Optimization of Production Process Time with Network/PERT Analysis Technique and SMED Method

Muhammad Kholil¹, Bonitasari Nurul Alfa², Supriyanto³
Industrial Engineering Department, Universitas Mercu Buana
Jakarta, Indonesia
m.kholil2009@gmail.com¹, bonitasari.na@mercubuana.ac.id²

Abstract. As a company that does the production process based on orders from customers, the timeliness of completion of the product and the quality of the product is important. Companies were given a period of time to complete the order. So that the company can complete orders on time, the company must have good production planning. For scheduling was done by the method of analysis of network / PERT and SMED method. The study of literature and data collection either through observation, interviews and the collection of documentation do. Data processing is done is identify the critical path with network analysis techniques / methods PERT by collecting data while optimistic, pessimistic and then with accelerating network machine set-up time with SMED method then obtained acceleration time from 10:58 hours to 8 hours set-up compacting machine so that the time that they got 2.6 hours wane. Thus the method SMED obtain optimum results even though they can be accelerated by other methods.

1. Introduction
Nowadays in the dynamic and rapidly changing world of competitive industry, demands effective and efficient production operation performance. One of the problems faced by a manufacturing company is how to carry out the production process as efficiently and effectively as possible without any waste of time and production. In general the goal of the company is to achieve maximum profit. In an effort to achieve these objectives, the company must manage them as well as possible by guiding the management function consisting of planning, organizing, mobilization and supervision. In carrying out its activities the company needs to arrange a series of activities, where all series of activities must be completed in accordance with the time of completion that has been determined. A slower completion time from the specified time will interfere with the smooth operation of the company's operations. So that in the execution of the work can be completed on time it is necessary to determine the order of activities and the completion time of each activity. Delays in the completion of the work will result in additional time and cost. Another section of your paper.

PT. SSCI is a manufacturing company in the spare part producing car parts that supply to various car and motorcycle company such as Astra Honda Motor, Akasa Wahana Indonesia, Indomobil Manufacture Suzuki, AISIN, TMN, IHARA, FCC, DENSO and plan there are some more customers which will enter as a new customer PT. Sumiden Sintered Components Indonesia. As a company that performs the production process based on orders from consumers, the timeliness of product completion and the quality of the resulting product is very important. Companies are given a certain period of time to complete the order. In order for the company to complete the order on time, the company must have production planning. Completion of orders in accordance with a predetermined
time period will ensure customer satisfaction. Consumer satisfaction is one way to gain trust from consumers. During this time PT. SSCI has not implemented the use of network analysis in its production process, so in this company there is a problem of time and cost inefficient in production process. To discuss about the above problem, the writer wanted to try to analyze the production process scheduling system and write the results in the final project by taking the title. The existence of the production set up process that has not been efficient and effective in the compacting process 100 tons, resulting in delays to the next process thus will impact on delivery to the customer. With such circumstances will cause mistrust of customers so that will have an impact on the decline in demand or orders. What causes the process and set up the machine that has not been efficient and effective so it takes about 32.53 hours (?). To answer the problem, then the required method that can accelerate the production process. The method is using network analysis technique that is PERT and SMED method that can optimize process and machine set up time.

2. Literature Review
2.1. Scheduling
Scheduling is one of the important activities in determining the time and sequence of production activities. With the scheduling of the company will get a picture of the production activities to be implemented so that the company will be able to estimate the needs of production completion time and costs incurred. That way the company will be able to avoid as early as possible if during the production process occurs irregularities and errors that arise and activities that do not fit the plan, so as to reduce risks that can harm the company either loss of time or cost. According Subagyo (2005: 77) scheduling is a scheduling activity when to start, how long to do each stage of activity and when completed. According to Soeharto (2001: 263) Scheduling is the detail arrangement required to implement the plan. Meanwhile, according to Render and Heizer (2004: 77) states that the project scheduling set a certain period of project activity to be completed. Companies that implement scheduling have several advantages including: with scheduling to be effective, the Company uses its assets effectively and generates more investment that will reduce costs. Scheduling adds the associated capacity and flexibility to deliver faster delivery time and thus better customer service. Competitive advantage with reliable delivery (Render and Heizer, 2001: 456).

Various techniques can be applied for scheduling. The technique used depends on the volume of production, product variation, operating conditions, and the complexity of the work itself. Based on the volume of production scheduling is divided into 3:
1. Line balancing
   Line balancing scheduling techniques are widely used in high volume systems (mass production). This technique emphasizes the allocation of tasks to the work stations so as to balance the working time between the work stations.
2. Run-out time
   Run-out time is a scheduling method with batch system processing that shows how long a particular product will run out of inventory. This method is used when a production facility is used together to produce multiple products.
3. Ordering (Sequecing)
   Sorting methods are widely used in low volume production systems. Scheduling in a low volume production system is directed to determine how the job loads are divided on the work centers (loading) and how the sequence of work is. In general, frequent scheduling as production guidelines and supervision is the Gantt Chart and PERT (Program Evaluation and Review Technique) models. Scheduling with a Gantt chart is a method of determining when the work begins and ends for various activities at a work station using the help of the chart. Scheduling method is divided into two non-network such as Gannt chart and network such as PERT. Scheduling methods for non-network such as Gantt chart are divided into two methods.
a. Scheduling forward
Scheduling begins activities as early as possible so that the work is completed before the promised deadline assumes that material procurement and operations begin as soon as the order is received. Advanced scheduling has consequences for the accumulation of inventory until the outcome of the work is required at the next working center. Advanced scheduling is widely used in companies where operations are made on order and delivery is done as soon as the job is done.

b. Scheduling backwards
Contrary to advanced scheduling, rescheduling prioritizes the last scheduled operation, followed by scheduled previous events one by one in reverse. This method can minimize inventory because the new job is done when the job is needed at the next work station. However, this method requires accurate lead time planning, no break down during the process.

Network method or network analysis is one method to compile a planning and control of an activity. This method is a model used in the implementation of activities to produce a good. According to Render and Heizer (2004: 79) network analysis is a means of production analysis both for product flow analysis and analysis of production time to see the most efficient and effective production flow and timing.

Several methods are commonly used in calculating the timing of completion of the work by network analysis:
1. PERT (Program Evaluation and Review Technique)
PERT is a project management technique that uses estimated time. This time estimate is used to calculate the expected value and standard deviations for the event (Render and Heizer, 2004: 40). The PERT network components decreased Render and Heizer (2001: 508), among others:
   a. Activity (activity)
      It is part of the overall work carried out / activity consumes time and resources and has start time and end time of activity.
   b. Events (event)
      Is marking the beginning and end of an activity. Usually events are depicted with a circle or nodes and are also given a number with smaller numbers for the events that precede it and usually associated with using arrows.
   c. Activity time (activity time)
      It is an element that is part of the overall work to be done. Activity time is divided into three estimates of the completion time of activities:
      1) Optimistic time (a) is the time spent solving activity when everything goes smoothly without any constraint / delay.
      2) Realistic time (m) is the most appropriate time to complete the activity.
      3) Pessimistic time (b) is the time of activity in case of obstacles or delays exceeds should be. The estimated activity time (t) can be calculated by the formula t = (a + 4 (m) + b) / 6
   d. Start time and end time
      Start time and end time consisting of the earliest start time (ES), slowest start time (LS), earliest completed time (EF) and slowest finish time (LF).
   e. Fake Activity (Dummy)
      That is an activity that is not actual and usually indicated by dashed lines.
2. CPM (Critical Part Method)
CPM is an unbroken path through the project network starting on the first project activity then stopping at the last project activity and consisting only of critical activities. Critical activity is an activity that does not have time slanck (Render and Heizer, 2004: 92). According to Render and Heizer (2004: 80) the critical path is the path that has the longest sequence or the longest of all paths starting from the beginning to the end of a process. Identification in critical path process known some terminology and formulation of calculation that is:
   a). ES (Early start) is the earliest start time of an activity.
   b). EF (Early Finish) is the earliest completion time of a job.
   c). LS (Late start) is the last start time of a job.
d). LF (Late finish) is the last time to finish the job

2.2. SMED Technique
The SMED technique at its core is to reduce as much as possible the internal elements. Therefore, the internal setup element is maximally changed to external. Meanwhile, internal elements, which can not be changed externally, are attempted to shorten the time by modifying those elements or by using the SME tool (Single Minute of Exchange Die) is the basic methodology used to reduce set up time, from hours to less from ten minutes. This SMED method consists of two stages:
1. First Stage
Differentiate internal set up and external set up. The internal set up operation is performed when the machine is inoperative while the external set up is performed when the machine is in operation. The following are effective techniques that can be used to categorize a set up process as an external set up.

a. Using Checklist, make a list of checklists of all machine parts and the steps required in an operation. This list contains names, specifications, pressures, temperatures, dimensions and numerical numbers for all machine sizing types.

b. Checking the Performance and Function of the Machine, based on the existing checklist can be determined whether the whole part of the machine can still function or not.

c. Improving Transportation Systems and Other Parts In a production process there are certainly parts that will be moved from storage to production machine, and the parts will be returned to the storage after one lot of product has been completed. This condition will cause operators more often to transport when the machine operates. Therefore it is necessary to improve the transportation system more efficiently.

2. Second Phase
Convert the internal set up into an external set up. By converting internal set up to external set up will be able to reduce set up time up to 30% -50%. The steps performed in converting the internal set up into this external set up include:

a. Preparing Good Operational Conditions
   This can be done by conducting a heating test on the casting machine and preheating.

b. Function Standardization
   This is done by standardizing the size and dimensions of all machine parts and tools used, especially those associated with set up operations. To implement the standardization of this function, the individual functions of each part must be analyzed one by one, the engineer must choose which parts should be standardized.

3. Third Stage
Fixed all aspects of the set up operation. Despite this reduction time by converting the internal setup into an external set up, there are many other factors that can affect this reduction in some set up cases. Therefore, there should be standardization efforts to streamline the basic procedures in the internal and external set up operations. So this third stage is an analysis of each of the previous basic operations. In some companies, standard procedures for a common set up process have been established and implemented. For a rare set up, the set up process is based on the expertise and capabilities of the operator.

3. Research Methodology
Machinery / equipment that became the object of research is on compacting machine in PT. Sumiden Sintered Components Indonesia is on 100 ton compacting machine. then the data collection techniques used in this study are:

3.1. Primary Data
Primary data is the data obtained by themselves directly from research sources (companies), data of this type of data production process and the length of completion. To obtain concrete primary data is done in the following way:

a) Field study (Field research)
That is the way to obtain data by holding observations and data collection directly from the object under study.

b) Interview

That is how to obtain data by conducting direct interviews with employees who presumably can provide information in detail and clear about the data supporters who are careful as the percentage of schedule changes during production.

3.2. *Indirect Data (Secondary Data)*

That is the type of data obtained through reading various literatures from libraries or reading sources that are closely related to the problems that writers face in preparing the thesis. This data will be the theoretical foundation that will be used in solving the problems encountered, among others:

a. Manual or guidance and data set-up of 100 ton compacting machine
b. Organizational Structure and Literature that support the content of this final project.
c. Other sources obtained during the course of the research.

The step research are problem identification, factor identification, data collection, data processing, analysis, design, implementation, evaluation and validation.

4. Results and Discussion

Business activities of PT. SSCI covers the production of various kinds of powder metal based articles. The resulting products include automotive parts such as hub clutch, transmission gear. Powder metallurgy is one of the process of making part by using metal powder either with one element or some element of alloy. This principle is to solidify the metal powder mixture into a cooled form and then heat it below the melting temperature. PT SSI's production activities are divided into six work areas, are mixing, compacting, sintering, sizing, selection and inspection, and packing.

Attempts to anticipate the delay of completion of the activity one of them is by using network analysis tool / network analysis with PERT method (Program Evaluation and Review Technique) which is a tool in planning, scheduling and supervision of production completion with time and cost efficient.

4.1. *Elements and time of completion of work*

From the observation results of the product completion can be made a work sequence that provides complete instructions of a production process, which can be seen in Table 1.

| No | Activity                              | Symbol | Working time (Hours) |
|----|---------------------------------------|--------|----------------------|
| 1  | Preparation of raw materials          | A      | 0.45                 |
| 2  | Tool Preparation (mixer)              | B      | 1.5                  |
| 3  | Tool Preparation (machine)            | C      | 10.58                |
| 4  | Mixing raw materials                  | D      | 2                    |
| 5  | Compacting                            | E      | 6                    |
| 6  | Sintering                             | F      | 3                    |
| 7  | Sizing                                | G      | 5                    |
| 8  | Selection dan Inspection (QC final)   | H      | 3                    |
| 9  | Packing                               | I      | 1                    |
|    | Total                                 |        | 32.53                |
Work routing in the production process for SI-00172 model can be seen in Figure 1.

![Figure 1. Process routing of SI-00172 model](image)

4.2. Measurement of Activity Time
PERT analysis uses 3 time estimates are optimistic time, realistic time and pessimistic time. Adapaun completion time for each element of work is in Table 2.

| No | Activity                              | Symbol | Work Time (Hours) | ET  |
|----|---------------------------------------|--------|-------------------|-----|
|    |                                       |        | A     | M     | B    |     |
| 1  | Preparation of raw materials          | A (1-2)| 0,25  | 0,45  | 1,5  | 0,6 |
| 2  | Tool Preparation (mixer)              | B (2-3)| 1     | 1,5   | 2,5  | 1,6 |
| 3  | Tool Preparation (machine)            | C (3-5)| 9     | 10,58 | 12   | 10,6|
| 4  | Mixing raw materials                  | D (2-4)| 1     | 2     | 3    | 2   |
| 5  | Compacting                            | E (4-5)| 5     | 6     | 7    | 6   |
| 6  | Sintering                             | F (5-6)| 2     | 3     | 4    | 3   |
| 7  | Sizing                                | G (6-7)| 4     | 5     | 6    | 5   |
| 8  | Selection dan Inspection (QC final)   | H (7-8)| 3     | 3     | 4    | 3,2 |
| 9  | Packing                               | I (8-9)| 1     | 1     | 2    | 1,2 |
|    | Total                                 |        | 26,25 | 32,533| 42   | 33,1|

To get the desired time (ET) can be search using PERT method, with the following formula
ET = ((a + (4xM) + b) / 6

Where:
- ET: Expected time
- a: Time is optimistic, activity time when all goes well without any obstacles.
- M: Realistic time, time of activity that occurs when an activity is carried out under normal conditions
- b: Pessimistic time, activity time in case of obstacle / delay more than appropriate.

4.3. Determining the Critical Path of Work Completion

The critical path is determined through the identification of event events connected by the activity activity with loose time zero or EF = LF to find out the most recent time in start or end (LS and LF), where ES (early start) is start time of the earliest activity, LS (late start) is start time of last activity, EF (early finish) is time of completion of the earliest activity, LF (late finish) is completion time of last activity, and S (slack) is activity retreat time. To calculate ES, LS and S with the following formula

EF = ES + t
LF = LS + t-
S = LS-ES or S = LF-EF
Table 3. Activity and Working time of completion of ES, EF, LS and LF

| No | Activity                     | Symbol | Work Time (Hours) | ES | EF | LS | LF | Slack |
|----|------------------------------|--------|-------------------|----|----|----|----|-------|
| 1  | Preparation of raw materials | A      | 0.5, 0.0          | 0.5, 0.0 | 0.5, 0.0 | 0.5, 0.0 | 0.5, 0.0 |
| 2  | Tool Preparation (mixer)     | B      | 1.5, 0.6          | 2.1, 4.4 | 5.9, 3.8 |
| 3  | Tool Preparation (machine)   | A      | 10.6, 1.3         | 11.9, 5.1 | 15.7, 3.8 |
| 4  | Mixing raw materials         | B      | 3.0, 0.6          | 3.6, 3.6 | 3.6, 0.0 |
| 5  | Compacting                   | A      | 6.0, 1.2          | 7.2, 1.2 | 7.2, 0.0 |
| 6  | Sintering                    | B      | 3.0, 5.0          | 8.0, 8.0 | 8.0, 0.0 |
| 7  | Sizing                       | A      | 5.0, 7.2          | 12.2, 7.2 | 12.2, 0.0 |
| 8  | Selection dan Inspection (QC final) | B | 3.0, 12.2 | 15.2, 12.2 | 15.2, 0.0 |
| 9  | Packing                      | A      | 1.0, 14.2         | 15.2, 14.2 | 15.2, 0.0 |

In the Table 3 there are two non-critical work is the activity of two preparation tools mixer and the preparation of machine tools, meaning that in the activity there is a slack time of 3.8 hours. Based on activity path and identification of critical / non critical activity, the production process used is A-B-C-E-F-G-H-I with time 31.06 hours. From the description of the explanation that to produce products from process A to I still takes about 31.06 hours.

4.4. Shorten the Critical Path with the SMED Method

Acceleration in the machine compacting set-up process is done by SMED method. The focus of improvement on the compacting machine is to reduce the set-up time, as for the details as follows:
1) Make gear oilpump / SI-000172 product
2) Produce different types of products with different sizes and malls
3) The need for set-up time = 635 minutes
4) Production capacity = 1pcs / 6 dt = 10 pcs / minute = 600 pcs / hour
5) Total break time = 90 minutes
6) Working Hours = 450 minutes (7.5 hours) from 7: 30-4: 30 = 540 minutes (9 hours) at
7) Cut clock break = 90 minutes. Total work 7.5X2 shift = 15 hours (900 minutes).
### 4.4.1. Identify Internal and External Activities by Separating Internal and External Activities

Table 4. Internal and External Activities

| Unloading the Phone (Bring Out)       | Location | Time (mins) | Category |
|---------------------------------------|----------|-------------|----------|
| 1. Retrieve data settings             | Cupboard | 15          | Internal |
| 2. Position the machine in Original position (270-280) | Machine | 3          | Internal |
| 3. Change the hold down button to the OFF position | Machine | 3          | Internal |
| 4. Open passline, pick-up, turn over (if used) and all hose | Machine | 30         | Internal |
| 5. Place the kamashi between the die plate and the upper punch plate | Machine | 25         | Internal |
| 6. Change the hold down button in the down position | Machine | 3          | Internal |
| 7. After the down punch plate is up, open the clamp up punch plate | Machine | 35         | Internal |
| 8. Change the hold down button again in the up position | Machine | 3          | Internal |
| 9. Change the feeder motion & feeder clamp button to the OFF position | Machine | 3          | Internal |
| 10. Close the valve hose powder then remove it from the feeder | Machine | 15         | Internal |
| 11. Take the feeder from the die set, clean it then save | Machine | 25         | Internal |
| 12. Change the die set clamp button to the OFF position | Machine | 3          | Internal |
| 13. Place kamashi between the base plate and die plate | Machine | 25         | Internal |
| 14. Push the die set to the back of the machine | Machine | 25         | Internal |
| 15. Lift and then put the die set on the stand | Machine | 20         | Internal |
| 16. Clean the die set area and die set line on the machine | Machine | 25         | Internal |
| **Total**                              |          | 258         |          |

| Loading Dies (Bring In)                | Location | Time (mins) | Category |
|----------------------------------------|----------|-------------|----------|
| 1. Clean old male mallets with a cleaning cloth | Machine | 35         |          |
| 2. Move the old dies to the machine to enter / settings | Machine | 45         |          |
| 3. Lift the dies and place them on the machine line set (make sure to install Kamashi) | Machine | 25         | External |
| 4. Place kamashi between the base plate and the die plate then push the dies to the front until it touches the dies stopper | Machine | 25         |          |
| 5. Change the die set clamp button to the ON position | Machine | 3          |          |
| 6. Change the hold down button in the down position, then install the punch clamp up | Machine | 3          |          |
| 7. Return the hold down button in the UP position | Machine | 3          |          |
| 8. Take all the kamashi on the die set (make sure no kamashi is left behind) | Machine | 25         |          |
| 9. Place the feeder on the die set then attach the hose powder to the feeder | Machine | 25         |          |
| 10. Change the feeder motion button to the neutral position, then ON the feeder cup clamp button | Machine | 3          |          |
| **Total**                              |          | 192         |          |

| Product Settings                       | Location | Time (mins) | Category |
|----------------------------------------|----------|-------------|----------|
| 1. Enter the last production settings data then do product settings | Machine | 25         |          |
| 2. Hatsumono                           | QC Room  | 35          |          |
| 3. Check Crack on MFD Process          | MFD Process | 45        | External |
| 4. Waiting judgment from QC Manager   |          | 45          | External |
| 5. 5S / cleaning equipment            | Machine  | 35          |          |
| **Total**                              |          | 95          |          |
| **Total Setting**                      |          | 280         |          |
From the activity in gaining internal activity is 520 minutes. From the above set-up machine activity with the external category is 115 minutes. So the total for internal and external activities is 635 minutes.

4.4.2. Convert from Internal Activities to External Activities. To reduce machine setting time then the next step is to convert from internal activities with external activities. This conversion is done by changing the order of activities without changing the time required for each type of activity, so the procedure is better. Here is the conversion of internal activities to external activities.

| Conversion from internal to external activities (loading unloading) & Product Settings | Location   | Time (mins) | From  | To    |
|--------------------------------------------------------------------------------------|------------|-------------|-------|-------|
| 1. Retrieve data settings                                                          | Cupboard   | 15          | Internal | External |
| 2. Clean old male mallets with a cleaning cloth                                      | Machine    | 35          | Internal | External |
| 3. Move the old dies to the machine to enter / settings                              | Machine    | 45          | Internal | External |
|                                                                                  | Total      | 95           |         |       |
| 4. Enter the last production settings data, then do product settings                | Machine    | 25          | Internal | External |
| 5. 5S / cleaning equipment                                                         | Machine    | 35          | Internal | External |
|                                                                                  | Total      | 60           |         |       |
|                                                                                  | Total Setting | 155            |         |       |

So for the following internal activities after they are some activities in convert to external activities.

Streamlining internal and external activities
1. Using a tool box and a good mall so that there is no activity looking for malls or tools that will be used. This can certainly reduce the time taken for tools and malls.
2. Using a good means of transporting malls and machines that have wheels that can save time.
3. As for some uapaya to reduce the set-up frequency of the machine is
   Produce in large quantities and use the machine for one course or similar items set-up operation.
4. Waiting for decision / adjustment product
5. Changed the layout of the machine set up to facilitate the set up of the machine and equipment retrieval.

4.4.3. Results Time Improvement Through Critical Path With SMED Method.
So after there are some activities that are converted from internal to External then the set-up time of 520 minutes to 365 minutes when the activity can be done at the time the engine is in production. So the total time the machine stops during the set-up process is 365 minutes. So the savings that occur are the total set-up time (internal and external activities) - the total set-up time of internal activity is now divided by the total set-up time (internal and external activities) = (635-365) / 635 = 42.5% or there is a reduction from set-up machine stops 520-365 = 155 minutes or 2.58 hours. So the total set-up of the machine from 10.58 hours to 8 hours set-up of the machine on the compacting 100 tons. So for the critical path 31.06 will be reduced because there is a reduction of set-up of 2.58 hours to be 31.06-2.58 hours = 28.48 hours. For comparison before and after repair can be viewed through network diagram / PERT. Network diagram before repair is shown in Figure 2. with a total time of 31.06 hours.

![Figure 2. Network diagram before repair](image-url)
Network diagram after repair is shown in Figure 6. with a total time of 28.48 hours.

4.4.4. Investment and Profit from Set up Activity of Machine by SMED method
With the investment for machine set up activities with SMED method it will get some benefits, for the details are as follows:

a. Change the layout where the machine set up at a cost of about Rp 45,000,000

b. Calculation of 1 hour overtime per person is Rp 35,000 if for machine compacting 100 tons there are 3 people.

c. Average machine set change in 1 month is 5 times set up machine

d. From the picture layout set up the machine above there is the most fundamental change that changes material storage / raw material previously far from the mixing machine / mixer tool is now adjacent it is aimed at when the taking of materials does not require a long time and for storage of malls and equipment in make a place where the previous means are located far apart now adjacent to the goal when the retrieval of equipment and malls more quickly and easily, so that will get the following benefits:

1. The calculation is the number of people overtime X overtime per hour X acceleration of SMED method X number of machine set ups per month. So 3 People X 35,000 X 4.05 X 5 set up machine is Rp. 2,127,125.

2. So the payback period of investment of 45,000,000 divided by Rp. 2,127,125 is about 21.16 months or 1.76 years old.

4.4.5. Production output Before any time / process optimization and After Optimization time with SMED Method

From the initial production scheduling before production optimization is 32.53 hours and the acceleration result becomes 28.48 so there is a saving difference of about 4.05 hours while production capacity = 1pcs / 6 dt = 10 pcs / menit = 600 pcs / hour so, there is an increase of production output 4.05 hours X 600 pcs = 2,430 pcs.

5. Conclusion
Based on the research and analysis obtained, it can be drawn conclusion as follows:

1. In the network diagram can be seen sequences of each activity that become components of the production process is Preparation of raw materials (A), Preparation Tool (mixer) (B), Preparation Tool (machine) (C), Mixing raw materials (D), Compacting (E), Sintering (F), Sizing (G), Selection and Inspection (H) and Packing (I).

2. Time needed after repair to finish each job.

Based on the network diagram below the critical path of activity is A-B-C-E-F-G-H-I with each value (0.6 + 1.6 + 8 + 6 + 3 + 5 + 3.2 + 1.2) = 28.48 hours
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