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Production Line Arrangement to Increase Output in order to Meet PT. DMR's Delivery Time in Surabaya

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ABSTRACT

PT DMR is a job order that produces ± 285 product items. This study focuses on 3 items, namely Wheels (wheels 30, 40, and 50), Hinge T 86, and Handle 28. Currently, the company has not been able to determine the capacity of each production line and has not been able to determine the Delivery Time accurately. The company wants to know and increase its production capacity so that it can be determined when the Delivery Time is on time. The analysis method used is the arrangement of the production line with line balance.
After the calculation and analysis, it was obtained that the efficiency of the Wheel 40 product line increased from 52.43% to 78.19%, Balance Delay decreased from 47.57% to 21.87%, while the Cycle Time of production operations decreased from 15.84 "to 9.00", this occurred due to the use of expanded mattress holes from 10 holes to 14 holes. Wheel 50 experienced an increase in track efficiency from 48.83% to 95.31%, with a decrease in Balance Delay from 51.17 to 4.69, while for the Cycle Time of operations decreased from 19.52 "to 10.00", this occurred due to the use of expanded mattress holes from 8 holes to 12 mattress holes. Hinge T 86 increased from 46.40% to 50.3%, with balance delay decreased from 53.60% to 49.7%, while the operating Cycle Time decreased from 28.8" to 26.58", an increase due to the addition of outsourcing capacity from 6000 pieces / 2 days to 7000 pieces / 2 days, namely by adding other sources, or still with the condition of additional outsourcing capacity. Handle 28 was not changed because the calculation results showed a production line efficiency of 93.3% (quite high) and Balance Delay 6.7%.

INTRODUCTION

The business world continues to change rapidly and dramatically. Companies will no longer see the stability of the past, rapid reorganization becomes the standard. Business organizations must continuously create and reorganize themselves in order to meet market demands [8].

Companies face the challenge of developing a diverse workforce with fundamental knowledge of how manufacturing works, production processes and systems, and more.

Information needs to be collected, refined and updated continuously at all times to know what is happening in the company under our control. The information contained here will be very valuable for the company if the management wants [4]):

- Speed up production turnaround time or increase capacity.
- Become more flexible, and react to changes without additional costs.
- Know the capabilities of each existing part, machine or department.
- Know how much production increase is possible without making investments, or just by adding auxiliary equipment with low investment.
- Know the bottle necks that occur on the production line.

PT. DMR as a company engaged in the manufacture of "various needs", produces around 285 types of products, depending on customer orders. Some are made in-house, some are outsourced from other companies (for example, outer coating). However, of the many products produced, there are three types of products that control around 80 percent of the company's overall output.

The products in question are plastic wheel products with all kinds of sizes and variations (including: Wheel 30, Wheel 40, Wheel 50), T-86 Hinge, and T-28 Handle. These products are (almost always) produced continuously.

Currently the company has not been able to determine the capacity of each production line. The number of items produced varies with the number of machines, such as in the Injection work center there are 23 machines (the machine can be used to produce many items just by replacing the matress), the Plong work center has 43 machines, the lathe work center has 30 machines. Currently PT DMR has not been able to determine the Delivery Time accurately, there are some machines that have not been used optimally. The company wants to know and increase its production capacity so that it can be determined when the Delivery Time is on time.

MATERIALS AND METHODS

Data Collection Techniques

Data was collected through direct field observations and interviews. The data collected included:

1. Production realization data for each work area
2. Equipment/Machine data and their capacities
3. Mattress Hole Data
4. Network Data
5. Operating Hours Data

Analysis Techniques

The collected data is then processed using the following data processing steps:

Calculating Processing Time: Once the processing time data is available, data uniformity and adequacy tests are performed, followed by calculations of normal and standard times [11] and [13] using the following model:

1 Subgroup Average

$$\overline{X} = \frac{\sum Xi}{K}$$ Actual Standard Deviation of Completion Time

$$\sigma = \frac{\sqrt{\sum \left(Xi - \overline{X} \right)^2}}{n-1}$$

2 Standard Deviation of the Subgroup Average Distribution

$$\sigma \overline{x} = \frac{\sigma}{\sqrt{k}}$$

3 Upper and Lower Control Limits

BKA = $\overline{X} + 3\ \sigma$

BKB = $\overline{X} - 3\ \sigma$

4 Data Adequacy Test

$$N' = \left[\frac{40\sqrt{N \sum X^2 - \left(\sum X \right)^2}}{\sum X} \right]^2$$

5 Cycle Time (Average Operating Time)

$$Ws = \left[\frac{average\ production\ realization}{machine\ operating\ time} \right]^{-1}$$

6 Performance Rating or Adjustment (Skill, Effort, Condition, Consistency)
7 Normal Time = Cycle Time x Performance Rating
8 Personal Allowance and Fatigue Allowance (%)
9 Standard Time

$$\text{Wb} = Wn\ x \frac{100\%}{100\% - Allowance\%}$$

10 Balance Delay

$$BD = \left[\frac{NC - \sum ti}{NC} \right] x 100\%$$

11 Line Efficiency

$$EFF = \left[\frac{\sum ti}{NC} \right] x\ 100\%$$

RESULTS AND DISCUSSIONS

Results

Analysis of Production Output at Each Work Center on the Production Line for each is:

Wheel products, each set consists of the following components: 1) One pair of wheels (two pieces), 2) One wheel body, one socket, one middle clamp, and one upper clamp. The R-30, R-40, and R-50 are the sizes of the wheels. The use of this wheel product is mainly to connect the legs of furniture, or other products with the aim of making them easy to move (moveable). Based on the report data, information was obtained that the R-40 wheel dominates the wheel product, with a share of over 70%. The R-50 wheel is over 20%, and the rest is the R-30 wheel.

Hinge T-86 is one of PT. DMR's leading products, whose main function is to hold (clamp) window leaves, cupboard door leaves, or other leaves and also functions as a hinge for the clamped leaves. Each set consists of 1) U-shaped bent leaves made of iron plate, 2) Clamps from Betoneser, 3) Two fastening screws / clamps, 4) T-86 Hinge Clamp as a glass layer, 5) T-86 Hinge Ring which functions as a connector.

Handle T-28, is one of the most sought after Handle products by consumers besides other Handle types. Its main function is as a handle to open and close an object, for example Door Handles, Window Handles, Cupboard Handles and other Handles.

PT. DMR in making its superior products involves several work centers, the work centers involved are the Injection work center, the Lathe work center, the Plong Machine work center, the Metalizing work center, the Zing Coating work center, the Assembly work center.

Wheel Products

Wheel Products are the largest output, and control more than 80% of the total superior products of PT. DMR. The most dominant Wheel Product is the R-40 product, which fills more than 70% of the overall Wheel products, so that the R-40 Wheel Product is produced continuously. Then followed by Wheel 50 which is produced more than 20%, and the last is the production of Wheel 30 which is less than 10%.

The Wheel product manufacturing process involves the Injection work center, the Lathe work center, the Zing Coating work center, and the Assembly work center. The components made at the Injection work center are Wheels, Body, and Sockets whose raw materials come from plastic. The Upper Rivet and Middle Rivet are processed at the Lathe work center, then forwarded to the Zing Coating center. The Middle Rivet will be assembled with the Body when the injection body process is complete. The final stage is the assembly process of all components.

Process of Determining the Operating Time of R-40 Wheel Products

Socket Making Injection Operation, using a 90 ton capacity machine and a 110 NR capacity machine is 2.58 " per piece. This time is obtained from the inverse of the average data per shift (8845.82 pieces) divided by the total operating time in seconds per shift.

$$Ws = \left[\frac{average\ production\ realization}{machine\ operating\ time}\right]^{-1} = \left[\frac{8845.82}{7x60x60}\right]^{-1} = 2.58''$$

Injection Operation of R-40 Wheel Making, by operating machines with a capacity of 75 tons, 105 tons, 140 tons, and 150 tons, the operating time obtained is 7.92 " (2x) per piece, multiplied by two because one set requires two wheels. This time is obtained from:

$$Ws = \left[\frac{average\ production\ realization}{machine\ operating\ time}\right]^{-1} = \left[\frac{3181.62}{7x60x60}\right]^{-1} = 7.92''$$

Injection Operation of R-40 Body making, by utilizing machines with a capacity of 140 tons, 150 tons, 180 tons, and 220 tons, the operating time obtained is 9" per piece. This time is obtained from:

$$Ws = \left[\frac{average\ production\ realization}{machine\ operating\ time}\right]^{-1} = \left[\frac{2800.22}{7x60x60}\right]^{-1} = 9''$$

Operation of R-40 Upper Rivet Making Lathe, which uses T-32 lathe, obtained operating time of 8.3” for short cutting and long cutting operation per bar. This time is obtained from:

$$Ws = \left[\frac{average\ production\ realization}{machine\ operating\ time}\right]^{-1} = \left[\frac{3456.43}{8x60x60}\right]^{-1} = 8.3''$$

The R-40 Top Rivet Zing Coating Operation is 0.34 " per rod with full capacity usage. At the Zing Coating work center, one operation uses 2 tubs, one tub contains 4 barrels, one barrel contains 20 kg, one kg contains 49 rods, one operation uses 45" time.

$$Ws = \left[\frac{Zinc\ coating\ capacity}{operating\ hours}\right]^{-1}$$

$$Ws = \left[\frac{2bak\ x\ 4\ barrel\ x\ 20kg\ x\ 49\ rod}{45x60}\right]^{-1} = 0.34"$$

Lathe Machine Operation for Making Center Rivets R-40 and R-30 is the same, This time is obtained from

T-15 Lathe Machine: KT-30 : Output 78,536 rods for 21 machine units.
KT-40 : Output 262,227 rods for 66 machine units
T-32 Lathe Machine: KT-40 : Output 191,363 rods for 45 machine units

$$Average\ Engine\ Capacity\ = \frac{\sum Central\ Rivet\ Output}{\sum\ \ Machine\ Unit}$$

$$= \frac{78536 + 262227 + 191363}{21 + 66 + 45} = 4031{,}26$$

$$Ws = \left[\frac{average\ production\ realization}{machine\ operating\ time}\right]^{-1} = \left[\frac{4031.26}{8x60x60}\right]^{-1} = 7.14"$$

The operation of Zing Coating Middle R-40 and or R-30 is 0.073" per rod with full capacity usage. In the Zing Coating work center, one operation uses 2 tanks, one tank contains 4 barrels, one barrel contains 20 kg, one kg contains 155 rods, one operation uses 30" time.

$$Ws = \left[\frac{Zinc\ coating\ capacity}{operating\ hours}\right]^{-1}$$

$$Ws = \left[\frac{2bak\ x\ 4\ barrel\ x\ 20kg\ x\ 155\ rod}{30x60}\right]^{-1} = 0.073"$$

The Assembly Center that functions to form a complete set of Wheels, is as follows. There are two types of assembly lines, namely the first manual assembly line, consisting of three lines, one line served by 10 workers. The manual assembly line assembles R-30 and or R-40 with a capacity of 210 boxes per shift per line. One box contains 30 sets. One set consists of a Body, two Wheels, Upper Rivet (KA), Middle Rivet (KT), and Socket. Second, the automatic assembly line, has two lines, each served by one person. One line for R-40 and the other line for R-50. The capacity of each line is 75 boxes per shift The operating time of the assembly line assuming the majority assembles R-40 is:
* Manual Assembly Line: 210 boxes x 30 sets x 3 lines = 18,900 sets per shift
* Automatic Line: 75 boxes x 30 sets x 2 lines = 4,500 sets per shift
Total output per shift = 23.400 set

$$Ws_{manual} = \left[\frac{Total\ output\ per\ hour}{operation\ time}\right]^{-1} = \left[\frac{18900}{8x60x60}\right]^{-1} = 1{,}52"per\ set$$

$$Ws_{automatic} = \left[\frac{Total\ output\ per\ hour}{operation\ time}\right]^{-1} = \left[\frac{18900}{8x60x60}\right]^{-1} = 1{,}52"per\ set$$

$$Ws_{combined} = \left[\frac{(1{,}52x3) + (6{,}4x2)}{5}\right] = 3{,}472"per\ set$$

Using relatively similar methods, the T-86 Hinge and 28 Handle products are obtained as follows:

T-86 Hinge Product.

The T-86 Hinge is another of PT. DMR's flagship products, produced daily as a continuous product. Each work center involved continuously produces T-86 Hinge components. The T-86 Hinge manufacturing process involves the Injection work center, Lathe work center, Punch work center, and Assembly work center. The injection process for making T-86 hinge rings is 1.04" per piece using a 75-A injection machine. The injection process for making T-86 hinge clamps using a 75-A or 90-A machine is 2.54" per piece. The lathe process for making T-86 hinge rivets is 7.3" per machine. The cutting process using a plate cutting machine is 0.3" per leaf. The leaf cutting process using a 10-ton drilling machine is 4.83". The 3-ton drilling machine for making T-86 hinge leaves, using one machine per shift, is 4.77" per leaf. The leaf bending operation with one 10-ton drilling machine per shift is 4.77" per leaf. The T-86 Hinge Drill-Tab operation with one Drill-Tab machine per shift is 9.55" per leaf. The rivet assembly operation with a T-86 Hinge Plate with one 6-ton drilling machine is 9.4". The assembly operation for the T-86 Clamp, Ring, Hinge Body, and Packing is 4.8".

Handle 28 Product

The T-28 Handle manufacturing process involves the Injection work center and the Metalizing work center. The Injection work center produces the T-28 Handle in a rough form, which is injected (molded) into a plastic mat. The next step is the Metalizing work center, where the Handle is clamped into a clamping cradle for plating. After plating, it is placed in an oven. The next step is Metalizing, followed by Coating. The next step is drying, followed by specific processing that is outsourced. The final process is packaging and shipping to the warehouse (See FPC and OPC of T-28 Hinge).

The injection operation for making T-28 handles is 7.3 per piece when using a 140-ton injection machine with a 44-inch timer and 6-hole matress. The operation time is 2.4 inches per piece when using a 220-ton machine with a 44-inch timer and 18-hole matress. The T-28 handle clamping operation at the metalizing work center involves 2 to 4 workers, with 28 to 30 pieces per bar (clamping tool). The T-28 handle installation time into the bar takes approximately 5 minutes per worker. The sheathing operation involves a maximum of 14 workers per shift, with a capacity of 30 units per worker per 30 minutes. The resulting operating time (14 employees): 4.3 inches. The sheathing operation involves a maximum of 14 workers per shift, with a capacity of 30 units per worker per 30 minutes. Operating Time (14 employees): 0.5". Vacuum Metalizing Operation, Standard Operating Time at full capacity is: 0.94". Coating Operation, based on information obtained, this process requires a maximum of 10 workers with a capacity of 3,000 bars/hour. The operating time is 2 minutes per 60 bars. Standard Operating Time at full capacity is: 0.2". Drying Operation: Drying is carried out by placing the coated product in an open area for 24 hours, where it will dry naturally. The capacity of the open area is considered unlimited. Outsourcing: The dried Hadel will undergo further processing outside the factory. The outsourcing capacity is considered unlimited (very large compared to current output), with a 24-hour timeframe. Packing: Maximum staff strength is 5 people, 3 boxes per hour per person, and 1 box contains 1,200 pieces. Standard Operating Time is 0.2".

Discussions

Wheel Products Line Balance Analysis

The process of making wheel products (in general) goes through 3 work centers, namely the Injection work center, the Turning work center, and the Assembly work center. The largest operating time is in wheel making with an operating time of (7.92” x 2) = 15.84” which is in the Injection work center, the operating time of the Turning work center is 8.64”, while the operating time of the Assembly work center is 0.434”. The total operating time is 24.914”. Based on this data, the path balance can be calculated as follows:

$$BD = \left[\frac{NC - \sum ti}{NC}\right] x\ 100\% = \left[\frac{(3)(15{,}84) - 24{,}914}{(3)(15{,}84)}\right] x\ 100\% = 47{,}57\ \%$$

$$EFF = \left[\frac{\sum ti}{NC}\right] x\ 100\% = \left[\frac{24{,}914}{(3)(15{,}84)}\right] x\ 100\% = 52{,}43\ \%$$

Information: N = Number of work centers
C = Cycle Time (largest operating time)
∑ti = total operating time
BD = Balance Delay
EFF = Track Efficiency

The calculation results above show that the efficiency of the Wheel product manufacturing line is very low, with a bottleneck in the Wheel manufacturing operation, which requires 15.85" per set. To overcome this, what needs to be done is to increase the wheel manufacturing capacity by using an Injection machine with a capacity of 140 tons or more, making mattresses with maximum holes, and reducing defective products by increasing machine reliability. The increase that can be done is around 41% or more.

For example, the injection machine used to make 40 wheels is a machine with a capacity of 140 tons, with 10 mattresses, a fixed timer, assuming the level of machine reliability has been improved, then the operating time will be approximately:

$$Ws = \left[\frac{5233{,}23}{7x60x60}\right]^{-1} = 4{,}82''$$

$$BD = \left[\frac{NC - \sum ti}{NC}\right] x\ 100\% = \left[\frac{(3)(9{,}64) - 24{,}914}{(3)(9{,}64)}\right] x\ 100\% = 13{,}85\ \%$$

$$EFF = \left[\frac{\sum ti}{NC}\right] x\ 100\% = \left[\frac{24{,}914}{(3)(9{,}64)}\right] x\ 100\% = 86{,}15\% \qquad \text{(Pretty good)}$$

If the level of reliability of the machine used is as it is now, 10-filled mattresses, with an average defect of 20% (using the same 140 ton injection machine and above), the following results will be obtained:

$$Ws = \left[\frac{5233{,}23\,x\,0{,}80}{7x60x60}\right]^{-1} = 6{,}02''$$

$$BD = \left[\frac{NC - \sum ti}{NC}\right] x\ 100\% = \left[\frac{(3)(12{,}04) - 24{,}152}{(3)(12{,}04)}\right] x\ 100\% = 33{,}13\ \%$$

$$EFF = \left[\frac{\sum ti}{NC} \right] x\ 100\% = \left[\frac{24{,}152}{(3)(12{,}04)} \right] x\ 100\% = 66{,}87\%$$

If the level of reliability of the machine used is as it is now, 12-filled mattresses, with an average defect of 20% (using the same 140 ton injection machine and above), then the following results will be obtained:

$$Ws = \left[\frac{6280\, x\, 0{,}80}{7x60x60} \right]^{-1} = 5{,}02''$$

$$BD = \left[\frac{NC - \sum ti}{NC} \right] x\ 100\% = \left[\frac{(3)(10.04) - 22{,}152}{(3)(10{,}04)} \right] x\ 100\% = 26{,}45\ \%$$

$$EFF = \left[\frac{\sum ti}{NC} \right] x\ 100\% = \left[\frac{22{,}152}{(3)(10{,}04)} \right] x\ 100\% = 73{,}55\%$$

If the level of reliability of the machine used is as it is now, 14-filled mattresses, with an average defect of 20% (using the same 140 ton injection machine and above), then the following results will be obtained:

$$Ws = \left[\frac{7326{,}524\, x\, 0{,}80}{7x60x60} \right]^{-1} = 4{,}23''$$

(2x = 8.46”) there was the largest shift in operating time during the Body 40 manufacturing operation which was 9”, so that:

$$BD = \left[\frac{NC - \sum ti}{NC} \right] x\ 100\% = \left[\frac{(3)(9) - 21{,}112}{(3)(9)} \right] x\ 100\% = 21{,}81\ \%$$

$$EFF = \left[\frac{\sum ti}{NC} \right] x\ 100\% = \left[\frac{21{,}112}{(3)(9)} \right] x\ 100\% = 78{,}19\%$$

T-86 Hinge Product Line Balance Analysis

Time data from the FPC found:

BD = 53.60%; EFF = 46.40%

The bottleneck in the T-86 Hinge dyeing (Outsourcing) operation is 28.8" per set, and this is beyond the control of PT. DMR management.

Proposal: Increase outsourcing capacity without relying on a single location.

Handel T-28 Product Line Balance Analysis

The time data from the FPC found:

BD = 6.7%; EFF = 93.3%

The calculation results above indicate that the efficiency of the Handel T-28 product line is very good, assuming each operation is operating at its maximum capacity.

CONCLUSION

The results of processing and analyzing operational process data for PT Daimaster's flagship product show that:

1. The current operating cycle time for the R-40 wheel is 15.85%, the R-50 wheel is 19.52%, and the T86 hinge is 28.8%, while the T28 handle is not problematic. This can be improved to the proposed operating cycle time for the R-40 wheel is 9%, the R-50 wheel is 10%. The T-86 hinge is out of control.
2. The production line efficiency for the flagship product, the T-86 wheel and hinge, is very low. The efficiency of the R-40, R-50, and T-86 hinge is 52.43%, 48.83%, and 46.40%, respectively, while the Very Good handle is 93.3%. The line efficiency can be improved to: R-40 = 78.19%, R-50 = 95.31%, while the T-86 hinge is out of control.
3. The production line balance delay for the flagship product, the Wheel 40, R-50, and Hinge T-86, are very high, respectively 47.57%, 51.17 and 53.60% while for the Handle product is amazing at 6.7%. The first three products can be improved to: R-40=21.87%, R-50=4.69%, While Hinge T-86 is out of control.

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