set up, improper performance of a previous or succeeding operation, and attempts to give a product more sales appeal.

4. What has been the impact of the computer in connection with paperwork?

   With computer controlled systems, there should be a reduction in the generation of forms and paperwork (although, this does not always appear to be the case).

5. What four thoughts should analysts keep in mind to improve design?

   1) Reduce the number of parts, thus simplifying the design.
   2) Join parts better and make the machining and assembly easier
   3) Utilize a better material
   4) Rely for accuracy upon “key” operations rather than upon a series of closely held limits.

6. What is meant by ‘tight’ tolerances?

   A ‘tight’ tolerance is a small clearance (e.g., 0.0001 inch).

7. Explain why it may be desirable to “tighten up” tolerances and specifications.

   “Tightening up” tolerances may be necessary to facilitate assembly or other secondary operations.

8. What is meant by lot-by-lot inspection?

   Lot-by-lot inspection is a sampling procedure in which a sample is inspected in order to determine the quality of the production run or the lot.

9. When is an elaborate quality control procedure not justified?

   An elaborate quality control procedure may not be justified: 1) if the product does not require close
tolerances, 2) if its quality is easily checked, and 3) if the generation of defective work is unlikely.

10. What six points should be considered when endeavoring to reduce material cost?

1) finding a less expensive material
2) finding materials that are easier to process
3) using materials more economically
4) using salvage materials
5) using supplies and tools more economically
6) standardizing materials

11. How does a changing labor and equipment situation affect the cost of purchased components?

Both can significantly affect the cost of purchased parts. Labor intense products are dramatically affected by the hourly rates of labor. Similarly the output per unit time of production equipment has a major impact on product costs.

12. Explain how rearranging operations can result in savings.

Rearranging of operations may eliminate an operation. For example burs thrown up after drilling can often be removed by turning or grinding if they follow the drilling operation.

13. What process is usually considered the fastest for forming and sizing operations?

A press operation is usually considered the fastest for forming and sizing operations.

14. How should the analyst investigate the setup and tools to develop better methods?

The analyst should determine the quantity to be produced, the chances for repeat business, the amount of labor involved, delivery requirements and the amount of capital required.

15. Give some applications of bar coding for the improvement of productivity.

Bar coding can be used to count and control inventory, to route specific items to or through a process, and to control work in process.

16. When would you recommend the use of energy-efficient motors?

Energy efficient motors are best for continuous installations such as compressors, pumps, fans and blowers.

17. What are the two general types of plant layout? Explain each in detail.

In product or straight-line layouts, the equipment and workstations are located so that the flow from one operation to the next is minimized for any product class. In process or functional layouts, similar facilities or workstations are grouped together.
18. **What is the best way to test a proposed layout?**

The best way to test a layout is to trace the flow of the various products or product lines produced. This can be done using different colored lines on a floor plan, either on paper or on a computer.

19. **Which questions should the analyst ask when studying work performed at a specific workstation?**

   a) Are both hands working at the same time and in opposite symmetrical directions?
   b) Is each hand going through as few motions as possible?
   c) Is the workstation arranged so that long reaches are avoided?
   d) Are both hands being used effectively and not as a holding device?
   e) Are large muscle used for force and small muscles for precision?
   f) Is muscle force maintained below 15% of maximum?
   g) Is momentum used advantageously?
   h) Are short, frequent, intermittent work-rest cycles being utilized?

20. **Explain the advantages of using a checklist.**

A checklist helps assure that the analyst considers all the improvement possibilities. It will also stimulate creative thinking for further improvement possibilities.

21. **Why do costs vary little with distance in connection with automated guided vehicles?**

Because AGAS utilize little power and maintenance does not vary directly with usage.

22. **On what does the extent of tooling depend?**

Extent of tooling depends upon the quantity to be produced, the probability or chance for repeat business and the labor content of the operation.

23. **How can planning and production control affect set-up time?**

By planning similar jobs to follow one another, much setup time can usually be save since similar jobs will frequently have common tooling.

24. **How can you best handle a material?**

Minimum handling is best.

25. **How is the travel chart related to Mother’s SLP?**

The travel chart will provide quantitative flow information to establish qualitative relationships needed in the first step of Mother’s SLP.

26. **Why does the travel chart have more application in process layout than in product layout?**
The travel chart has more application in process layout than in product layout because product grouping already provides for short distances between successive operations in the production of a product.

27. Explain the fundamental purpose of group technology.

Group technology provides enough volume of a product line to take advantage of the economics of product group layout and universal tooling.

28. Explain how the conservation of welding rod can result in 20 percent material savings.

Much of the welding rod is held in the holder and is often discarded when there are still several inches of usable rod left. Often this discarded portion amounts to as much as 20% of the usable rod.

29. Identify several automobile components with which you are familiar that have been converted from metal to plastic in recent years.

Many body parts including fenders, doors, bumpers, fuel tanks, fittings, etc. have been converted from metal to plastic in recent years.

30. Where would you find application for a hydraulic elevating table?

Hydraulic lift tables would be used in storerooms, stockrooms, tool cribs, and punch press facilities were dies are frequently changed. They are also very useful in palletizing or packing operations.

31. What is the difference between a skid and a pallet?

The pallet has a bottom covering and to be moved must be lifted by a fork lift. A skid does not have a bottom, is usually of heavier construction, and can be moved with a load by a variety of means.

32. When would you recommend using three-dimensional models in layout work?

Three-dimensional models, whether computer generated or mockups, are useful if the layout is extensive and involves several levels, where height as well as floor area must be considered.

Problems

1. How much more efficient is a typical 50 HP energy-efficient motor than a standard 50 HP motor?

Energy-efficient motors are approximately 2-4% more efficient than standard motors.

2. The finish tolerance on the shaft in Figure 3-4 was changed from 0.004 inches to 0.008 inches. How much cost improvement resulted from this change?

From the graph in Figure 3-4, the approximate cost of production will be reduced from 2.1 to 1.5 or a 0.6/2.1 = 29% reduction.
3. What overall tolerance would be applied to three components making up the overall dimension if component one had a tolerance of 0.002 inches; component two, 0.004 inches; and component three, 0.005 inches?

The overall tolerance is equal to the square root of the sum of the squares of the individual tolerances comprising the overall tolerance.

Overall tolerance = \[\sqrt{0.002^2 + 0.004^2 + 0.005^2}\] = 0.0067 inches

4. A ceramic material is being considered as a possible mold material in conjunction with the die casting of 60-40 brass. A cylinder of the material 8 inches in diameter and 10 inches long was used to obtain a stress-strain relationship in compression. The material failed under a load of 265,000 pounds and a total strain of 0.012 inches. What was the material's fracture strength, percent contraction at fracture, and modulus of toughness?

Use strength of materials to solve this problem:
Fracture strength = \[\frac{265,000 \times 4}{\pi \times 8 \times 2}\] = 5,270 lb/in²

Percent contraction = \[\frac{0.012 \times 100}{10}\] = 0.12%

Modulus of toughness = \[2 \times 5270 \times 0.0012 / 3\] = 4.216 in-lb/in³

5. The Dorben Company is designing a cast-iron part whose strength \(T\) is a known function of the carbon content \(C\), where: \(T=2C^2+\frac{3}{4}C-C^3+k\). To maximize strength, what carbon content should be specified?

To solve the problem, take the derivative of strength with respect to the carbon content and set equal to zero.

\(\frac{dT}{dC} = 4C + \frac{3}{4} - 3C^2 = 0\) \(C = 1.5\%\) carbon content

6. To make a given part interchangeable, it was necessary to reduce the tolerance on the outside diameter from ±0.010 to ±0.005 at a resulting cost increase of 50 percent of the turning operation. The turning operation represented 20 percent of the total cost. By making the part interchangeable, the volume of this part could be increased by 30 percent. The increase in volume would permit production at 90 percent of the former cost. Should the methods engineer proceed with the tolerance change? Explain.

Obviously, the change should be made since total cost is reduced 10 percent. Total cost is always the bottom line.

7. The analyst in the Dorben Company is considering replacing five 50 HP motors with five 50 HP energy-efficient motors. Assume a 3 percent improvement in efficiency. These motors will all be operated seven days per week and three shifts per week at an estimated 85 percent of full load. If the cost of electric power is $0.06 per KWH, how much can the company afford to pay for the five energy-efficient motors?
Power cost/yr (standard motor) = 50 × 0.746 × 0.85 × 365 × 24 × 0.06 / 0.88 = $18,936.53
Power cost/yr (energy efficient motor) = 50 × 0.746 × 0.85 × 365 × 24 × 0.06 / 0.91 = $18,312.25
Savings in power per year = $624.28

Assume the company requires a return of capital in three years. Then the company could afford to pay for the five motors:

\[ 5 \times 3 \times 624.28 = 9,364.20 \]

8. The methods analyst in the Dorben Company is considering the installation of a state-of-the-art solid state electronic energy conservation system that will tune and balance the whole fluorescent system, including lamps, ballast, and power supply in the plant. The system will regulate the voltage and the current on an ongoing basis to establish and hold the system at optimum performance. It will also protect the system with special safety circuits. Based on estimates received from the supplier, the system will save 30 percent of the lighting energy cost, 50 percent of the lamp replacement cost, and all of the present ballast replacement cost. If the cost of the installed system is $15,000, how many months would it take the investment to pay for itself based on the following data:

<table>
<thead>
<tr>
<th>Lighting Energy Costs</th>
<th>Lamp Replacement Cost</th>
<th>Ballast Replacement Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fixtures--445</td>
<td>Number of fixtures--445</td>
<td>Number of fixtures--445</td>
</tr>
<tr>
<td>Average KWH/fixture--0.187</td>
<td>Average lamps/fixture--2.25</td>
<td>Average ballasts/fixture--1.1</td>
</tr>
<tr>
<td>Cost per KWH--$0.085</td>
<td>Average lamp life--2.5 years</td>
<td>Average ballast life--4.5 years</td>
</tr>
<tr>
<td>Annual operating hours--4,440</td>
<td>Cost of lamp installed--$6.50</td>
<td>Cost of ballast installed--$40.00</td>
</tr>
</tbody>
</table>

Lighting energy cost = 445 fixtures × 0.187 KW/fixture × 4,440 hrs × $0.085 = $31,405.34/year

Lamp replacement cost = \[ \frac{445 \text{ fixtures} \times 2.25 \text{ lamps/fix} \times $6.50}{2.5} \] = $2,603.25/yr

Ballast replacement cost = \[ \frac{445 \text{ fixtures} \times 1.1 \text{ ballasts/fix} \times $40.00}{4.5} \] = $4,351.11/yr

Estimated time for payback if solid state electronic energy conservation system is installed:

\[
0.30 \times 31,405.34 = 9,421.60 \\
0.50 \times 2,603.25 = 1,301.62 \\
1.00 \times 4,351.11 = 4,351.11 \\
\text{Total} = 15,074.33
\]

\[ 15,000 / 15,074.33 \times 12 = 11.94 \text{ months} \]
9. The Dorben Group suite consists of five rooms having areas and relationships shown below. Obtain an optimal layout using Muther’s SLP and SPIRAL. Compare and contrasts the resulting layouts.
10. Using the from-to chart showing the number of units handled from one area to another per hour and the desired size of each area (in square feet), develop an optimal layout using Muther’s SLP. Note that you will need devise a relationship scheme for the given flows. Also, * means an undesirable relationship.

<table>
<thead>
<tr>
<th>Size</th>
<th>Area</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<tbody>
<tr>
<td>150</td>
<td>A</td>
<td>-</td>
<td>1</td>
<td>20</td>
<td>8</td>
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<tr>
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<td>B</td>
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<td>30</td>
<td>0</td>
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<td>C</td>
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<td>5</td>
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<tr>
<td>90</td>
<td>D</td>
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<td>*</td>
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<tr>
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<td>E</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>0</td>
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</tbody>
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Note that with the SPIRAL output, almost all of the adjacencies are fulfilled (except for the minor A-E).