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Determining the Real Capacity of an Automated Production Line for an Aerospace Company

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Abstract: This study aims to determine the real capacity of a machine in an automated production line by analyzing cycle times, including both cyclic and periodic activities affecting performance. The A3 methodology was used to systematically diagnose the machine's capacity, focusing on time measurement and identifying factors that influence its operational performance. Data on cycle times were collected under normal operating conditions, from which both theoretical and real capacity were calculated based on measured times, without modifying the process. The research revealed that the machine's capacity is impacted by factors like variability in cyclic activities and periodic interruptions. The study provides an accurate measurement of the machine's real capacity, capacity is a key tool for understanding machine performance and making informed decisions.

Keywords: Automated production line, cycle time, cyclical work, capacity, observation sheet, periodic work.

1. Introduction

This project aims to determine the real capacity of an automated production line in a company within the aerospace sector. The study will focus on evaluating the current performance of the production line, identifying the factors that differentiate it from the designed capacity. This introductory chapter provides an overview of the problem to be investigated, without delving into considerations about potential improvements.

1.1 Background

The aerospace industry has evolved rapidly over more than a century, marked by significant milestones in aviation and space exploration. Mexico has become a key manufacturing hub, benefiting from its geographic location, trade agreements, skilled labor, and abundant resources [1].

In Cajeme, industrial activities dominate [2] with Hermosillo hosting aerospace companies like Latécoère (Boeing 787 doors) and Figeac (Boeing components). AT Engine manufactures turbine parts, while Amphenol and Carlisle in Nogales produce connectors and cables. Mefasa in Cumpas manufactures electronics for aircraft, and Ellison Surface Technologies in Guaymas provides turbine coatings. Ciudad Obregón hosts Radiall and QET Tech Aerospace for aircraft maintenance [3].

The company under study, founded in 1952 to produce coaxial connectors for television, is now a global supplier of high-reliability interconnection components. Based in Sonora, it employs 777 people (59% women, 41% men) and operates three industrial facilities since 2007.

1.2 Problem Statement

The increasing demand in the aerospace industry has led companies to implement automated production lines designed to optimize processes and enhance efficiency. However, despite these lines being designed with a theoretical capacity, significant discrepancies often arise between the planned and actual capacity in practice. Capacity analysis in automated lines is crucial to ensure that quality standards, which are fundamental in the aerospace industry, are maintained at all times. Table 1 displays the designed capacity data for hard bonding and silicon bonding processes.

Table 1. Design capacity for hard bonding and silicon bonding

Module	Cycle Time	Shift Capacity (12 Hr)	Day Capacity (24 Hr)	Week Capacity (Monday – Thursday)	Month Capacity (4 Weeks)
Hard Bonding	15.80	2734	5468	21873	87494
Silicon Bonding	19.00	2274	4547	18189	72758

Table 1 outlines the machine's designed capacity: 2,734 units per 12-hour shift for hard bonding process and 2,274 units for silicon bonding process. The 24-hour shift capacity is double the 12-hour shift, and the weekly and monthly capacities are derived by multiplying the daily capacity accordingly. This highlights the need for an analysis to compare the theoretical capacity with the actual capacity of a specific automated line in the aerospace sector.

1.3Objective

Determine the real capacity of the bonding machine in the automated production line in order to provide information that supports decision-making by senior management.

2. Results

Throughout this section, the findings related to the capacity of the automated production line are presented, based on the analysis of cycle time data and the countermeasures implemented, supported by the steps of the A3 methodology.

2.1 Problem Situation

Data provided by the company under study revealed a discrepancy between the designed capacity of the line and its actual performance during operation. As shown in table 1, for hardbonding process, the capacity is 2,734 units per 12-hour shift, while for silicon bonding process, the capacity is 2,274 units per 12-hour shift.

2.2 Objective

The objective was established to determine the current capacity of the automated line, specifically in terms of the maximum achievable production within a given time frame, in order to understand the limitations and actual potential of the line.

2.3 Cause Analysis

The causes that led to the discrepancy between the designed capacity and the actual capacity of the line were identified: Lack of precision in machine configuration, lack of monitoring, setup time, corrective and preventive maintenance, non-standardized processes, change of procedures, operators' personal time, human errors, lack of training or experience, low-quality material, disorganized work environment

2.4 Counter Measures

Cycle times for the processes were collected through a time study. First, the process was carefully observed to identify the cyclic and periodic activities. A time study was then conducted on the activities to determine the cycle time of the operation. For this, an Excel sheet previously formulated and provided by the company under study was used.Figure 1 shows the results of the time study for hard bonding process, the time study for silicon bonding process was conducted in the same manner.

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OBSERVATION SHEET

HARD BONDING (FEMALE assy) 30 cav SEPTEMBER 2024

Cyclical Work

Activity	VA/INC/NVA	Elements	1	2	3	4	5	6	7	8	9	10	Max	Min	Fluct.	Adjust	Minimum time
1	VA	Rotative	1.49	1.65	1.66	1.64	1.48	1.45	1.82	1.75	1.19	1.65	1.82	1.45	0.36	0.18	1.63
2	VA	Camera 3 and 4	1.42	1.46	1.42	1.34	0.89	1.19	1.71	1.54	1.41	1.39	1.71	1.19	0.53	0.26	1.44
3	VA	Scale reset 0	0.94	1.04	0.93	0.94	0.71	0.72	0.76	1.29	1.40	0.80	1.40	0.72	0.68	0.33	1.05
4	VA	Stick	1.21	1.34	0.99	1.45	1.29	0.97	1.34	0.83	1.05	1.09	1.45	0.97	0.47	0.23	1.20
5	VA	Rotative	1.63	1.60	1.37	0.87	0.81	1.19	0.68	0.89	0.79	1.11	1.63	0.79	0.84	0.41	1.20
6	VA	Camera 3 and 4	1.11	1.34	1.31	1.34	1.41	0.75	1.37	1.21	1.11	0.95	1.41	0.95	0.46	0.22	1.17
7	VA	Flip	1.59	1.37	1.26	1.60	1.60	1.32	1.20	1.15	1.55	1.45	1.60	1.20	0.40	0.20	1.40
8	VA	Scale	1.43	0.85	0.97	0.91	1.05	0.79	0.97	1.32	1.29	1.24	1.43	0.85	0.58	0.28	1.14
9	VA	Front and rear insulator assembly	4.08	3.29	3.08	2.22	3.28	2.77	3.01	3.76	3.20	3.79	4.08	2.77	1.31	0.64	3.41
10	VA	Clamping	2.50	2.58	2.52	2.22	2.54	2.85	2.40	2.13	1.55	1.53	2.85	1.55	1.30	0.64	2.19
		Cyclical total time	17.39	16.52	15.50	14.52	15.04	13.99	15.27	15.87	14.54	15.01	19.37	12.44	3.39	Total ciclico	**15.83**

Periodic Work

Activity	VA/INC/NVA	Elements	1	2	3	4	5	6	7	8	9	10	Max	Min	Fluct.	Adjust	Minimum time
1	VA	Adjust stick rollers	0.15	0.14									0.15	0.15	0.00	0.000	0.153
2	NVA	Take material to prepare rubber	0.04	0.03									0.04	0.03	0.01	0.000	0.026
3	VA	Prepare rubber	0.42	0.56									0.56	0.42	0.14	0.001	0.422
4	INC	Computer Rubber	0.05	0.05									0.05	0.05	0.00	0.000	0.051
5	VA	Disassemble machine	0.01	0.00									0.01	0.00	0.00	0.000	0.004
6	NVA	Look for tools to load machine with rubber	0.22	0.22									0.22	0.22	0.00	0.000	0.219
7	VA	Put rubber in syringe	0.12	0.12									0.12	0.12	0.00	0.000	0.121
8	NVA	Change rubber of container	0.03	0.03									0.03	0.03	0.00	0.000	0.029
9	VA	Put rubber in syringe	0.05	0.05									0.05	0.05	0.00	0.000	0.054
10	VA	Load stick #1 with rubber	0.06	0.03									0.06	0.03	0.03	0.000	0.028
11	VA	Load stick #2 with rubber	0.02	0.01									0.02	0.01	0.01	0.000	0.013
12	VA	Load matriz with rubber	0.01	0.02									0.02	0.01	0.01	0.000	0.013
13	NVA	Move to work-table	9.00	7.00									9.00	7.00	2.00	0.015	7.015
14	INC	Go to tool drawers and grab gloves	0.03	0.02									0.03	0.02	0.01	0.000	0.024
15	NVA	Go to computer	3.00	4.00									4.00	3.00	1.00	0.008	3.008
16	INC	Computer	0.01	0.01									0.01	0.01	0.00	0.000	0.013
17	NVA	Go and collect MO	5.00	5.00									5.00	5.00	0.00	0.000	5.000
18	NVA	Take MO to work-table	8.00	6.00									8.00	6.00	2.00	0.015	6.015
19	NVA	Take MO	6.00	4.00									6.00	4.00	2.00	0.015	4.015
20	INC	Fill up MO	7.00	10.00									10.00	7.00	3.00	0.023	7.023
21	NVA	Go to tool drawers	5.00	4.00									5.00	4.00	1.00	0.008	4.008
22	INC	Take registrations	12.00	8.00									12.00	8.00	4.00	0.031	8.031
23	NVA	Go to computer	5.00	4.00									5.00	4.00	1.00	0.008	4.008
24	INC	Fill up registration	24.00	20.00									24.00	20.00	4.00	0.031	20.031
25	INC	Go and take robot control	10.00	7.00									10.00	7.00	3.00	0.023	7.023
26	INC	Fill up MO	23.00	19.00									23.00	19.00	4.00	0.031	19.031
27	NVA	Go to computer	4.00	5.00									5.00	4.00	1.00	0.008	4.008
28	VA	Mo scanning	29.00	27.00									29.00	27.00	2.00	0.015	27.015
29	INC	Fill up registration	11.00	15.00									15.00	11.00	4.00	0.031	11.031
30	VA	Operate on computer	24.00	28.00									28.00	24.00	4.00	0.031	24.031
31	VA	Put trays in machine	9.00	11.00									11.00	9.00	2.00	0.015	9.015
32	VA	Start in computer	8.00	6.00									8.00	6.00	2.00	0.015	6.015
33	VA	Adjust rubber in computer	25.00	27.00									27.00	25.00	2.00	0.015	25.015
34	VA	Close door of conveyor	6.00	3.00									6.00	3.00	3.00	0.023	3.023
35	INC	Return to computer	4.00	3.00									4.00	3.00	1.00	0.008	3.008
		Periodic work total time	6.28	5.91									255.39	207.2	0.37	Total Periodic (100 pcs)	**207.5**
		Cyclical + periodic time	23.7	22.4									274.8	219.6	1.2		**17.90**

Fig 1. Observation sheet for hard bonding process

In Figure 1, it can be observed that the 10 cycle times for each cyclic element were recorded, as well as the relevant data for the periodic elements. In the periodic activities, some tasks are performed each time a new order is initiated, while others are carried out every 8 hours, such as preparing the rubber and loading the machine with rubber. This is because the rubber remains in good condition for eight hours, which needs to be replaced after this time.

The sum of all cyclic elements is calculated, as well as the sum of all periodic elements. The result of this summation is called the "Cycle Time," which represents the actual time it takes for the operator to complete all elements involved in the process operation. The cycle time was calculated using the following formula:

(1) Cycle Time=∑Minimum Cyclic Time+(∑Minimum Periodic Time/100)

The cycle time for the hard bonding process is composed of the sum of the cyclic time (15.83 seconds) and the periodic time (207.5 seconds / 100 pcs), resulting in a total of 17.90 seconds.

2.5 Implementation

Using the results from the previous step, it was possible to calculate the capacity. The theoretical capacity for a twelve-hour shift was calculated using the following formula:

(2) Theoretical Capacity = Available Operating Time / Cycle Time

Figure 2 shows the calculation of the theoretical capacity, which includes the capacity for a shift (twelve hours), a day (24 hours), a week (Monday to Thursday), and a month (4 weeks) hard bonding process.

Theoretical maximum capacity					
MODULE	CYCLE TIME	SHIFT CAPACITY 12HR	DAY CAPACITY 24 HR	WEEK CAPACITY MONDAY - THURSDAY	MONTH CAPACITY 4 WEEKS
Hard Bonding 1 module	17.90	2413	4826	19302	77209
(+)Hard Bonding 2 module	17.90	4826	9651	38605	154419

Fig 2. Calculation of the theoretical capacity of the hard bondingprocess

By applying the formula Theoretical Capacity = 12 hours * 60 * 60 / 17.90, the calculated capacity per shift is 2,413 units. For a 24-hour period, this is doubled, and for the weekly and monthly capacities, the 24-hour capacity is adjusted based on the number of working days and weeks.

Additionally, a simulation was performed for the "(+)Hard Bonding 2 module " scenario, where two orders are processed simultaneously. This requires two operators, but currently only one is available. If two orders were processed together, the capacity per shift would increase to 4,826 units.

The real capacity was calculated by considering an OEE of 90%. The following formula was used:

(3) Real capacity = (Available Operating Time / Cycle Time) * 90%

Figure 3 shows the calculation of the real capacity with a 90% OEE, including the capacity for a shift (12 hours), a day (24 hours), a week (Monday to Thursday), and a month (4 weeks) for the hard bonding process.

Capacity OEE					90%
MODULE	CYCLE TIME	SHIFT CAPACITY 12HR	DAY CAPACITY 24 HR	WEEK CAPACITY MONDAY - THURSDAY	MONTH CAPACITY 4 WEEKS
Hard Bonding 1 module	17.90	2172	4343	17372	69488
(+) Hard Bonding 2 module	17.90	4343	8686	34744	138977

Fig 3. Calculation of real capacity of the hard bonding process

The 12-hour shift was converted to seconds, divided by the cycle time, and then multiplied by 90% to account for operational inefficiencies, resulting in a shift capacity of 2,172 units. The 90% OEE reflects factors like setup, maintenance, breaks, and operator personal time. This data, provided by the company, was not further calculated in the study.

For 24-hour capacity, the 12-hour shift capacity is doubled. For the weekly capacity, the 24-hour capacity is multiplied by 4 working days, and then by 4 for the monthly capacity. The same calculations were applied to silicon bonding process.

In the case of “(+) Hard bonding 2 module” it was simulated that two orders could be processed simultaneously, requiring two operators. The simulation yielded 4,343 units per shift for hard bonding process when two orders are processed together.

2.6 Follow Up

With the obtained results, a simulation was conducted to analyze how the capacity would change by adding another bonding machine. Figure 4 shows this simulation.

Theoretical maximum capacity (Simulation Complete line)								
Process	Hours	Schedule	Cycle Time	Qty Module	SHIFT CAPACITY 12HR	DAY CAPACITY 24 HR	WEEK CAPACITY MONDAY - THURSDAY	MONTH CAPACITY 4 WEEKS
Hard Bonding	12	7:00 am - 7:00 pm	17.90	1	2413	4826	19302	77209
Silicon Bonding Female (Grommet)	6	7:00 am - 1:00 pm	23.74	2	1820	3639	14558	58232
Silicon Bonding Male (Grommet + seal)	6	1:00 pm - 7:00 pm	23.33	1	926	1852	7407	29627
Total Capacity Silicon Bonding					2746	5491	21965	87859

Fig. 4 Simulation complete line

To calculate the capacities for this simulation, the formulas explained earlier were used. In Figure 4, it can be observed that in the simulation, one machine is dedicated exclusively to hard bonding process for the entire shift, resulting in a capacity of 2,413 units per shift. The other two machines would be used for silicon bonding process, either male or female, with each process receiving half a shift, meaning 6 hours for each. For silicon bonding female process, both robots can be used to handle two orders simultaneously, resulting in 1,820 units per shift. For silicon bonding male process, both robots are used to produce one order, resulting in 926 units per shift. The total capacity for bonding process 2 was calculated by summing 1,820 units + 926 units = 2,746 units per shift.

Also, the real capacity with a 90% OEE was calculated for this simulation. This capacity is shown in Figure 5.

Capacity OEE 90%								
Process	Hours	Schedule	Cycle Time	Qty Module	SHIFT CAPACITY 12HR	DAY CAPACITY 24 HR	WEEK CAPACITY MONDAY - THURSDAY	MONTH CAPACITY 4 WEEKS
Hard Bonding	12	7:00 am - 7:00 pm	17.90	1	2172	4343	17372	69488
Silicon Bonding Female (Grommet)	6	7:00 am - 1:00 pm	23.74	2	1638	3276	13102	52409
Silicon Bonding Male (Grommet + seal)	6	1:00 pm - 7:00 pm	23.33	1	833	1667	6666	26665
Total Capacity Silicon Bonding					2471	4942	19768	79074

Fig 5. Simulation complete line OEE 90%

To calculate the capacities for this simulation, the formula applying the 90% OEE, as explained earlier, was used. As shown in Figure 5, the capacity for hard bonding process is 2,172 units per shift, and the total capacity for silicon bonding process is 2,471 units per shift.

This chapter has provided a detailed analysis of the discrepancy between the designed capacity and the real capacity of the automated line, identifying the key causes contributing to this difference. After collecting operational data and simulating the line with the addition of an extra bonding machine, it was determined that the theoretical and actual capacities of the process differ significantly. The results obtained provide a solid foundation for strategic decision-making.

3. Conclusion

The capacity analysis of the automated line revealed a significant gap between the designed and actual capacity. The designed capacity, based on ideal cycle times and technical specifications, was much higher than the actual capacity due to factors such as setup times, operator breaks, maintenance, and unplanned downtime. This highlights the common difference between design expectations and real-world operational outcomes.

Based on the data gathered, the company can now adjust production mixes according to demand and estimate the impact of adding an extra bonding machine. This information supports informed decision-making for management.

For future studies, it is recommended to analyze cycle times further to identify areas of capacity loss, minimize downtime, and optimize maintenance. Additionally, reducing setup times could help increase overall capacity.

REFERENCES

[1]. Aerospace Equipment Manufacturing. (n.d.). Data México. Retrieved September 7, 2024, from https://www.economia.gob.mx/datamexico/es/profile/industry/aerospace-product-and-parts-manufacturing

[2]. Government of the State of Sonora. (n.d.). Gob.mx. Retrieved September 10, 2024, from https://www.sonora.gob.mx/datos/economia

[3]. Bahena, R. (2021, May 4). Sonora aerospace cluster, an expanding industry. El Sol de Hermosillo | Local News, Police News, and News on Mexico, Sonora, and the World. Retrieved from https://www.elsoldehermosillo.com.mx/finanzas/mercados/cluster-aeroespacial-sonorense-una-industria-en-expansion-empresas-megarregion-6670812.html