PURSUING EFFICIENT PRODUCTION AND EXCELLENT QUALITY WITH DATA-DRIVEN DECISION-MAKING, ASIAN AEROSPACE PARTS SUPPLIERS LEAP INTO THE INTERNATIONAL MARKET

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2022/10/25

Abstract

Organization Profile

NATIONAL AEROSPACE FASTENERS CORPORATION (NAFCO) mainly produces fastener products for aerospace and advanced industrial applications. It is one of the four largest suppliers of aerospace engine fasteners in the world, and one of the few enterprises which has become the certified manufacturer of aerospace engine fasteners in the Asia-Pacific region.

- Approximately 600 employees worldwide.
- Up to 90% of the products are exported, mainly in European and American countries.
- With more than 6,000 customer-approved aerospace parts.
- Incorporated into the supply chain by several global leading aerospace companies.

Participants

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Audience

Digital transformation leaders

Business Challenges

- Products highly associated with air safety, the correctness and traceability of production information are vital: All aerospace products are subject to professional certification, in which the quality and traceability of products are highly required. Furthermore, even upstream production equipment and materials shall be subject to customer approved lists.
- Price-cutting competitions pressure from the international markets: The aerospace industry needs to enter the international market in order to obtain a certain economic scale, while it also faces the pressure of fierce

price-cutting competition from European/American and emerging Asian enterprises.

- Ever-serious labor shortage and difficulty in attracting talents: Labor shortage, a common issue in Taiwan's traditional manufacturing industry, is no exception in NAFCO. Nowadays, young people's lack of desire to engage in such traditional manufacturing industry gives rise to a lack of manpower.

Solutions

- Establishment of data measurement indicator: After all the equipment connectivity has built up, NAFCO implemented preliminary manufacturing data measurement indicator, and then spread and apply other advanced indicators to optimize the manufacturing process.
- Digitalized production and quality control: NAFCO further introduces APS based on the foregoing data indicators to enhanced cross-system and cross-over analysis. And then it has developed its own quality control platform to more immediately control over production line quality.
- Smart control system (the AI tapping machine project): After 2020, NAFCO began to move towards advanced smart control system. With External resource supports and internal R&D development, it has created various AI models and automatic error monitoring methods in order to reduce human errors.

Business Results

- Reduce production and labor cost: Since 2020, NAFCO has completed more than 96% of its machines networking, increasing 7 machines managed by 1 person to 15 machines now, doubling the man-machine ratio and significantly reducing labor demands. Additionally, the tool life has been nearly doubled to produce fasteners from 600 pieces to 1,200 ones.
- Maintain good and stable product quality: So far, the yield rate of manufacturing process remains above 6 Sigma. That means the pass rate of the product is nearly 100%.

- Build a culture of continuous improvement: From the very beginning, there was no dedicated team dealing with digitization. By far, NAFCO has gradually developed into an enterprise with Smart Development Center composed of around 25 members. The Center works on smart manufacturing and maintenance, as well as R&D and manage of data visualization modeling, mining and model analysis. The employees have gradually been equipped with digital thinking patterns thanks to constant innovation and sharing culture, inspiring them to actively come up with digital solutions, attempt to optimize workflows; by now, 2 digital transformation projects have been implemented.
- Provide high-standard services for aerospace customers: Reduce from 33 customer complaints a year to 10; shorten the order delivery date from 74 to 64 days with APS and cross-system analysis applied.

What You'll Learn

- How has NAFCO, as a traditional mid-sized manufacturing company in Asia, successfully overcome its operational difficulties through a step-by-step digital transformation program when it confronts the high quality and international competition in the aerospace industry?
- What key resources and methods have been successfully applied to the concept of digital transformation and data analysis to enable them to internalize such concepts, turning it into long-term enterprise management culture?
- How to improve the machine and equipment's operation efficiency through digital transformation to reduce NAFCO's labor demands in the face of labor shortage challenges?

I. Organization Background

Founded in October 1997, NAFCO has been focusing on technology, optimizing manufacturing processes and committed to providing high-quality fastener products for aerospace and advanced industrial fields. With its production plant located in Taiwan and Shanghai, up to 90% of NAFCO's products are sold worldwide.

As the aerospace fastener manufacturer, NAFCO is different from other industrial manufacturer in the following aspects:

(1) Product characteristics: Heavy capital expenditure, with product manufacturing requiring a number of professional certifications and a long certification period; and pays great attention to product quality and delivery time.

(2) Industrial characteristics: Although the overall industry is not fluctuating, it is not easy to obtain new orders, and each order has a contract lasting at least 3 to 5 years, so it is vital to maintain customer relationships.

(3) Global competition: The aerospace industry faces the global competition, especially in the Asia-Pacific region where Taiwan encounters fiercer competitors. According to PwC's 2021 Global Aerospace Manufacturing Attractiveness Survey, the top five Asia-Pacific countries in terms of overall aerospace manufacturing environment are Singapore, South Korea, Australia, Japan and Taiwan.

II. Impetus for Digital Transformation

1. Products related to flight safety requires the transparency of its information. COVID-19 has accelerated its digitalization process

Different from general manufacturing industry, aerospace customers have high quality requirements. First of all, the manufacturers must pass the AS 9100 aerospace quality management certification. In this regard, it is necessary to pass: the traceability of the entire product life cycle and the controllability of changes in the production process. Besides, for

manufacturing quality, the control over upper-stream production equipment and materials, all suppliers shall be subject to the customer-approved qualification list.

Among all clients, the European customers are the most rigorous, attaching great importance to product details. Not only the detailed product quality traceability, but also the real-time presentation of all traceability data is required to ensure that the products are of quality. Some customer representatives used to be residents in the plant to examine parts and manufacturing status. An entire production process details from the raw material serial number, by whom and on which equipment, to the serial number of all the equipment, etc.; in fact, the entire production process details must be strictly recorded for traceability. Furthermore, affected by the COVID-19, the provision of remote digitalized information reports will become a new norm for enterprise collaboration.

2. Intensifying international market competitions require digitalized process to improve efficiency and reduce cost

Given that the local market demand for high-precision fasteners produced relying on aerospace technology is diseconomies of scale in Taiwan; thus, if Taiwanese manufacturers want to engage in the manufacturing of aerospace fasteners, they must first take the global markets into account; that means, they must stand the test of international markets to survive, which is an extremely challenging for emerging manufacturers.

NAFCO's competitors are long-standing European/American enterprises with sophisticated production capacity and technologies. They have also gradually moved to low-cost countries to set up factories, which can further reduce costs and compete at low prices, in order to improve its price competitiveness. In addition, the Chinese mainland and Indian markets have also joined the competition in recent years, which has also threatened NAFCO's long-term advantage of being the only supplier in Asia-Pacific that has passed the engine manufacturer certification. Facing with the adverse factors, such as threat of

new and old competitors, price-cutting competition and high cost of raw materials, how to utilize digital tools to reduce manufacturing costs, and improve both production efficiency and quality, are the major challenges for NAFCO.

3. The ever-severe lack of labor and talents requires the introduction of automated and user-friendly digital environment

In recent years, NAFCO has pointed out in problem summary that the primary challenge is the shortage of labor, which is a common problem for traditional manufacturing industry. Except that the plants are generally remotely located, the production working environment and occupational injuries are particularly inhibited young people from working there. According to statistics from Taiwan's Ministry of Labor, manufacturing is the industry with the most serious occupational disasters. Taking NAFCO's employees as examples, they have faced the risk of occupational injuries such as heat stroke and being rolled or pinched.

In terms of talent attraction, young people today are less willing to engage in the traditional manufacturing industry with poor working environment and low-level work, resulting in a lack of manpower. Additionally, most of them are less interested in repetitive work, making it difficult for companies to retain long-term talents.

Driven by both the lack of labor and attractiveness of the industry, automation and a friendlier digital production environment become the inevitable trend.

III. Digital Transformation Strategy

1. From standardization to smart automation production

Faced with the market competition of labor shortage, production cost and quality yield rate, NAFCO adopts a step-by-step approach. Firstly, it introduced data indicators and production management model for the management; then, to standardize the connectivity, production, operation and QC process management, interface and parameters. After 2020, NAFCO

began to move forward to an advanced smart automatic control system, mainly for strengthening overall operation and production.

2. Build customer trust through End-to-End information transparency

It's important to build trust between customers in aerospace industry. The foundation of trust lies in the fully transparent information. To establish transparent data structure, NAFCO has invested a lot of efforts to induce digital tools and new ways to collect and present digitalized data, so that these production and quality control information can be presented to customers in real time, on-line and visibly. In this way, the overall customer experience can be improved to win their trust.

3. Establish fact-based performance improvement mechanism to promote corporate digital transformation cultures

Traditionally, employees tend to follow past experience, rather than break through and innovate. To form a culture of sustainable and creativity, NAFCO has established a management mechanism for data-driven decision-making. By detecting more sophisticated AI models and actual data to prove problems as well as establishing data measurement indicators, employees are not only more willing to try and make mistake, but also can clearly identify the attribution of responsibility and countermeasures that lead to waste. NAFCO can better know their own ability level and growth space in the industry.

With the introduction of these fact-based indicators, changes have taken place in the overall corporate cultures from Know What (know the problem) in the past to Know Why and How now (know the root cause of the problem and solve it creatively). The mechanism can predict and reason autonomously based on the past and real-time data, so that it can be used to make decisions and keep improving with the help of human.

IV. Implementation Approaches

For approaches to digital transformation, NAFCO practices Industry 4.0

Maturity indicator with three phases. First is from the connectivity to the production visualization and quality visibility; then, understanding the root cause of problems, and the final comes to more accurate prediction of the future (Predictability) and the ability to automatically respond to issues (Self-optimising).

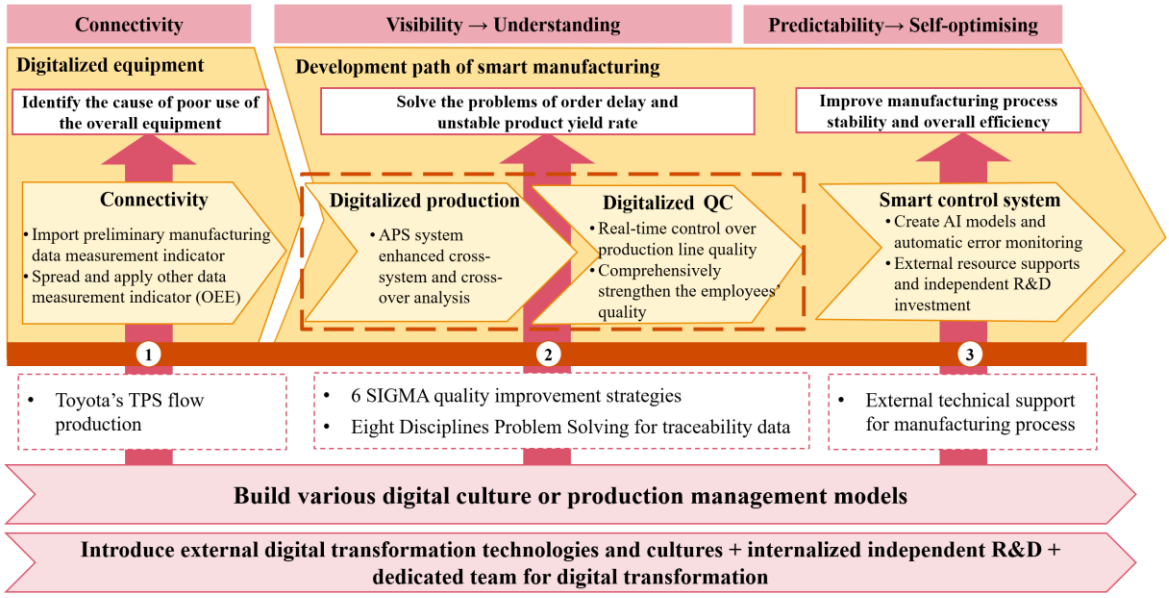


Fig. 1: NAFCO Digital Transformation Blueprint

1. Connectivity and establishment of data measurement indicator

As early as 2017, more than 90% of NAFCO's machines were networked, and as of 2020, the figure reached over 96%. At the initial stage of its computer networking, NAFCO collected a large amount of production data and digitalized the key process parameters of components. Through continuous data collection, collation and metric analysis, it gradually built up the deep-level knowledge related to production technology.

(1) Import preliminary manufacturing data measurement indicator

In the early days of connectivity, NAFCO encountered many obstacles, including the reluctance of machine suppliers to help with the connection, the inability to connect machines that were too old, and the inability to obtain services from the domestic solution providers. In addition, when there is a problem with the machine, European customers will not accept the problem to

stay unsolved for too long even during the Spring Festival. Therefore, NAFCO decided to train its own internal engineers to develop and solve the problem of machine networking by itself.

After the initial connectivity, the team would review the reason for poor utilization rate, such as equipment failure, lack of personnel or improper scheduling. The visualized data dashboards were created so that the specialized personnel could know the status of the machine.

The utilization rate is classified into four colors: green is for full-auto, without manual operation; yellow is for semi-auto, such as tool replacement, loading and unloading or iron scrap removal by specialized personnel; red is for machine failure or error, with reminders always being displayed if not handled; gray is for downtime for repair, maintenance, upgrade or test.

Thus, with these data indicators, NAFCO can further improve/manage the utilization in the plant. In case of poor data obtained, the failure, lack of labor or equipment failure or improper capacity scheduling can be identified. As shown in Figure 2, to solve machine breakdown as displayed in red that lengthens the yellow part of other machines, so prior manpower deployment shall be made. The above information is very helpful for regular review of the reasons behind it.

Fig. 2: Utilization Rate Data Dashboard

(2) Spread and apply other data measurement indicators

The successful initial import of utilization rate helps NAFCO to spread and refine the digital culture; also, calculate the Overall Equipment Effectiveness (OEE) in the next step. OEE includes actual availability rate, performance rate of each unit of production as well as quality rate. By leveraging OEE management, NAFCO can grasp the waste of equipment breakdown, equipment performance and defective production.

However, the indicators established can facilitate to clearly identify who wastes resources and formulate countermeasures. More importantly, NAFCO can accurately know its maturity level in the industry and the gap to be improved. For example, the OEE value of an industry-leading enterprise is 75-80%, which still a goal must be achieved by NAFCO. Or the utilization rate is only around 50-60%, performance rate is lower than 70% or yield rate is lower than 97%, it probably means that the production line can be further improved or the manufacturing process can be optimized more.

With the above data indicators, the monthly review is conducted to preliminarily know its own abilities and further think about how to improve the efficiency of resource utilization and meet customers' expectations. With the data, NAFCO can also know how to allocate resources when customers place orders. By now, its OEE has increased from 45% to more than 55%.

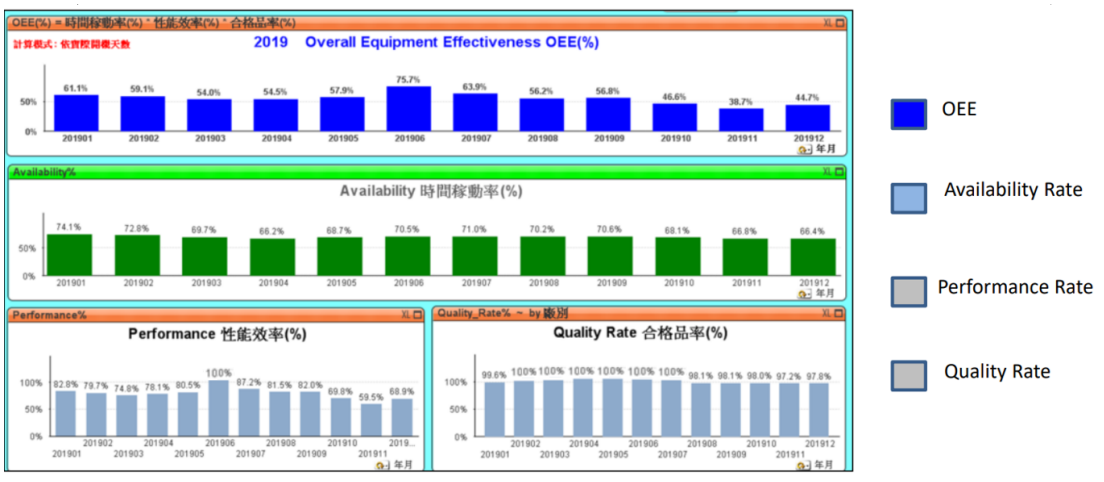


Fig. 3: OEE Data Dashboard

2. Digitalized production

NAFCO further introduces Advanced Planning & Scheduling System based on the foregoing data indicators. With the system, all production data, such as utilization rate and product cycle time can be used to predict the time taking to complete tasks, and understand the feasible order delivery date.

(1) APS system imports enhanced cross-system and cross-over analysis

The old Planning & Scheduling System of NAFCO failed to consider the capacity constrain, resulting to the machine's overload. In view of this, NAFCO implements APS to integrate the constrains and requirements of capacity, material, machine and production line change. The combination of different parameters, such as On-time Delivery (OTD) commitment, Work in Process (WIP) status, main parts supply situation, etc., to achieve the best capacity.

NAFCO then estimated how many works orders the product will have in the green sign? or the batches of goods will be postponed if it delays for 2, 4 or 7 days (as shown in Fig. 4).

With such a simulation system, it's clear how many products will be produced in a day; and reckon the gap between the output predicted by APS system and actual output produced by the machines. Such information will be displayed on the dashboard of production lines to help production line operators to adjust production planning in real time, in order to set reasonable target output. The field supervisors can also know which machine is not running smoothly. They can turn to other machines for help to prevent task delay (as shown in Fig. 5).

In addition to this, the cross-over analysis of APS and connectivity can also be applied to detect and control status of works in process. When the production line is under supply shortage, the inventory of work-in-progress will often increase. However, the more work-in-progress waiting to be produced, the

more complex to control the production, and the more time it takes to collect and find the materials, thereby prolonging product manufacturing cycle, increasing inventory management costs and reducing the company's capital liquidity.

Therefore, the processing capacity of bottleneck workstations can be estimated by the APS in order to improve the machine utilization and reduce the work-in-progress product quantity optimally; thereby, properly balancing the pace between feeding and production plans. What's more, NAFCO further promotes Toyota Production System (TPS) to establish flow production and optimize the production process. Working with APS, production connectivity and integrated production scheduling, ultimately reduced the invisible waste during the production process, and improved the company's production capacity and efficiency.

Fig. 4: Dashboard of Comparisons between OTD and APS

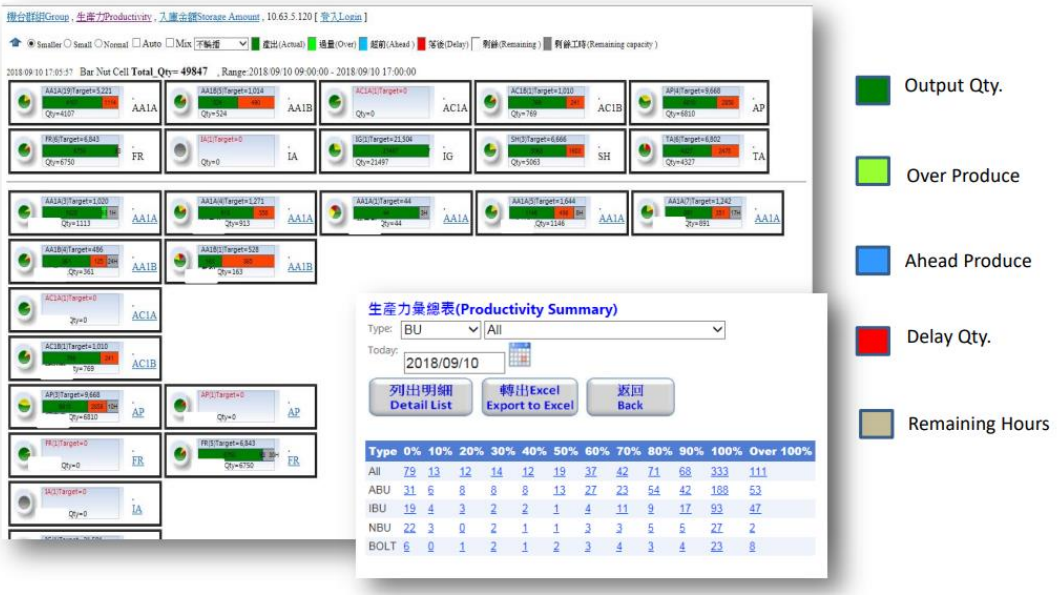


Fig. 5: Capacity Target Monitoring Dashboard

3. Digitalized QC

Supported by its internal R&D personnel, NAFCO has developed Product Defect Control (PDC) system to detect the defective products. The data control concept of Statistical Process Control (SPC) is introduced to facilitate the real-time monitoring of manufacturing quality of managers. Besides, through the regular reviews work order error on PDC and cross-analysis with the HR system, NADCO can also ensure that the production line has sufficient and high-quality manpower.

(1) Real-time control over production line quality

PDC can detect the work orders under exceptions. In case that there is quality exception or task delay, PDC will then send out corresponding sign to the customers, plants or suppliers, reminding employees to timely deal with the defective products or adjust production plans based on the delayed tasks. The field operators can use the system to check the basic information of product and work orders to confirm the operation situation of production line.

Integrated with SPC, PDC is divided into levels of field operator, manager, executive as well as finance, so that managers of different levels can

understand the real-time status of production process flaws. SPC includes 6 SIGMA of strategies and methods for quality improvement.

In NAFCO, if the PDC panel appears red sign, it means that the number of Sigma may be less than one, indicating the most unstable process level. NAFCO currently maintains more than 6 Sigma, suggesting that the quality rate of product is almost 100%, higher than general requirements for product quality of manufacturing industry.

NAFCO can perform better on SPC with two functions based on the establishment of machine connectivity. The first is real-time monitoring. Thanks to smart networking, the inspection data of each product can be presented on the dashboard in real time so that operators can refer to it for debugging timely. For example, during the product production process, the operator can view the upper and lower limits as specified on the dashboard. If the value deviates too much from the center value, real-time correction can be made to maintain the product in the best range to maintain a certain quality level. The second is to serve as reference for monthly or weekly review, mainly for counting the Process Capacity Indicator (CPK), identifying the CPK value of particular difference, and paying special attention or improving the problem of the process.

Fig. 6: Cross-system Analysis of PDC and SPC

(2) Comprehensively strengthen the employees' quality

Based on Eight Disciplines Problem Solving method (8D), PDC records historical abnormal work orders so that NAFCO can trace them. PDC will display the details of abnormal work orders, including when, where, what, severity, root cause of incident, corresponding emergency response and subsequent preventive measures, etc. (as shown in Fig.7).

Therefore, NAFCO learned lessons from the data to enhance education and training on the production lines. NAFCO used to make written record on paper, which is not informative enough to analyze. After implementing the PDC, the detailed related materials and data can be presented before morning meeting, to remind employees to take this as a lesson and avoid making similar mistakes. In fact, continuous improvement is an ongoing effort to improve the competitiveness of an organization.

After the quality control system has been established, NAFCO finds that the key to the smooth operation of production line lies in enough manpower. In view of this, NAFCO also integrates the system with personnel attendance system, from which, it can know the attendance of employees timelier to

facilitate the manpower scheduling of production line supervisor. In case of absence, an alarm indicating how many people are missing from a production line, the scheduling of staff and the personnel who can be dispatched in real time (as shown in Fig. 8).

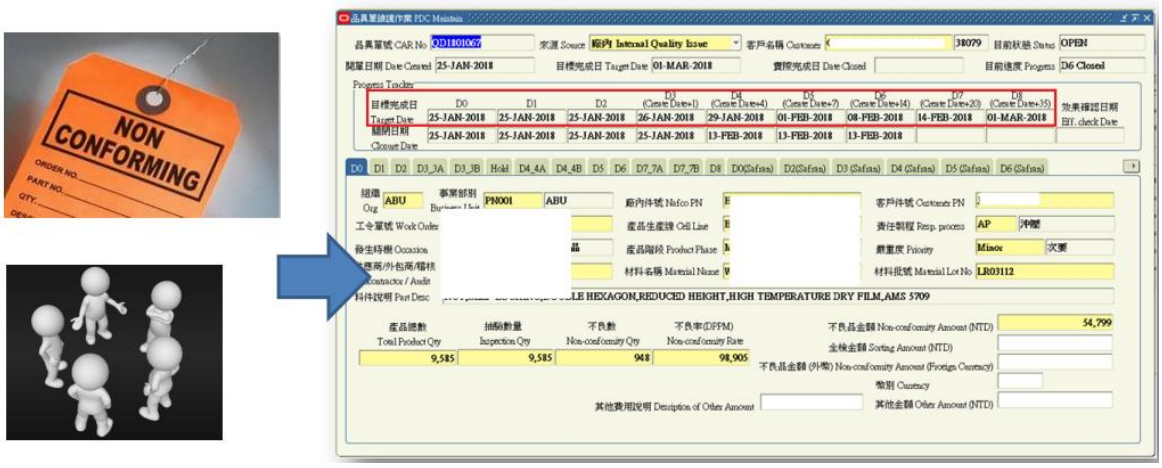
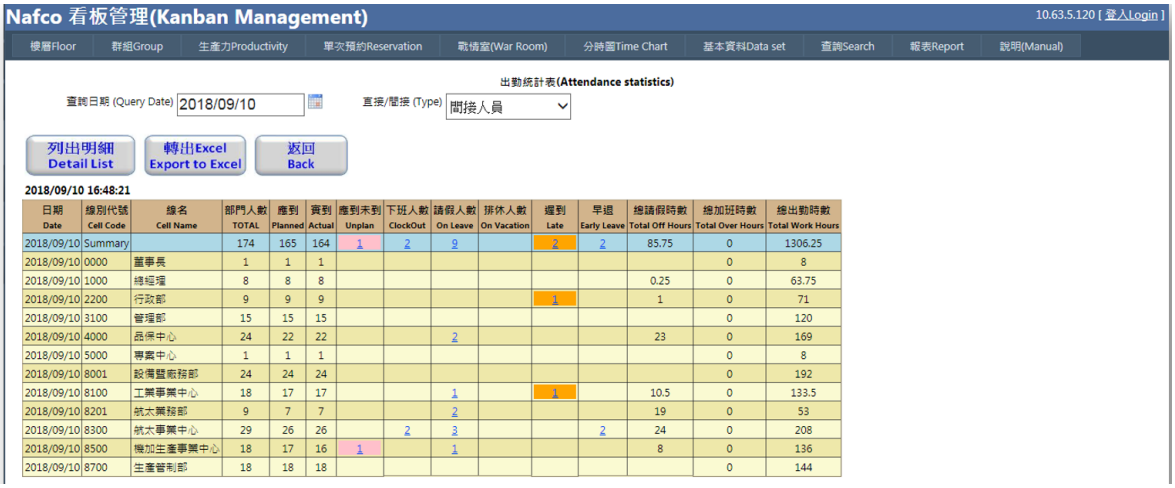


Fig. 7: 8D Recorded Data on PDC



日期 Date	線別代號 Cell Code	線名 Cell Name	部門人數 TOTAL	應到 Planned	實到 Actual	應到未到 Unplan	下班人數 ClockOut	請假人數 On Leave	排休人數 On Vacation	遲到 Late	早退 Early Leave	總請假時數 Total Off Hours	總加班時數 Total Over Hours	總出勤時數 Total Work Hours
2018/09/10	Summary		174	165	164	1	2	9		2	2	85.75	0	1306.25
2018/09/10	0000	董事長	1	1	1								0	8
2018/09/10	1000	總經理	8	8	8							0.25	0	63.75
2018/09/10	2200	行政部	9	9	9					1		1	0	71
2018/09/10	3100	管理部	15	15	15								0	120
2018/09/10	4000	品保中心	24	22	22			2				23	0	169
2018/09/10	5000	專案中心	1	1	1								0	8
2018/09/10	8001	設備整廠籌部	24	24	24								0	192
2018/09/10	8100	工業事業中心	18	17	17			1		1		10.5	0	133.5
2018/09/10	8201	航太籌備部	9	7	7			2				19	0	53
2018/09/10	8300	航太事業中心	29	26	26		2	3			2	24	0	208
2018/09/10	8500	機加生產事業中心	18	17	16	1		1				8	0	136
2018/09/10	8700	生產管制部	18	18	18								0	144

Fig. 8: Personnel Attendance Statistics

4. Smart control system: AI tapping machine project

After 2020, NAFCO began to move towards advanced smart control system, mainly by cooperating with external enterprises (NAFCO's major shareholders) in process parameter control and digital transformation experience inheritance.

(1) Create AI model and automatic error monitoring

The first project is to introduce tapping machine of artificial intelligence, staring with extracting the signals and data from the preset sensors, servers and digital dashboards. Then, parameters, such as speed, material, location, tool life and load status for each motor are set. In this way, relevant algorithms can be developed and the green line model chart for normal status can be set. However, in practical operation, the tapping machine will display blue line for real-time operation analysis and comparison to judge the status of production, thereby facilitating the staff to figure out the reason for machine failure and future traceability (as shown in Fig. 9).

For the parameter judgment and AI model establishment, it took 2 years to standardize parameters of process and train machine learning and modeling. As well as analyze the reasons for exceptions, including the motor not working well, tool collapse, short tool life, product materials mixed or machine idling, loose nut etc., thereby gradually developing technology of automatically monitoring human errors.

(2) External resource supports and independent R&D investment

It took a lot of work for NAFCO to uncover the reason and research on how to turn these problems into data signals and waveform. For example, NAFCO turned to professional statisticians and data scientists from external enterprises for help, with collecting the electronic signals and build a preliminary model. However, the actual operation of the advanced model construction depends entirely on NAFCO's own research and development, and it is also one of the most laborious processes of digital transformation for them.

Firstly, at least one engineer should be on duty when each machine is in operation to observe and set the input. Problems and values such as broken tools or insufficient cutting force should be recorded. There will be various models for each machine, with a typical tapping model accumulating about 8,000 samples. Then, the best model should be researched and developed, the

parameters of materials characteristics, dimensions and speed should be standardized; finally, the model will be customized for each machine. The machine should be adjusted one by one due to different characteristics.

It took two years for on-site research, which is an important process for NAFCO to embark on a real smart journey. Now that NAFCO has identified the problem to be corrected, it can avoid it in the subsequent designs. For example, if it turns out to be a matter of machine, material or tool, it can set up SOP after reviewing and figuring out the problem, thereby generating benefits by reducing tool cost, cutting down manpower cost, improving utilization rate, enhancing management function or improving productivity. In terms of knowledge management, faced with the shortage of senior employees who can inherit knowledge, NAFCO visualizes signal analysis and other machine data with this AI project, so that new employees can better get started and further optimize the efficiency of plant.

As for actual cost effectiveness, the tool life is doubled from producing 600 fasteners to 1,200 ones thanks to more accurate data model analysis. Traditionally, the engineers used to follow the predefined tool life provided by the supplier or their past experience of the tooling lifespan. When 600 fasteners are tapped, the tooling blade will definitely be replaced to avoid being held accountable when things go wrong. Now that there have been AI model with more accurate detection to monitor, problems will be detected and tool life will be estimated. With actual supporting data, engineers are more willing to try and make mistakes. Extending tool life brings invisible savings.

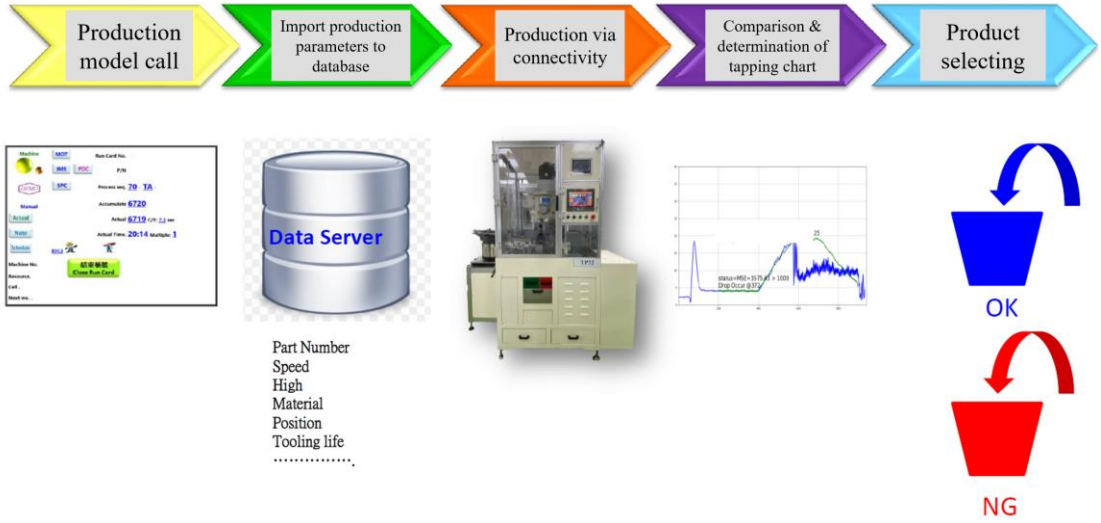


Fig. 9: Structure of AI Implemented to Traditional Tapping Machine

Items	Past	Now
Reduced labor cost	• Man-machine ratio of 1:7 • Field inspection required to identify anomalies	• Man-machine ratio of 1:15 • The machine self-diagnoses and reports abnormality, and also informs the personnel to deal with it.
Enhanced utilization rate	• The machine cannot produce due to breakdown, requiring troubleshooting	• Error data directly collected by the system and provided for manager for analysis • The machine produces while automatically judging and selecting OK and NG products
Improved productivity	• Distorted utilization rate occurs when personnel keys it in	• Utilization rate calculated directly based on machine conditions

	the system • It takes long time to troubleshoot, influencing the utilization rate and reducing the productivity of the machine	• Troubleshooting can be timely made in case of warning prompts
Strengthened management function	• Risk of material mixing and appearance damage in the machine offline production quality inspection	• Online quality inspection realized with system database • Process monitoring, record process parameters and generate production reports

Table 1: Comparison Table before and after AI Is Implemented to the Tapping Machine

V. How to Measure Digital Transformation Benefits?

The aerospace industry has high standards for product quality and traceability, and NAFCO needs to ensure that the functions and materials of products meet customers' demands of high quality. Thus, the digital transformation is ambitious to digitally master the whole production process, assist in production with data analysis and model, thereby achieving customers' goal of high-quality aerospace products.

Through the gradual introduction of digital tools, models and methods, it brings digital transformation benefits in three aspects: operation management, corporate culture and customer relationship.

Risks	Descriptions
Operation Management	• The connectivity can effectively reduce the cost due to improper scheduling and monitor the yield rate. With visualized data dashboard, the specialized personnel can allocate machine and labor more accurately; the PDC and SPC are also used for quality management, reaching a level of 6 SIGMA. Overall, these digital management systems enable NAFCO to balance manufacturing costs with product quality and increase market competitiveness. • The AI tapping machine has realized automated process, which not only increases process stability, but also doubles the human efficiency, increasing from one person managing 7 machines to 15 ones; thus, dramatically decreasing labor needs and alleviating labor shortage.
Corporate Culture	• Integrated the financial data and software management cultures of external cooperative enterprises into NAFCO, which led NAFCO's employees to intensively review the connectivity system in the initial stage; thus, promoting the development of data analysis department. • Not only integrates the external company's financial data and software management culture into NAFCO, but also leads its employees to intensively develop various systems in the early stage of digitalization, it finally brings benefits to build up the data analysis team. By now, NAFCO has established a smart development center composed of 25 persons. Subsequently, NAFCO brought in data science experts to assist in the development of the AI tapping machine project. Under the influence of external resources and

	internal continuous independent research and development, data-driven thinking has been deeply rooted in NAFCO, which has brough the benefit of enhancing the overall digital capabilities of all staff. By far, two digital transformation projects have been implemented and rolled out.
Customer Relationship	• With APS, NAFCO can preliminarily estimate the order delivery date, not only satisfying customer's goals, but also providing production data of process in real time to ensure the quality and shorten the delivery date from 74 to 64 days. • In case of customer complaints, NAFCO can immediately identify the cause with the system; for example, interpreting the current waveform chart of process with AI tapping machine to know the root cause of the product and amend it. Thus, meeting the stringent requirements of aerospace customers for product quality. In this way, the customer complaints are reduced from 33 cases per year to 10 now.

Table 2: Measurement of Digital Transformation Benefits

VI. Critical Success Factors

1. Encourage employees to develop core technical skills

NAFCO has its own way to deal with the overwhelming obstacles by investing manpower in technology research and development in order to cultivate them with core technical capabilities. Employees are required to explore and grasp from the basic connectivity technology to AI model establishment and training; as well as, production management and introduction of digitalized model and methods, all need to be researched and mastered by themself. Only if employees can master these core technologies, they will not be controlled by others. When facing emergencies in the future or continuous improvement is required, employees can tackle them more quickly and flexibly.

2. Have clear and transparent data-driven goals

Every digital transformation project invested should have clear data indicators, through which you can quickly measure whether the enterprise's investment and its own input are relatively proportional to its output. Take NAFCO as an example, the internal assessment of investment benefits should be made with these data indicators before the budget is spent. Moreover, the measurable and transparent common goals also effectively assist NAFCO in promoting cross-departmental digital transformation projects, help with the closer partnership of all departments to generate good values and results.

3. Accelerate digital transformation and reduce risk through external experts

To accelerate digital transformation and reduce learning cost, NAFCO introduced software know-hows and experts from external resources. For example, it brought in the financial analysis cultures: evaluating investment benefits before spending the budget, requiring the visualized production data of production lines. Also, through regular and intensive review of production status and counseling by retired consultants, it has become the key to successfully boost morale and willingness of digital transformation among departments. It can be seen that NAFCO has shorten the long journey of self-exploration by following and learning the external digitization and management culture.

VII. Lessons Learned

To sum up, NAFCO takes two key steps to create new values. Firstly, NAFCO has changed the distinct Patriarchal Leadership style of traditional enterprises. Instead, by introducing various data indicators and management models, NAFCO gives employees the opportunity to automatically find out problems from data, develop the best solutions, participate in innovation and make contributions. At the same time, the daily morning meeting not only enables the staff of each production line to reflect the real situation at the front line, but also enables the senior management to understand and solve problems

more clearly, linking the organization from the bottom to the top.

The second is to make your organization outcome-oriented and formulate strategies based on data. In digital transformation, employees are prone to muddle through their work. NAFCO, however, subverts the traditional way of working independently, so that employees can make concerted effort by creating dedicated departments and teams for digital transformation projects to bring IT, data analytics, and engineering people from their original departments into one team. Retired consultants and data scientists are also hired to help employees make the transition through the established management culture, digital systems and data metrics.

For NAFCO, digital transformation is not a one-time project but a long journey to go. Looking back on its digital transformation, NAFCO not only imported external data analysis and management culture, but also created an environment for internal leaders and employees can work together to develop new technologies, and internalize them into their own digital transformation culture; even attempts to grasp customers' demands to satisfy the high-standard service needs of them. Chief Intellectual officer Li, Chia-Chu concluded "NAFCO's digital transformation aims to anticipate what events are likely to occur in the production process, and to be able to manage them. Through the extracted data to analyze and simulate the application situation, it will help us solve the problems we encountered, and finally ensure that all the functions and materials of the product meet the needs of customers." This is the best interpretation.