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OPTIMIZATION OF A SHOCK ABSORBER ASSEMBLY LINE USING SIMULATION

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ABSTRACT

This paper reports findings of a optimization study of shock absorber assembly line using computer simulation software. The shock absorber assembly line feeds shockers to the motorcycle assembly line. The assembly line simulated in this project is located at an OEM for the largest motorcycle manufacture in Indonesia. In this paper, results of simulation are presented from two scenarios. The first is the original layout of the system. The second simulation is the suggested optimization modifications. Data was gathered and evaluated to determine the necessary parameters to be used. The new demand required the OEM to increase its capacity by 100 shock absorbers per day. After implementing the proposed model the daily output increased by 120 shock absorbers per day. The highlights of our analysis was this increase in production rate by balancing the flow process cycle time with new allocation resources.

Key words: *computer simulation, assembly line.*

1. INTRODUCTION

To stay competitive, companies need to make long as well as short-term capacity decision with proper planning. This paper documents such a simulation study in a shock absorber assembly line. The assembly includes 11 operations. Among these, the piston rod subassembly and the spring fitting operations are critical to the assembly process. The piston rods assembled at the stations, along with the base valve assembly are combined with the inner tube and the outer tube to form a basic damper. After testing for its damping force, the damper is fitted with bush, adjuster, spring and eyelets. The finished shock absorber is inspected for its center-to-center distance before it is packed at the packing station. The preliminary study at the plant revealed. The following characteristics, which were the basis for achieving the desired objective:

- From time study analysis, it was found that the pneumatic force testing machine required higher setup time
- The base valve assembly operation was considered a critical process due to its larger process time
- The loading and transferring of finished shock absorber from packing station to loading zone was done manually.

Thus, the production rate is not adequate to the daily demand, leaving subsequent gap between daily demand and the production rate. Production capacity can be increased in numerous ways, such as reduction in process time, addition, allocation and/or proper utilization of resources. Thus the objective of this study is to propose an reduction process time the current assembly line that could increase the capacity to 780 parts from the current 660 parts per day.

2. THEORETICAL BACKGROUND

Simulation refers to a broad collection of methods and applications to mimic the behaviors of real system (Kelton et. al 2003)

Manufacturing applications include both facility design, as well as enterprise-wide supply chain modeling. The typical manufacturing model is usually used either to predict system performance or to compare two or more system designs or scenarios. Facility design applications may involve modeling many different aspects of the production facility, including equipment selection/layout, control strategies (push/pull logic), material handling design, buffer sizing, dispatching/scheduling strategies, material management, etc. Depending on the objectives of the study, a detailed model of a facility level process can be very large and complex (Miller, 2000).

3. RESEARCH METHOD

Necessary data were collected by conducting time and workstudy at every workstation. The current layout runs for 3 shifts a day, 6 days a week. At each station ten sample values for operation time were collected. we determine the distribution followed by the data.

4. RESULT AND DISCUSSION

One fundamental issue in quantitated modeling is whether to model an input quantity as a deterministic (nonrandom) quantity, or going to model as a random variable following some probability distribution. In this case we used probability distribution from the data collected at Table 1

Table 1. Current Process Times in Seconds

No	Operation	Distribution
1	Start:Piston Rod Assy	TRIA (6.4,7.4,8.3)
2	Base Valve Assy	LOGN(1.2,1)
3	Inner &Outer Tube Assy	NORM (0.3,0.1)
5	Oil Filling Assy	BETA (2.2,1.1)
6	Pneumatic Press	GAMM((2.2,2.1)
7	Inspection 1	TRIA (0.5,1,1.5)
8	Sealing	LOGN (3,2)
9	Spring Seat &Adjuster Assy	GAMM (5,1.2)
10	Spring Fitting	TRIA (0.5,1,1.5)
11	Inspection 2	TRIA (0.5,1,1.5)
12	Finish:Cleaning&packing	TRIA (1,2,3)

Thus the shock absorbers tend to be of different specifications depending upon the vehicle it is to be assembled onto. One of the shock absorbers 5240KEV882 is shown below in Figure 1.

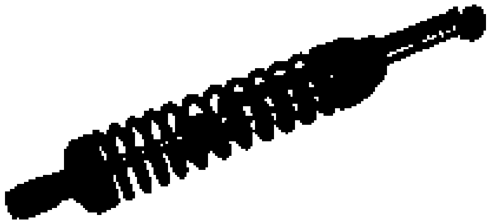

Figure 1. Type 5240KEV882 Shock Absorber

These shock absorbers are used in motorcycles model Supra . The company makes four kinds of shock absorbers differentiated depending upon the following specifications:

- Center-to-Center Distance (210 mm)
- Diameter of top Eyelet (12 mm)
- Diameter of bottom Eyelet (15mm)
- Spring seat to bottom end distance (60mm).

All the parts going into making the five shock absorbers are the same with same time amount of times required for every model of shock absorber. The only differentiating characteristics are the four parameter stated above. The assembly line at the plant can be best described as a transfer line producing shock absorbers of different specifications for two-wheelers. The same assembly line is used to make different classes of shock absorbers depending upon the orders coming in from motor manufactures. The assembly line starts with simultaneous sub-assemblies of piston rod and the base valve. They are pre-assembled at two separate stations before they are introduced into the main assembly line. The piston rod assembly is the most critical sub assembly in the shock absorber. It starts with inserting a pre-lubricated oil seal, rebound spring and rod guide onto the piston rod. Later a spring valve, orifice valve, bush, plate valve and a nylon nut are assembled in that order. The components of the piston rod assembly are shown in Figure 2:

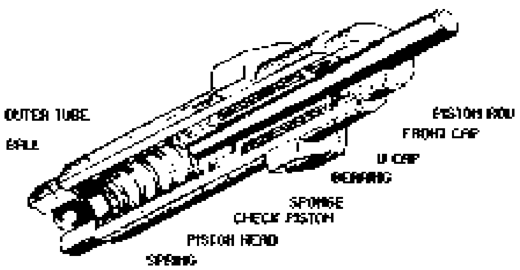

Figure 2: Piston Rod Assembly

The base valve assembly starts with inserting the plate valve, spring valve and orifice valve over a base valve case. These three parts are pressed together using a pneumatic press to produce the base valve subassembly. This subassembly is then press fitted onto a ball passed and cleaned inner tube. The inner tube is then manually inserted into the outer tube. Here preset amount of oil is filled in the tube depending upon the damping force characteristics required. After oil filling, the piston rod subassembly is manually inserted into the outer tube subassembly using a thimble to ease and speed up the process. This assembly is then pneumatically pressed to form the damper. This unsealed damper is then taken to the servo hydraulic machine where a 100% inspection occurs to check for the damping force at different velocities. Any rejects are disassembled and re-fed into the system for reuse. The unsealed dampers move over a constant speed conveyer to the sealing machine . These dampers move on to the bush fitting machine where the bottom center of the damper is bushed. before leaving the bush-fitting machine a spring adjuster and a spring seat are inserted in the damper. The dampers move on to the spring fitting machine where a dust cover and pre-assembled top eyelet are used in conjunction with a spring to complete the whole shock absorber assembly. The shock absorber is then inspected for its top to bottom center distance. It is then cleaned with pressurized air and packed in boxes of 12. The Simulation Process Flow Diagram is shown in Figure 3.

4.1. Model Scenarios

The shock absorber assembly line simulation was run twice. First it was run to simulate the original or current assembly line at the plant. Later a modified proposed layout was run to study the effectiveness of the proposed model. Output data for both the scenarios were compared to justify the effectiveness of the proposed layout. In each case the model was run with a 30 minute warm-up, to eliminate the startup transients, allowing the system to fill up the bins, thus reaching steady state operation, and with 3 times replications. This makes the model more realistic, since the factory starts each day, with shock absorbers remaining in the system from the prior shift. After the warm-up period, the models were run for twenty-four hours (three shift). Two 15-minute breaks and one 30-minute lunch time are incorporated into the system using the simulation time provided in ARENA 10.0 explains the reasons for determining 30 minutes as the warm up period.

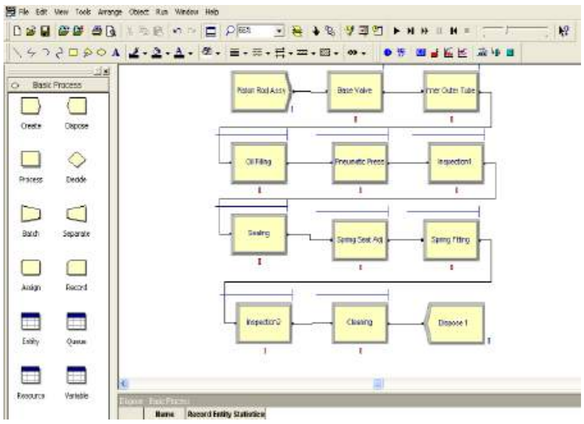
Figure 3. Simulation Flow Diagram

4.2. Model Assumption

To simulate the system in Arena we use assumption:

- In software, we used simulation time for each shift is 8 hours
- ratio of total production in simulation vs real is 1:20, it means 10 products in simulation software report, in the real system is 200
- Material transfer time was calculated in flow process time
- Manufacturing of piston rod subassembly and base valve subassembly does not cause delay in the manufacturing of other subassemblies and vice versa
- No machine downtime has been considered
- Operators and tools work at their full efficiency
- The conveyers belt has constant speed

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- Factory layout and the flow of process remained unchanged
- Each part are readily available at respective stations when needed.

4.3. Model Optimization

There is 15 operators are used at various location and fork lift is utilized to transfer the packed boxes from packing station to loading zone.
The following changes were made to the current model:

- Number of workers remain the same but have been moved around to different stations. Workers in Cleaning moved to base valve assy
- Two operators will work at base valve assy machine instead of one
- A new operation method at pneumatic press machine will be added to the proposed layout.

Table 2: Optimized Process Times in Seconds

No	Operation	Distribution
1	Start:Piston Rod Assy	TRIA (6.4,7.4,8.3)
2	Base Valve Assy	LOGN(0.5,0.6)
3	Inner &Outer Tube Assy	NORM (0.3,0.1)
4	Oil Filling Assy	BETA (2.2,1.1)
5	Pneumatic Press	GAMM(2,1)
6	Inspection 1	TRIA (0.5,1,1.5)
7	Sealing	LOGN (3,2)
8	Spring Seat &Adjuster Assy	GAMM (5,1.2)
9	Spring Fitting	TRIA (0.5,1,1.5)
10	Inspection 2	TRIA (0.5,1,1.5)
11	Finish:Cleaning&packing	TRIA (2,3,4)

Table 3. Current Output ARENA

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value
Base Valve.Queue	5.6562	0.91	5.2321	5.8921	0.00
Cleaning.Queue	1.0542	0.10	1.0277	1.1023	0.00
Inner Outer Tube.Queue	4.5209	0.84	4.2732	4.9047	0.00
Inspection1.Queue	2.5586	0.75	2.2614	2.8667	0.00
Inspection2.Queue	1.4455	0.29	1.3218	1.5514	0.00
Oil Filling.Queue	3.8146	0.29	3.6854	3.9186	0.00
Pneumatic Press.Queue	3.1290	0.86	2.7643	3.4549	0.00
Sealing.Queue	2.1995	0.39	2.0181	2.3039	0.00
Spring Fitting.Queue	1.7804	0.38	1.6130	1.9098	0.00
Spring Seat Adj.Queue	1.9365	0.38	1.7993	2.1029	0.00

Table 4. Optimized Output ARENA

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Base Valve.Queue	4.7964	0.54	4.6212	5.0407	0.00	10.0000
Cleaning.Queue	1.3525	0.29	1.2187	1.4231	0.00	5.0000
Inner Outer Tube.Queue	4.0910	0.17	4.0300	4.1676	0.00	9.0000
Inspection1.Queue	2.6813	0.62	2.4291	2.9292	0.00	8.0000
Inspection2.Queue	1.5079	0.45	1.3633	1.7090	0.00	5.0000
Oil Filling.Queue	3.5411	0.17	3.4706	3.6088	0.00	9.0000
Pneumatic Press.Queue	3.3061	0.94	3.0131	3.7314	0.00	9.0000
Sealing.Queue	2.1655	0.42	1.9747	2.2932	0.00	6.0000
Spring Fitting.Queue	1.7193	0.55	1.4816	1.9249	0.00	5.0000
Spring Seat Adj.Queue	1.9118	0.52	1.7180	2.1323	0.00	5.0000

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4.4. Verification & Validation

The model of the manufacturing facility was verified by conducting the following tasks (Bowden et al 2000)

- Animation was used to aid in the visualization of entity flow paths. This technique made it possible to ensure that entities were traveling in accordance with the entity flow diagram. Colors were used for easier visual tracking of entity flow. In the end they were removed from the model to increase the speed of simulation
- The trace command was used to verify that the entity flow logic, resource operations, and path networks simulated the system processes as intended. Discrepancies in model logic discovered during the verification process were subsequently rectified.

The model of the manufacturing facility was validated by conducting the following tasks: The animation and trace techniques were applied to the model verification process to ensure proper model execution.A sensitivity analysis was performed to determine the effects of entity arrivals and manpower on the model output.(Gupta 2003) This analysis was included in the calibration process to represent current model conditions by adjusting the capacity (manpower) of the various locations so that the shock absorber production rate was 780 shock absorbers per day. The actual daily production was 770 shockers per day. The results are well within the typical variation limits between the model and the system performance. Typically 5 – 10 % difference is attributed to random variation. A warm-up period was determined to model the transient phase of the system. Adequate amount of warm-up period is essential in order to consider corresponding output is 30 minutes

5. CONCLUSION

The daily production requirement of the company has increased from 660 shock absorbers per day to 780 shock absorbers per day. The proposed suggestion does increase the production capacity to 770 parts per day, which is increase about 18% . Secondly no operators had to be hired or laid off in order to implement the system. The operator efficiency in the proposed layout is more than twice of the current layout. Thirdly, amount of queuing the parts stay in system has reduced drastically. We suggest that the human resources department might be looked into as the area to further improve the capacity of the system, since some operators work at a very low productivity level.

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AUTHOR BIOGRAPHIES

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