Machine Management Analytics Report

---- Based on Data of First Season 2023

Institution: Ramapo Controls LLC
Customer: Globe Die Cutting
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Date: May.1st.2023

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1.Introduction of Ramapo Controls LLC

Ramapo Controls LLC is a technology company located in upstate New York, developing control systems with clients in manufacturing industry. It offers services such as system development, system maintenance and so on.

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Dima Ostrenko (CEO)
Brian Duemmer (Technology Manager)

2.Introduction of Our Product

This product is a machine management system, widely used in manufacturing factories.

Firstly, the hardware components includes: sensors and operator interface (touch screen) mounted on each machine. Each machine has an Operator station, all are networked to a database server running on side. Database server connected to the facility network where plant management can use the management application to : centrally monitor production, schedule production, integrate with their enterprise recourse planning (ERP software) and ultimately improve efficiency.

Secondly, we designed an internal database based on client's requirement and the analysis purpose to store and organize all machine management related data.

Thirdly, we developed a machine management user interface system that allow the end users to import and export data, add filters and view the visualization of machine management data based on their preference on machine_id or time range and so on. This gives client a broad view of machine management.

Fourthly, we developed a dashboard using excel for further analysis. Including descriptive analysis, time series analysis and frequency analysis. The analysis focuses on both the overall view and each machine view. Also, the analysis

compares difference between time, state, alarm, and different machines, so the analysis is both horizontal and vertical.

Lastly, we wrap the whole thing up in an analytics report with detailed explanation, templated methodology and business recommendation based on the seasonal data. This report is based on the first season data in 2023.

3. Introduction of Globe Die Cutting

Established in 1962, Globe Die-Cutting Products is a family owned and operated business. Globe has grown to be an industry leading trade shop providing dedicated finishing solutions to the folding carton, commercial printing, and point of purchase display industries. Known in the industry as forward thinking innovators and problem solvers, Globe's outside-the-box solutions and technical expertise guide your most complicated and precise project toward success.

Since 1962 we have been a dedicated finisher providing solutions to the folding carton, commercial printing, and point of purchase display industries. These industries are still our primary focus. However, we have evolved into something more than just another trade shop. We are known in the industry as progressive thinking innovators and problem solvers. Some of the most complicated and precise processes in the industry are standard operating procedures for us.

There is no job too large or too small for us; from hundreds of thousands of oversized die-cutting impressions to perfectly mounting 50 sheets to foam core for a special pharmaceutical release. No finishing project is too challenging. Globe has a 100,000 sq ft, climate controlled, state of the art facility in central New Jersey servicing the North East region. The real secret to our success is the success of our customers, some of whom are still with us from the beginning.

4. Dataset Introduction

This report is based on first season data of 2023, specifically Janurary.1st.2023 to April.1st.2023.

The main table is machine_status, which linked to other tables with foreign keys. There are three main components of the dataset, machine production related, machine speed related, and machine alarm related. All the data are collected by our company's hardware designed touchpad installed on the machines and automatically transferred into our database. All data are collected and updated every five seconds. For machines, we have eight machines properly installed and linked with the system. Below is the table of machines working in the first season of 2023, which will be the sample we used to analyze in this report.

In conclusion, we have data of eight machines, date range from Janurary.1st.2023 to April.1st.2023. In the main table of machine_status, there are 785,878 rows of data for each machine and 6,287,024 for all eight machines.

Machine ID	Machine Name	Data Start Date	Data End Date
35	BOTTOM FEEDER	Jan.1st.2023	Apr.1st.2023
40	ALPINA	Jan.1st.2023	Apr.1st.2023
49	MOLL 40"	Jan.1st.2023	Apr.1st.2023
50	MOLL 2 "RED"	Jan.1st.2023	Apr.1st.2023
51	KOHMANN	Jan.1st.2023	Apr.1st.2023
55	MEDIA 100-2	Jan.1st.2023	Apr.1st.2023
57	MEDIA 3	Jan.1st.2023	Apr.1st.2023
58	MEDIA 4	Jan.1st.2023	Apr.1st.2023

5. Data Analytics

We provided data analytics from three aspects, descriptive analysis, frequency analysis and time series.

5.1 Descriptive Analysis

Data proceeded descriptive analysis are production data and speed data in a single time unit, which is 5 seconds. For each machine, we collected data between Janurary.1st.2023 to April.1st.2023, three months in total and updated every five seconds. So, there are 785,878 rows of data for each machine.

Below is the table of average value of the data of eight machines. The reason for calculating average data is to show a general view of eight machines data and process analytics for each machine by comparing that machine data with the average data.

Average		
	Production	Speed
Mean	8.4687	21.2073
Standard Error	0.01516	0.03610
Median	0	0
Mode	0	0
Standard Deviation	13.4362	32.0028
Sample Variance	188.7534	1071.9056
Kurtosis	-0.02277	-1.2562
Skewness	1.1735	0.8333
Minimum	0	0

Maximum	65.8750	75.8750
Sum	6655396.25	16666388.5
Count	785878	785878

Machine 58 MEDIA 4 has the best performance, with the fastest average unit speed 28.23 and largest average unit production 11.37, also has the largest maximum value of 92 for unit production and 106 for unit speed. However, machine 58 also has the largest standard deviation 18.65 for production and 44 for speed, each 5 and 12 higher than the average, which means the data stability is low and is way below the average. As a result, for Machine 58, it needs further analytics in time series analysis and frequency analysis to find out is there any hourly or seasonal trend in machine production and speed, so as to follow the trend and increased utilization of high-volume machines by following the trend.

Machine 49 MOLL 40" has the worst performance, with the lowest average unit speed 15.73 and smallest average unit production 6.40, which are below the average 2 and 6 for each. Also, machine 49 has the smallest maximum value of 41 for unit production and 47 for unit speed. Machine 49 also has the lowest standard deviation, 8.81 for unit production data and 20.54 for unit speed data, below the average by 5 and 12 each. Machine 49 also has the smallest sample variance, 77.61 for production and 422.04 for speed. This shows that even though machine 49's productivity is low and steadily low.

Machine 50, Machine 51 and Machine 57 have an overall good performance, all of them have higher unit production and unit speed compared with average.

Also, their standard deviation are above the average so all of them need further analysis.

Machine 40 and machine 55 have a slightly unsatisfied performance, their average unit production and average unit speed are slightly below the average and the standard deviation are lower than the average as well. This means that their production rate and speed is below the average and is steadily below the average.

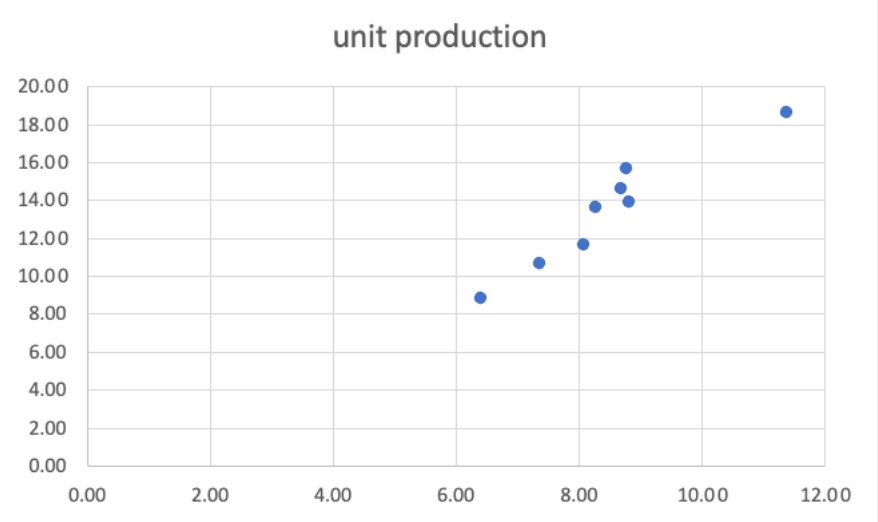
Machine 35 has a neutral performance. Its average unit production and average unit speed are slightly below the average, but the standard deviation is above the average. This means that even though the overall performance may not as good as the other machines with a higher mean but further analytics can be processed to see if there's any seasonal or hourly trend for machine 35 with a higher mean data.

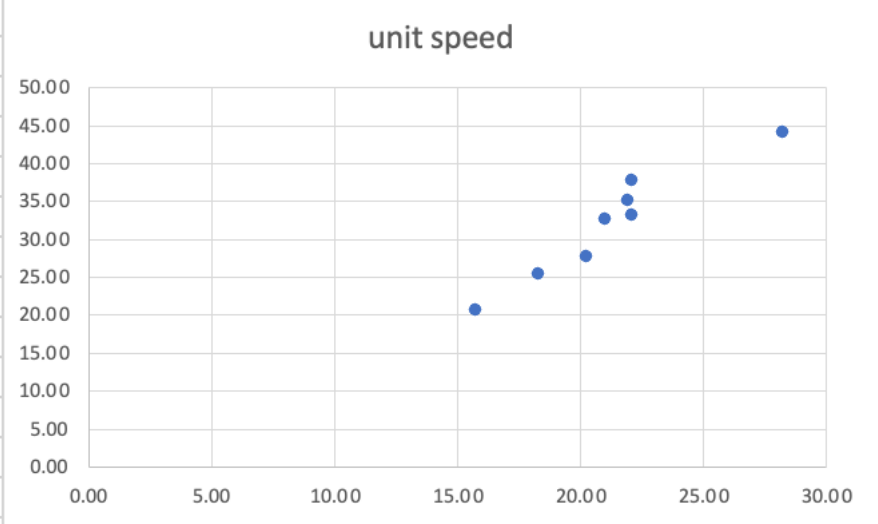
In conclusion, based on the descriptive analysis, machine 58 has the best performance, machine 35 has a neutral performance. Machine 40 and machine 55 has a slightly unsatisfied performance. Further analysis is needed for these machines to analyze the seasonal trend and hourly trend to follow the trend so as to maximize the productivity of these machines. Machine 49 has a unsatisfied performance and both the unit production and unit speed is below and steadily below the average.

	Machine 35		Machine 40		Machine 49		Machine 50	
	Production	Speed	Production	Speed	Production	Speed	Production	Speed
Mean	8.27	21.01	7.35	18.29	6.40	15.73	8.81	22.08
Standard Error	0.02	0.04	0.01	0.03	0.01	0.02	0.02	0.04
Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mode	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Standard Deviation	13.61	32.59	10.68	25.31	8.81	20.54	13.88	33.15
Sample Variance	185.22	1062.17	114.02	640.65	77.61	422.04	192.53	1098.87
Kurtosis	0.35	-1.14	-0.67	-1.53	-0.68	-1.67	-0.16	-1.26
Skewness	1.31	0.92	0.96	0.67	0.89	0.55	1.16	0.85
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	69.00	78.00	51.00	59.00	41.00	47.00	69.00	78.00
Sum	6502415	16512065	5777347	14373422	5030609	12361302	6926159	17356105
Count	785878	785878	785878	785878	785878	785878	785878	785878

	Machine 51		Machine 55		Machine 57		Machine 58	
	Production	Speed	Production	Speed	Production	Speed	Production	Speed
Mean	8.68	21.94	8.08	20.28	8.77	22.09	11.37	28.23
Standard Error	0.02	0.04	0.01	0.03	0.02	0.04	0.02	0.05
Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mode	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Standard Deviation	14.58	35.01	11.64	27.70	15.64	37.71	18.65	44.00
Sample Variance	212.69	1225.77	135.59	767.57	244.67	1421.95	347.68	1936.22
Kurtosis	0.49	-1.04	-0.44	-1.58	0.70	-0.71	0.22	-1.12
Skewness	1.35	0.98	0.99	0.64	1.45	1.13	1.28	0.93
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	69.00	83.00	55.00	62.00	81.00	94.00	92.00	106.00
Sum	6820601	17244763	6353704	15936843	6893309	17358578	8939026	22188030
Count	785878	785878	785878	785878	785878	785878	785878	785878

Max
Min
Above Average
Below Average





5.2 Frequency Analysis

The frequency analysis of the machine management system is mainly focused in three dimensions, the machine status dimension, the alarm dimension, and the effective output dimension. This corresponds to the machine status table and alarm table in the database. These three aspects have been included in the important factors to measure the efficiency of the machine when designing the database.

5.2.1 Machine State Analysis

There are six machine states. Below is the table shows the names and id of 6 machine states.

Machine State	State ID
OFFLINE	1
IDLE, NO JOB	2
IDLE, WITH JOB	3
SETUP	4
RUNNING	5
BREAKDOWN	6

Machine State Analysis focuses on six main aspects for each machine separately: total time spend of each state, total production for each state, average unit production for each state, average unit speed for each state and maximum/minimum unit speed for each state.

Firstly, total time spend of each state. When calculate the percentage of this, offline is disregarded because only working hours are taken into consideration. For most machines except for machine 57 and machine 58, running state has the highest time percentage, then it comes to idle with job then breakdown.
The average time percentage for running state among eight machines is 38.80%, which is the highest, then it comes to the idle with job 37.78%, then is breakdown 11.17%. For machine 57 and machine 58, percentage of idle with job state is slightly higher than percentage of running, but these are still top two highest percentage.

Based on the data, an average of 38.80% running time is a bit low, so this is the factory should work on to improve the efficiency of running. This can be done by reducing the breakdown time, idle no job time and idle with job time. For idle no job state, the average percentage is 9.42% so the factory should work on their sales team to get more orders. For idle with job state, the main reason for this state is either lunch break or switching jobs (because switching jobs need changing job requirements and preparing materials, switching machines etc.). So, it would be effective to reduce job switching frequency, which should be working on by the operation team to management job and machine arrangement. For breakdown state, this needs further alarm analysis to analyze the specific reasons for machine breakdown.

Machine 40, machine 49 and machine 55 have the running state percentage higher than average. Machine 35, machine 50, machine 51 and machine 58 is around or slightly below the average. Machine 57 has only 31.34% on its running state which need to be improved.

Machine State	35	40	49	50	51	55	57	58	average
IDLE, NO JOB	11.94%	4.78%	1.56%	9.93%	21.62%	2.74%	15.47%	7.29%	9.42%
IDLE, WITH JOB	33.86%	39.72%	39.38%	36.88%	34.59%	40.66%	35.13%	42.03%	37.78%
SETUP	2.87%	3.04%	2.39%	3.63%	2.45%	2.56%	2.80%	2.91%	2.83%
RUNNING	36.39%	42.83%	47.01%	37.51%	35.20%	44.01%	31.34%	36.13%	38.80%
BREAKDOWN	14.94%	9.62%	9.67%	12.05%	6.13%	10.03%	15.26%	11.65%	11.17%

Secondly, average unit production for each state. For all machines, setup state and running state has the highest unit production average. Other states the unit

production average are almost 0. So it's important to keep the machine in running state or setup state. Complied with descriptive analysis, machine 58 has the highest unit production average in running and setup state, machine 57, machine 51, machine 50 and machine 35 are above the average. Machine 40, machine 55 and machine 49 need improvement in unit production.

Machine State	35	40	49	50	51	55	57	58	average
OFFLINE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IDLE, NO JOB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IDLE, WITH JOB	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
SETUP	28.36	21.25	17.37	28.43	30.99	22.88	34.45	39.07	27.85
RUNNING	28.06	21.35	17.25	28.55	30.68	23.14	34.20	38.80	27.75
BREAKDOWN	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01

Thirdly, average unit speed for each state. For all machines, setup state and running state has the highest unit speed average. Other states the unit speed average are almost 0. So it's important to keep the machine in running state or setup state. Complied with descriptive analysis, machine 58 has the highest unit speed average in running and setup state, machine 57, machine 51, machine 50 and machine 35 are above the average. Machine 40, machine 55 and machine 49 need improvement in unit production.

Machine State	35	40	49	50	51	55	57	58	average
OFFLINE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IDLE, NO JOB	0.04	0.03	0.02	0.04	0.02	0.05	0.02	0.11	0.04
IDLE, WITH JOB	0.03	0.02	0.05	0.04	0.03	0.02	0.04	0.02	0.03
SETUP	69.97	51.95	42.42	70.13	75.90	56.65	84.51	94.78	68.29
RUNNING	71.39	53.19	42.40	71.63	77.73	58.08	86.32	96.46	69.65
BREAKDOWN	0.01	0.02	0.01	0.02	0.03	0.02	0.01	0.02	0.02

5.2.2 Machine Alarm Analysis

We designed a table in database, machine_alarm, it has record of all alarm type and link with main table with alarm id. Below is the table shows all 9 alarm types.

Alarm	Alarm ID
ELECTRICAL	1
MECHANICAL	2
ALIGNMENT	3
CUSTOMER_QA	4
CUSTOMER_APPROVAL	5
GLUE	6
MISSING_CREW	7
MISSING_MATERIALS	8
MISSING_CUSTOMER_COMPONENTS	9

Alarm analysis has two dimensions: total count for each alarm type and alarm clear time (total clear time for each alarm type and average clear time for each alarm type).

For total count per alarm, machine 57 and machine 58 have smallest total count, which are 18 and 19. Machine 49 and machine 50 have the largest total count, which are 26 and 27. Sorted by the number of occurrences, the alarms are MISSING_CREW,CUSTOMER_APPROVAL,ALIGNMENT,MISSING_MATERIALS,ELECTRICAL,MISSING_CUSTOMER_COMPONENTS,MECHANICAL, GLUE and CUSTOMER_QA.

	Alarm Count									
Machine ID	ELECTRICAL	MECHANICAL	ALIGNMENT	CUSTOMER_QA	CUSTOMER_APPROVAL	GLUE	MISSING_CREW	MISSING_MATERIALS	MISSING_CUSTOMER_COMPONENTS	Grand Total
35	1	1	5	3	2	2	3	1	5	23
40	0	4	1	2	1	2	4	1	8	23
49	0	3	6	6	2	6	0	0	3	26
50	3	0	4	5	2	5	3	1	4	27
51	4	1	2	5	1	3	0	0	4	20
55	1	5	2	4	1	1	4	1	2	21
57	2	3	6	1	2	0	2	0	2	18
58	2	4	0	1	3	2	3	4	0	19
Grand Total	13	21	26	27	14	21	19	8	28	177

For alarm clear time, machine 50 and machine 40 got the highest total clear time and machine 51, machine 49 has lowest total clear time. Missing_crew, alignment and missing_customer_components are three main alarms that have the most grand total while customer_qa and missing materials have the lowest grand total.

Machine 49, machine 51 and machine 57 have the shortest average alarm clear time while machine 35 and machine 40 have the highest alarm clear time. Alarm average clear time represent the speed machine handle alarms. Glue and customer_qa has the shortest average clear time which means easier to handle while missing_crew, customer_approval and alignment need more time to handle. So factory needs to pay more attention to these alarms.

Machine ID	ELECTRICAL	MECHANICAL	ALIGNMENT	CUSTOMER_QA	CUSTOMER_APPROVAL	GLUE	MISSING_CREW	MISSING_MATERIALS	MISSING_CUSTOMER_COMPONENTS	Grand Total
35	18	15	34	8	18	34	58	14	48	247
40	0	21	7	8	7	11	91	45	89	279
49	0	24	50	25	54	28	0	0	18	199
50	20	0	70	6	26	35	85	3	35	280
51	80	0	18	9	17	16	0	0	5	145
55	11	14	30	5	4	2	143	9	32	250
57	2	43	132	7	22	0	20	0	27	253
58	18	78	0	5	14	8	73	36	0	232
Grand Total	149	195	341	73	162	134	470	107	254	

Machine ID	ELECTRICAL	MECHANICAL	ALIGNMENT	CUSTOMER_QA	CUSTOMER_APPROVAL	GLUE	MISSING_CREW	MISSING_MATERIALS	MISSING_CUSTOMER_COMPONENTS	Average
35	18.00	15.00	6.80	2.67	9.00	17.00	19.33	14.00	9.60	12.38
40	0.00	5.25	7.00	4.00	7.00	5.50	22.75	45.00	11.13	11.96
49	0.00	8.00	8.33	4.17	27.00	4.67	0.00	0.00	6.00	6.46
50	6.67	0.00	17.50	1.20	13.00	7.00	28.33	3.00	8.75	9.49
51	20.00	0.00	9.00	1.80	17.00	5.33	0.00	0.00	1.25	6.04
55	11.00	2.80	15.00	1.25	4.00	2.00	35.75	9.00	16.00	10.76
57	1.00	14.33	22.00	7.00	11.00	0.00	10.00	0.00	13.50	8.76
58	18.00	19.50	0.00	5.00	4.67	4.00	24.33	9.00	0.00	9.39
Average	9.33	8.11	10.70	3.39	11.58	5.69	17.56	10.00	8.28	

5.2.3 Machine Good/Bad Production Analysis

Good production means the production under running state, which means effective and efficient production. Good/bad ratio uses good production per machine divided by bad production per machine, which reflect the production efficiency. The higher the ratio is, the efficient the machine is. Machine 49 has the highest good/bad ratio and then it's machine 55. Machine 50 and machine 57 has a relatively low good/bad ratio which means these machines need to improve efficient and improve the state arrangement.

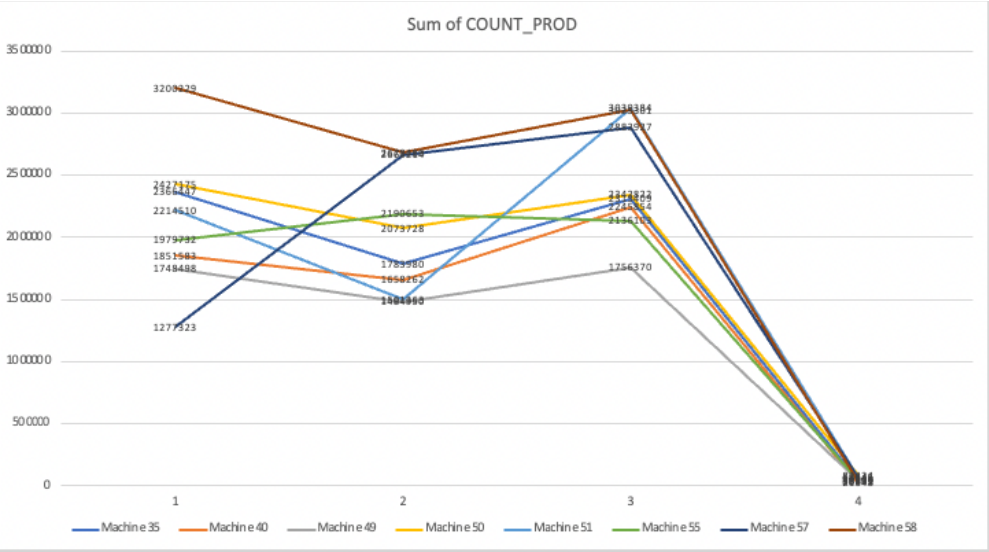
5.3 Time Series Analysis

Time series analysis has two dimensions. The first one is on hourly basis, trying to analyze for each machine, the trend during 24 hours. Data are collected and separate between hours, then get average to represent the hourly data. The second one is on a timely basis, simply the time series data start from Janurary.1st.2023 to April.1st.2023.

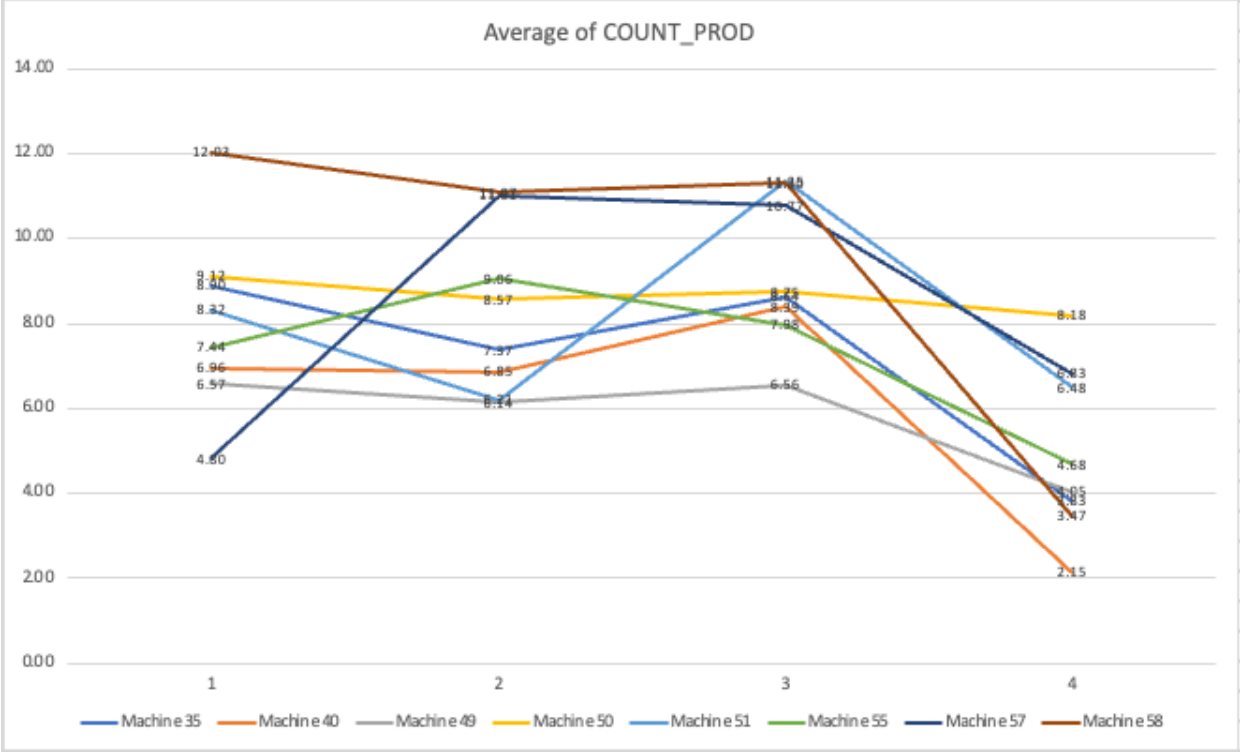
5.3.1 Timely

For timely analysis, there are three main ratios to measure the performance: average of unit production, sum of unit production and average of unit speed. For sum of unit production, the overall trend is January and March is higher and February is slightly lower. Only machine 57 is steadily increasing over the three months and machine 55 is a bit higher in February. Among all machines,

machine 58 has the highest total sum of production and machine 49 has the lowest total sum of production, which is compile with the descriptive analysis.

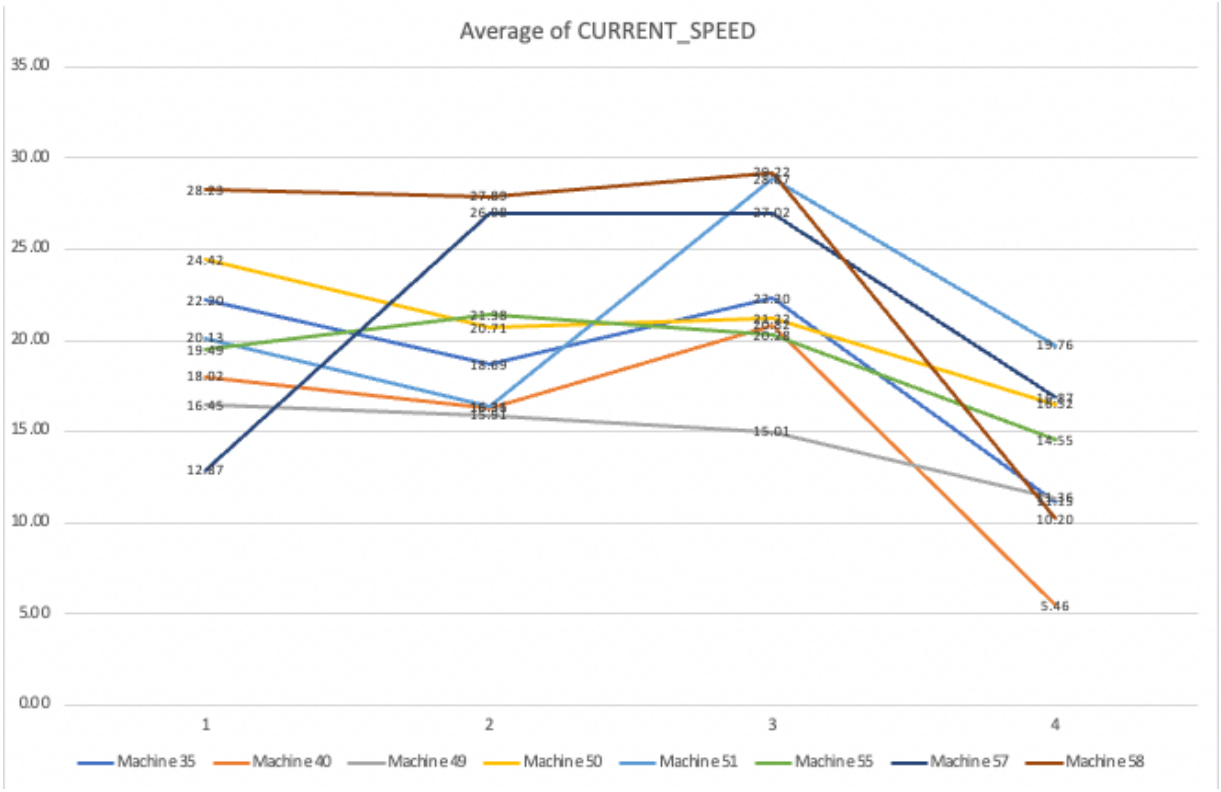


For average of unit production, the trend is same as sum unit production, with January and March higher and February lower for most machines except machine 57 and machine 55. Machine 58 has the highest average unit production and machine 49 has the lowest unit production.



For average of speed, the trend is similar as the production trend, with January and March higher speed and February lower speed among most of the machines except for machine 57 (increase steadily) and machine 55 (February higher). Among machines, machine 58 has the highest speed and machine 49 has the lowest speed. Also machine 51 increased sharply from February to March.

For this trend, both production and speed, the main reasons can be following: first, even February is lower, it's just slightly lower so the overall trend is stable. Second, the factory might want to achieve the seasonal goal, so they increase the speed and production at the last month of the first season. Third, it might because February's order is less than March and January.



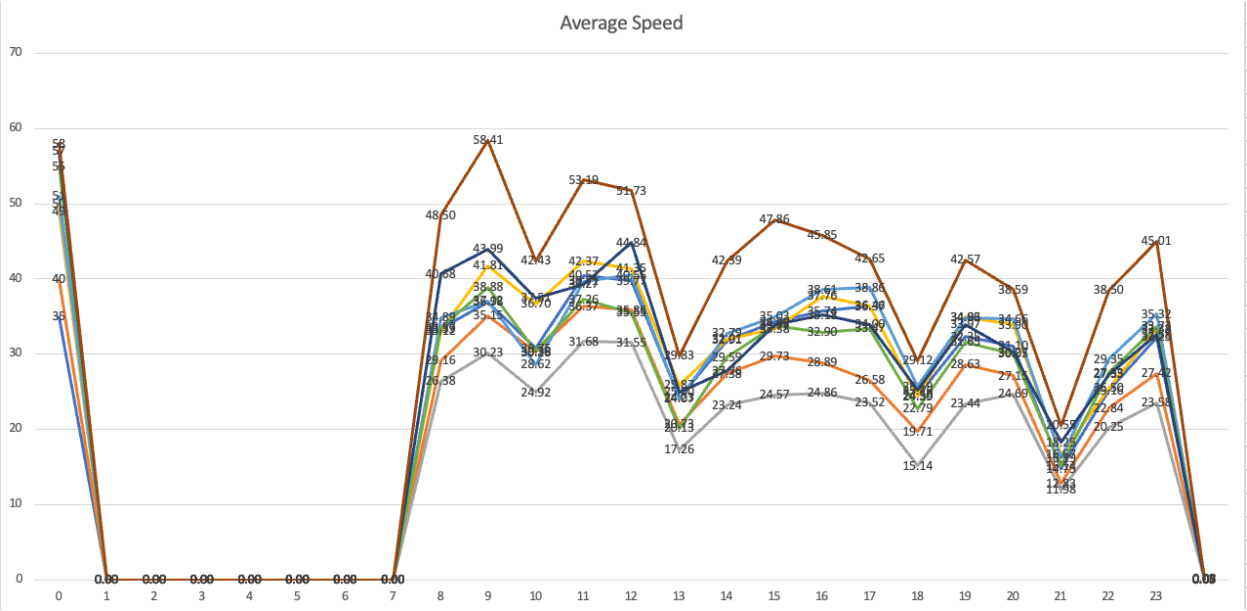
5.3.2 Hourly

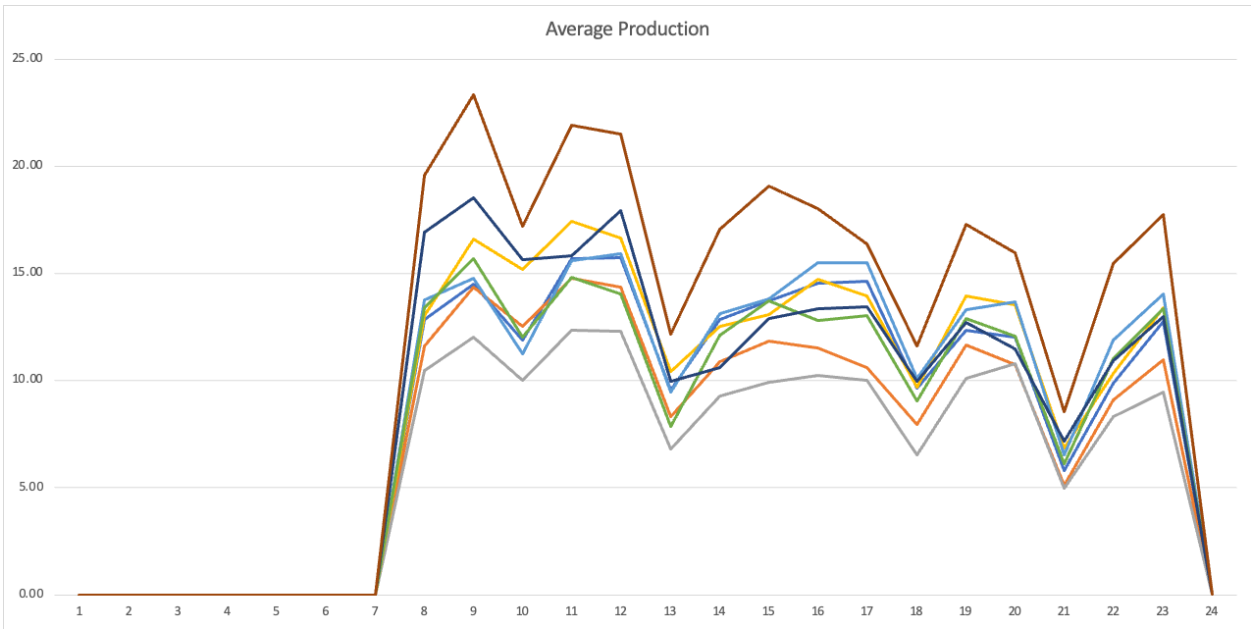
Hourly analysis for time series analysis focuses on average unit speed, average unit production, good production, and bad production.

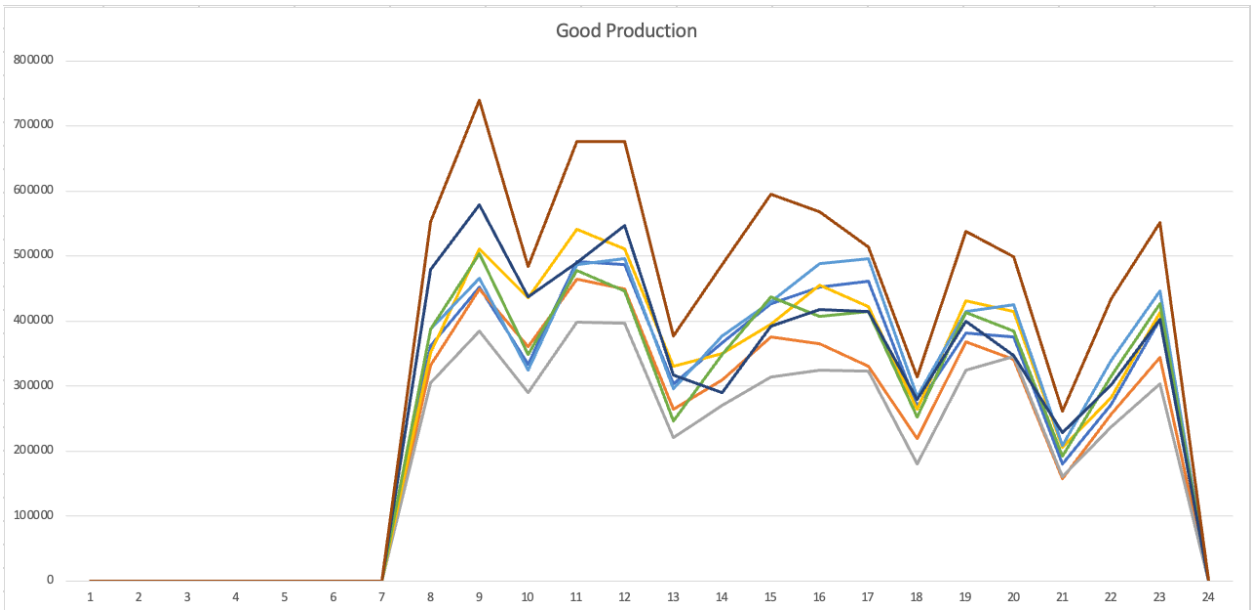
For the overall trend, we can see the there are four time points in a day that has a decrease of either speed or production, those are 10am, 13pm, 18pm and 21pm. These time points are the factory's morning break, lunch break, dinner break and night break. Also, we can see normal business hour for the factory is 7am-12am. From 12am till 7 am machines have 0 production and 0 speed. Day shift for the factory is 7am to 5pm and night shift is 5pm to 12am. From the chart we can see the overall production and speed for night shift is lower

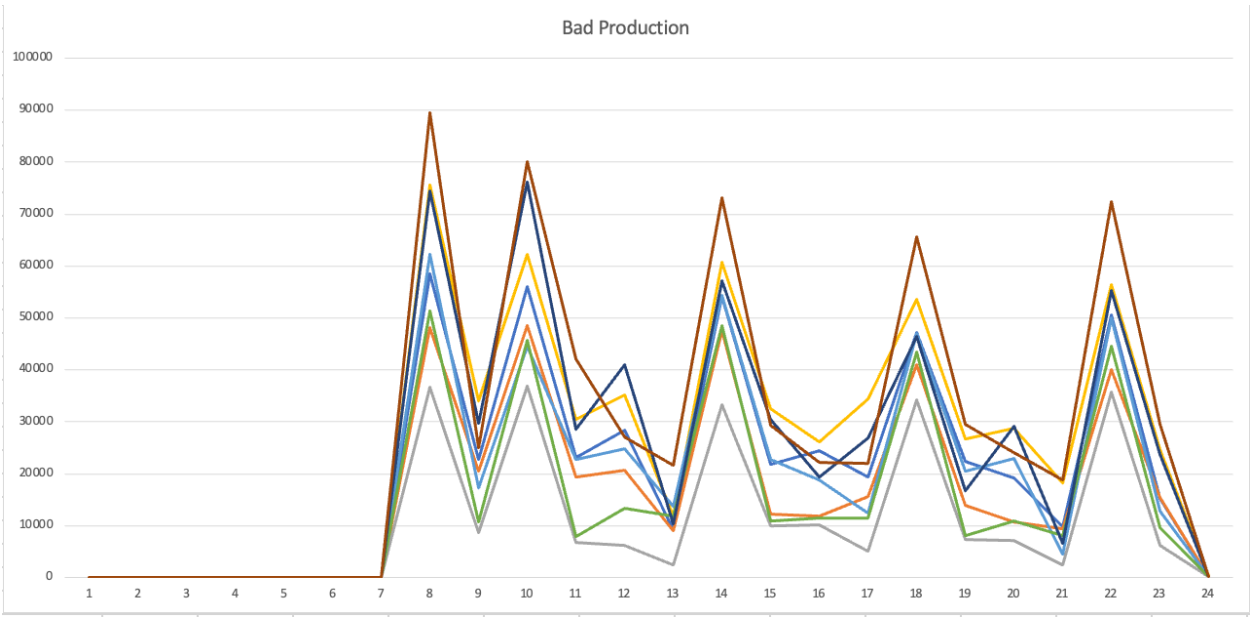
than day shift which mainly due to the inefficiency and lack of management during night shift. This should be an issue the factory should work on.

For machines, machine 58 has the highest average unit production and average unit speed, machine 49 has the lowest. Other machines' performance are on the same trend as descriptive analysis. Because machine 58 has the highest unit production and unit speed, it's the main reason for this machine to have the largest standard deviation because during break the data for all machines are relatively low.




Average Production
25.00
20.00
15.00
10.00
5.00
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


Good Production
800000
700000
600000
500000
400000
300000
200000
100000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


Bad Production
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
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23
24

6. Recommendation of Machine Management

6.1 Quantitative Analysis

Based on the descriptive analysis, overall the machine's average unit production is 8.47 boxes per five seconds and average speed is 21.21 meters per minute.

Machine 58 has the largest unit production and unit speed but also has the largest standard deviation. Machine 50, machine 51 and machine 57 has the overall good performance with both unit production and unit speed above the average. Machine 40 and machine 55 is slightly below the average and the standard deviation is below the average so the performance is slightly unsatisfied. Machine 49 has a low and steadily low production and speed so it's performance is worst.

However, based on the scatter point chart we can see a positive relationship between standard deviation and unit production and unit speed for all machines. So further analysis is needed to analyze in what condition machines have better performance to take the advantage of efficiency.

Machine ID	Unit Production	Unit Speed	Compare with average	SD for Prod	SD for Speed	Compare with average	Performance
35	8.27	21.01	Below	13.61	32.59	Above	Neutral
40	7.35	18.29	Below	10.68	25.31	Below	Unsatisfied
49	6.4	15.73	Minimum	8.81	20.54	Minimum	Worst
50	8.81	22.08	Above	13.88	33.15	Above	Good
51	8.68	21.94	Above	14.58	35.01	Above	Good
55	8.08	20.28	Below	11.64	27.70	Below	Unsatisfied
57	8.77	22.09	Above	15.64	37.71	Above	Good
58	11.37	28.23	Maximum	18.65	44.00	Maximum	Best

For further analysis, we analyzed the relationship between state and production/speed, alarm and production/speed and good/bad production.

For State Analysis, only running state and setup state has an effective speed and production, while other states the speed and production are around 0.

Overall running state takes the largest percentage, which is good, but still need improvement on the efficiency of running. This can be done by reducing the breakdown time, idle no job time and idle with job time. For idle no job state, the average percentage is 9.42% so the factory should work on their sales team to get more orders. For idle with job state, the main reason for this state is either lunch break or switching. So, it would be effective to reduce job switching frequency, which should be working on by the operation team to management job and machine arrangement. For breakdown state, this needs further alarm analysis to analyze the specific reasons for machine breakdown.

For most machines except for machine 57 and machine 58, running state has the largest percentage. For machine 57 and machine 58, idle with job has the largest percentage of time. This might be a reason machine 58 has a larger standard deviation.

For alarm analysis, there are eight alarms in total. Sorted by the number of occurrences, the alarms are:

MISSING_CREW
CUSTOMER_APPROVAL
ALIGNMENT
MISSING_MATERIALS
ELECTRICAL
MISSING_CUSTOMER_COMPONENTS
MECHANICAL
GLUE
CUSTOMER_QA

Sorted by total clear time, the alarms are:

MISSING_CREW	470
ALIGNMENT	341
MISSING_CUSTOMER_COMPONENTS	254
MECHANICAL	195
CUSTOMER_APPROVAL	162
ELECTRICAL	149
GLUE	134
MISSING_MATERIALS	107
CUSTOMER_QA	73

Sorted by average clear time, the alarms are:

MISSING_CREW	17.56
CUSTOMER_APPROVAL	11.58
ALIGNMENT	10.70
MISSING_MATERIALS	10.00
ELECTRICAL	9.33
MISSING_CUSTOMER_COMPONENTS	8.28
MECHANICAL	8.11
GLUE	5.69
CUSTOMER_QA	3.39

We can see missing crew, alignment and missing customer components are the three main alarm appears in the factory, they also take longer to solve as well. Customer qa, glue and missing materials are less likely to happen and easier to handle.

Based on machines, table as below.

Machine ID	Total Clear Time	Average Clear Time
50	280	9.49
40	279	11.96
57	253	8.76
55	250	10.76
35	247	12.38
58	232	9.39
49	199	6.46
51	145	6.04

For good/bad production analysis, we focus on the good/bad ratio which represent the efficiency of production. Below is the machines sorted by the ratio:

MACHINE_ID	GOOD_PROD	BAD_PROD	Good/Bad Ratio
49	4781419	249190	19.19
55	6005482	348222	17.25
51	6369176	451425	14.11
40	5393273	384074	14.04
35	6020219	482196	12.49
58	8266894	672132	12.30
57	6320954	572355	11.04
50	6314174	611985	10.32

For time series analysis, we have monthly analysis and hourly analysis to see if there's any monthly trend or hourly trend.

For monthly trend, we can see most machines have a higher production as well as speed in January and March, while there's a lower production and speed in February. The main reason can be the factory need to achieve the first season goal, so they speed up at the last month of the first season. Or it can be there' re less order in February.

For hourly trend, we can see the normal business hour in this factory is 7am to 12am. Two shifts in a day, day shift from 7am to 5pm and night shift from 5pm to 12am. There are four breaks during a day, 10am, 13pm, 18pm and 21pm. Also, day shift has a higher speed and production than night shift and it may because night shift is lack of management and less efficient. So, the factory needs to enhance the night shift management.

6.2 Qualitative Analysis

6.2.1 SWOT Analysis

Strength:

Founded early in 1962, the factory is experienced in the industry and has customer base and industrial reputation. Has certain maintenance team to work on machine maintenance and repairing.

Weakness:

Low efficiency in machine management. High cost of labor result in higher cost of machine managing. Tedious operator teams and low efficiency.

Opportunities:

Combining with high tech to improve the machine managing efficiency and lower the cost.

Innovation in machine management and operation.

Threat:

Competitors threat

Information privacy cannot disclose the machine management information to the operators who are about to be replaced.

6.2.2 Recommendation

Factory should work on the machine management building and combining high technology with traditional machine management to lower the cost and improve the efficiency.

Based on the first season data outcome, the recommendation is as below.

The factory should strengthen the utilization rate of machine 58, because the production efficiency of machine 58 is the highest during the effective working hours, and at the same time, the time of machine 58 in the state of idle with job is too long, so the frequency of changing machine 58 to different jobs should be reduced, so as to maximize Improve the utilization efficiency of machine 58.

The production efficiency of machine 50, 51 and 57 is also good. The utilization efficiency of these machines should be improved, the switching frequency should be reduced, and the effective working time should be increased.

For machine 40 and machine 55, it is more important to improve the work efficiency of these two machines, increase unit output and speed, and optimize machine performance.

The high variance but low production efficiency of machine 35 is due to the alarm. The analysis of the alarm is mainly due to the missing customer component, so the problem of machine 35 itself is not severe.

For overall, the factory should improve the production and speed for machines. Strengthen the management of the operation team, increase the proportion of each machine in the running state, and reduce the switching of machines between different jobs.

For the processing of alarms, the three most important alerts are missing crew, alignment and customer component, and personnel management, customer service and communication team management should be strengthened. Increase the effective output of the machine.

In terms of time, attention should be paid to controlling the overall progress and reducing the rush to progress in the last month. Strengthen night shift management and improve night shift efficiency.