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CASE STUDY ON MODERNIZATION TRANSFORMATION AND PERFORMANCE IMPROVEMENT OF PAPER PRINTING INDUSTRY

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ABSTRACT

After the COVID-19 pandemic, global economic growth slowed down in 2022. Although Taiwan was affected, its competitiveness remained strong. According to data from the Ministry of Economic Affairs, there are more than 1.63 million small and medium-sized enterprises in Taiwan, accounting for more than 98% of all enterprises, a record high; the number of employees in small and medium-sized enterprises is 9.132 million, accounting for 80% of the national employment, and its sales exceed 28 trillion NTD, accounting for more than 50%, and the export volume is 3.6 trillion NTD, with an annual growth rate of more than 7%, showing the importance of small and medium-sized enterprises in Taiwan's economic development. Since 2021, many industries have been crying out for a shortage of workers. Taiwan's low birth rate is severe, and the COVID-19 epidemic has also led to a serious shortage of workers in various industries. It is a common problem for traditional industries to "not find people". Taiwan's economic growth momentum is mainly concentrated in the manufacturing industry, among which "semiconductors" and "information electronics" are the main foundations. The country's tax revenue mostly relies on "export trade", and the manufacturing industry naturally becomes an important source of financial income. Today, traditional industries are facing high costs of land, labor, water and electricity, and raw materials, which have resulted in insufficient growth momentum and stagnation. Coupled with the reciprocal tariffs implemented by the United States in 2025, Taiwan's traditional industries are facing even more severe challenges to survival. How traditional industries should apply modern technology to transformation is the most important issue at present. How to find opportunities through R&D innovation, and then promote corporate culture transformation, technological innovation and guide new smart skills to apply sustainable manufacturing (also known as green production). Promoting the integration of traditional industries with innovative industries, reducing negative impacts on the environment and carbon emissions, and saving energy are currently important issues.

Keywords: *Modernization transformation, Performance improvement, Green production, Paper printing factory.*

1. INTRODUCTION

Manufacturing is the foundation of a country, so the United States is also willing to use tariffs to force various industries to return to the United States. In 2022, the COVID-19 epidemic continues to impact Taiwan's industry and economy, and even affects domestic labor market. Traditional industries have always been classified as "labor-intensive manufacturing industries." In general, the basic form of manufacturing is highly labor-intensive industry, and its business model is to maintain market competitiveness by "low cost, price-cutting competition for orders." This is also the beginning of a vicious cycle.

The present study mainly investigation the long-term labor shortage and talent loss in traditional industries, which in turn affect the company's production capacity and quality. In addition to the fundamentals, companies need additional added value to operate sustainably, and continuously inject new forces and self-growth to enhance their competitiveness, so that traditional industries are no longer what people call "traditional industries", but industries that can keep pace with the technology industry.

For the manufacturing industry, on-site personnel and production lines are the main body of the enterprise and the source of profit. They are related to the product yield and performance. In the face of fierce competition and meager profits, improving productivity and product competitiveness is the main control direction. The general impression of the working environment in the manufacturing industry is mostly "hard, dirty, and dangerous". The serious labor shortage here is undoubtedly worse. The emergence of new technologies has forced companies to make changes, but transformation is the only way out.

Companies should build a friendly workplace environment, identify employees' needs, provide stable jobs, and allow employees to have stable work performance, thereby increasing relative compensation. This is also one of the social responsibilities of business owners. Actively improve and simplify the process, and through the update of high-performance machinery and equipment, simplify the process, streamline manpower, increase production capacity, and eliminate unnecessary costs. Increasing yield means high profits. In addition, all raw materials used in automation are EU certified and are environmentally friendly. It meets the requirements of the brand and society, and we hope that the company can approach the goal of "net zero emissions" before 2050.

Based on the above international trends, policy trends and employment. The case company of present study hopes to achieve the following purposes:

1) Reducing human intervention and improving the process, the production speed of the precision printer can be increased to 3000 meter/hr.
2) In terms of electricity, the machines are improved year by year and replaced with 380 V high-voltage power supplies to save energy.
3) Gross profit margin will increase by more than 5% compared to the current level.
4) Transformation to a green production factory.

2. RESEARCH METHOD

Modernization of Traditional Industries

Driving Factors for the Modernization of Traditional Industries
Traditional industries that created economic miracles for Taiwan during the past decades have always been technology-oriented, believing that they are not afraid of not having orders if they have technology. In recent years, the global economy is still facing many uncertainties, including the ongoing war between Ukraine and Russia, the US tariff issue, and high inflation. Whether it is rising costs, geopolitical conflicts, net zero carbon reduction before 2050, or extreme climate issues, traditional industries have been hit hard. Whether traditional industries should transform or not is no longer a question to be considered, but a must.

However, with the continuous advancement of technology, the increase in resource circulation and the transparency of online information, the advantages of traditional industries in Taiwan is no longer exist. Faced with the increasing pressure of sustainable operation and second-generation succession, companies want to survive and break through the vicious cycle of low-price competition to avoid the phenomenon of bad money driving out good money. Only through the transformation and reform of traditional industries can their own strengths be fully demonstrated.

Challenges and Solutions in the Modernization of Traditional Industries
The environment faced by enterprises is changing rapidly and there are too many uncertain factors. What you can control is yourself, and you can only solve your own problems by yourself. Organizations need to have immediate, rapid and agile response capabilities to cope with external changes at any time. However, most employees are reluctant to learn new things. We need to change the mindset of the employees and make them understand that the introduction of new systems or machinery and equipment is not to replace anyone or cause trouble for anyone, but to improve work efficiency, product yield and maximize profits.

Lean Management

Currently, most manufacturing companies are faced with problems such as excessive data consumption, high costs, frequent labor shortages, and low product added value. The management philosophy and practice proposed by Toyota and the TPS lean management production method have gradually become the most suitable production management method for modern manufacturing (Lawal & Elegunde, 2020).

Intriduction of Lean Management
Lean management (LM), also known as lean production, originated from Toyota Production System (TPS). It represents a systematic production method that aims to reduce unnecessary waste in the production process. Its core is to create value with the least amount of work and get twice the result with half the effort.

The core spirit of LM is to speed up the process, reduce waste, save costs, improve efficiency, improve quality, and reduce inventory. Although TPS reduces costs and shortens delivery time, it also improves product quality.

LM includes three aspects, five principles (Table 1), and eight wastes (Table 2).

1) Three aspects of the LM: We all know that "profit = price - cost". In traditional cost thinking, the selling price is determined by the company, while the cost is not easy to control. However, under the operation of the free price mechanism, the price is actually determined by both buyers and sellers and will rise and fall with demand. Therefore, LM thinking takes a different thinking direction from traditional cost thinking, setting the market customers to have the right to decide the selling price, while the cost can be controlled and can be reduced through lean management. Therefore, how companies can reduce costs in the production process has become the three main aspects of lean management application, including "quality improvement", "accelerated process" and "improved capital investment".

2) Five principles of LM: Table 1 shows the five principles of lm, which includes: value, value stream, flow, pull system, and perfection.

Table 1. The five principles of LM

1. Determine value (Value): From the customer's perspective, clarify the value of the product or service, and carry out all activities around creating this value.
2. Master the value stream (Value Stream): Analyze the entire product or service process, identify which activities truly create value and which are waste, and start to eliminate waste.
3. Smooth flow (Flow): Ensure that the activities in the value stream can flow smoothly, eliminate bottlenecks and unnecessary delays, so that products or services can be delivered to customers quickly and effectively.
4. Pull management (Pull): According to customer needs, establish a "pull" production or service system. That is, only when customers have needs, start production or provide services, avoid overproduction and inventory backlogs.
5. Pursue perfection (Perfection): Lean management is a process of continuous improvement. Enterprises should constantly pursue excellence, eliminate waste, improve efficiency, and ultimately achieve perfection through continuous improvement and optimization.

3) Eight wastes of LM: Table 2 shows the eight wastes of LM, which includes: overproduction, waiting, transportation, defects, inventory, motion, processing, and underutilization of employees.

Table 2. The eight wastes of LM

1. Overproduction: Production exceeds actual demand or is produced ahead of schedule, resulting in inventory backlog and waste.
2. Waiting: Stagnation of personnel, equipment or materials in the production process due to waiting, such as waiting for the machine to be completed or waiting for parts to be delivered.
3. Transportation: Unnecessary movement of materials or products within the factory increases transportation time and cost.
4. Defects: Products that do not meet specifications are produced and need to be reworked or scrapped, resulting in waste.
5. Inventory: Excessive raw materials, work-in-progress or finished products take up space and funds and increase storage costs.
6. Motion: Unnecessary movement of operators or equipment, such as unnecessary bending, reaching, etc.
7. Processing: Unnecessary processing of products, such as excessive processing, repeated processing, etc.
8. Underutilization of Employees: Failure to fully utilize employees' knowledge, skills and creativity leads to a waste of their talents and potential.

LM and Enterprise Performance

LM requires thinking and sorting by product and delivery date to determine whether the delivery date will be delayed. If the delivery date is confirmed one by one, it will not happen easily, and the inventory of raw materials, semi-finished products or finished products will soar. Destocking is an extremely difficult process. LM helps enterprises increase their operating performance by eliminating waste, improving manufacturing processes and improving quality.

Challenges of LM

LM requires employees to "work" rather than just "action". First of all, employees should be made aware that they are also a cost. Talent training and reserve have always been the focus of enterprises to retain talents. The rise and fall of all enterprises are inseparable from people. Eliminating all unnecessary waste is to create maximum profits. If there is an unequal way of thinking between business owners and employees, there will be a waste of manpower in the organization.

To change the employees' mindset, employees must first change their "habits". Wasteful thoughts and actions are always hidden by habit. Each employees must always think that do I

always think about whether each action and process is correct? How can I be better and more streamlined to keep improving thoughts and actions in rotation? Whether it is manufacturing or service industry, good or bad management is often the key to winning or losing.

Production Automation

The manufacturing industry is facing increasing demands to rapidly adapt to new products, often requiring the construction of new facilities or the modification of current ones. To meet these challenges efficiently, it is essential to automate engineering processes that are traditionally carried out by hand (Lastra & Delamer, 2009).

Traditional manufacturing mainly relies on "manpower" for production. Factors such as labor shortage and talent exodus have caused problems such as labor shortage and the inability to pass on the experience of old masters. In addition, the market changes too quickly, and the trend of factory automation is becoming increasingly popular. Many companies hope to replace manpower with smart mechanical equipment to reduce costs, perform more dangerous and repetitive work, improve production line efficiency, increase product yield, standardize products, reduce costs, reduce inventory, and ensure quality consistency. Introducing automated production allows companies to keep pace with the market and maintain competitiveness.

Production automation refers to the use of automatic device system software, integrating scientific and technological technologies and mechanical equipment, etc., under the condition of reducing human operation, so that products can be manufactured automatically, or partially processed automatically, and the manufacturing capabilities of personnel can be improved, and personnel can be prevented from performing dangerous operations. Therefore, it is suitable for application in many industries with highly repetitive operations.

Green Production

The term “Green” carries a wide range of emotional and interpretive meanings, particularly when considered in the realm of manufacturing. For some, it is closely aligned with established notions like industrial sustainability, while for others, it resonates more with ideas such as ethical production and fair trade. This ambiguity can pose challenges for industry professionals and researchers--especially those rooted in conventional production methodologies—as they attempt to understand and incorporate these ideas into manufacturing practices (Baines et al., 2012).

Green supply chain management has become a hot topic in recent years. For some companies, adopting green supply chain management can demonstrate the company's determination to operate sustainably (Bacallan, 2000).

Green production strategies can play a pivotal role to meet the global demand without compromising environmental integrity and human health (Kaswan et al., 2019).

Green Energy
Green energy, often referred to as renewable or clean energy, is considered environmentally sustainable due to its minimal greenhouse gas emissions. It harnesses natural processes to produce a continuous and virtually inexhaustible energy supply. Simply put, green energy

refers to sources of power that do not contribute to environmental pollution (Serrano & Zaveri, 2020).

The case comapny installed rooftop solar panels - green energy rooftop photovoltaics in 2019 when the government promoted solar photovoltaics (Figure 1).

Figure 1. The rooftop solar panels of case company

Green Purchasing

Green purchasing refers to a more strategic and environmentally conscious approach to procurement. It aims to improve the efficiency of acquiring products and services while minimizing environmental harm. This method involves choosing alternatives that serve the same purpose as conventional options but have a significantly lower CO_2 emission (Slastanova et al., 2021).

The Energy Administration of the Ministry of Economic Affairs recently revised the date on 2023/09/08, and classified environmental protection products into three categories, which are included in the designated green procurement items as follows:

1) Those that have obtained the use permit of the environmental protection mark recognized by the Ministry of Environment, Executive Yuan, and those that have obtained the use permit of foreign environmental protection marks that have reached a mutual recognition agreement with Taiwan.
2) Products that are not included in the environmental protection mark product items announced by the Ministry of Environment, but are recognized by the Ministry of Environment as meeting the conditions of recycled materials, recyclable, low pollution or energy saving, and are issued with certification documents.

3) Products that are recognized by the relevant target industry competent authorities as meeting the requirements of "increasing social benefits or reducing social costs" and are issued with certification documents.

Therefore, the case company replaced the traditional oil-based ink with organic, non-toxic and water-based ink.

Figure 2. The organic, non-toxic and water-based ink

Green Transportation

The sustainability of transportation networks plays a crucial role in the process of urbanisation, as seen in the escalating air pollution challenges faced by many large cities. Although population growth and migration are difficult to regulate, the increasing reliance on both public and private vehicles has significantly harmed the global environment. As a result, future development of transportation infrastructure must be approached with careful planning to support environmental sustainability—commonly referred to as green or sustainable transportation (Shah et al., 2021).

The forklifts, hand-pull auxiliary tools, lifts, and paper clamps used in the case company are all rechargeable new equipment. When in use, they do not emit harmful exhaust gases such as hydrocarbons and carbon monoxide, and they are low-noise, greatly reducing the impact on the environment and ecology. Since pure electric vehicles are powered by batteries, and electric vehicles do not have internal combustion engines, fuel systems, exhaust systems, and ignition devices, their structures are simpler than fuel vehicles, so the maintenance cost is cheaper than fuel vehicles; plus the electricity price is much lower than the oil price, and it is easy to maintain.

3. RESULTS AND DISCUSSIONS

Printing Industry Classification

Traditional Intaglio Printing

The technology of transferring the pattern or text on the original manuscript to the printed object by using intaglio or other methods. Traditional printing requires color plates to be separated according to the pattern, and each color needs to be engraved on an independent plate cylinder. The production of the plate copper needs to be electroplated with copper and then

chrome-plated, and then placed on the printing press by the printing master in sequence. The ink color is mixed with the four primary colors of red, yellow, blue and black to form various colors. The overall color depth and concentration are mainly determined by the color master.

Digital Inkjet Printing
Digital printing uses computer inkjet printing, just like the principle of large-scale photocopiers, to quickly print graphic information directly from the computer. Simply put, digital printing is a new printing method that is different from traditional printing, where electronic files are directly imaged on the printing medium - paper or film. Digital printing uses cyan, magenta, yellow, and black, commonly known as cyan, yellow, magenta, and black (CMYK), to blend colors.

Digital printing is a new printing method that is different from traditional printing, where electronic files are directly imaged on the printing medium - paper or film. Digital printing has advantages over traditional printing because it does not require complicated plate-making processes and is free of color and material restrictions. In order to comply with the "sustainable consumption and production model" in SDGs, "plant dyeing" has also emerged in the traditional printing industry to reduce damage to the environment.

Dilemma Facing of the Printing Industry

In recent years, in response to market volatility and the wave of global digital transformation, traditional printing has also faced the pressure of transformation. The original mass production printing has gradually changed to small-quantity and diversified printing. The high cost and long printing time of traditional plate making have also been gradually replaced by digital printing as customers expect instant pickup, which has impacted the business model of the traditional printing industry.

Next, the energy consumed in the printing process is also a big problem, especially in some more traditional printing methods. High energy consumption is equivalent to a larger CO_2 emission, which is undoubtedly a big burden for the global climate change problem. In the past, companies only cared about the cost and output efficiency. While pursuing technological progress and quality improvement, the printing industry must also face up to the pollution it brings to the environment and actively find solutions. If we talk about environmental protection, it is undoubtedly a heavy cost increase.

There are 3,147 printing companies in Taiwan. Most of the printing company in Taiwan is small and medium-sized. However, traditional printing technology and processes cannot keep up with the changes in the overall environment. With the continuous development of information and digital technology and the rise of environmental awareness, the increase in costs is the biggest consideration for owners.

Case Company Profile

Case company is a small and medium-sized enterprise, belonging to the textile printing industry. It was established in 2011, about 14 years ago. At the beginning of its establishment, the company had only one production line, which was gradually expanded to four production lines due to increased demand. The current number of employees is about 36. The case study company is engaged in the textile paper printing manufacturing industry, specializing in original equipment manufacturer (OEM) for various sports brands, and is a member of the

textile supply chain. There are four traditional machines, 15 high-speed inkjet printers, and one ultra-high-speed inkjet printer.

The best way for a company to develop sustainably is to learn from, draw lessons from, and emulate excellent companies. This allows you to turn around brilliantly and not miss opportunities at critical turning points. However, innovation is the only way out. The operator hopes to manage the company through innovative ideas and also wants to convey innovative thinking to every employee. Even if it is just a small screw, it is indispensable.

The managers of the cases company have a strong desire to introduce new equipment, extended innovation or breakthrough innovation. From the traditional ink process to the current computer digital printing technology, there is no precedent to follow. We slowly build up step by step without over-relying on the needs of existing customers.

Never over-estimate the investment benefits and eat up the original profits. After all, investing in new products is inherently risky. Make bold assumptions, carefully verify, constantly experiment, and verify, set risk control within the range that the company can bear, and replace the old self with your own.

Case company adopts both "preventive maintenance" and "periodic maintenance" for machine maintenance. Because 80% of the machines are imported, spare parts must also be included. The inspection forms have the function of risk control in addition to inspection.

4. CONCLUSIONS AND SUGGESTIONS

Performance Improvement

1) Case company is a foundry company, and its biggest profit source is foundry fees. In recent years, various industries have been continuously upgraded, and the transformation of industries and innovative technologies have been carried out in parallel to create the advantages of individual product differentiation. With the improvement and speed of R&D capabilities, the functions and quality of products have been relatively upgraded. Most companies aim to produce "low cost and high quality". In production operation management, improving production efficiency is an important project, which is directly related to the competitiveness of enterprises. From implementing machine equipment maintenance, SOP operator training, and integrating the concept of the eight major wastes into the hearts of every employee, it is taken for granted. Naturally increase the company's profits.
2) We have always only seen the production part, but ignored the problem of warehouse management. The placement and priority of raw materials, semi-finished products, finished products, waiting for shipment, and immediate shipment are not properly managed, which will lead to unnecessary waiting and handling, which is a sunk cost. Replanning the traffic lines and clearly marking the locations can achieve twice the result with half the effort. The implementation of lean management can help companies improve production efficiency, reduce costs, improve product quality, and ultimately achieve the goal of improving competitiveness. After updating the traffic lines, we clearly felt that the fuel consumption of diesel stackers has dropped from 100 liters to 60 liters. The number of charging times for electric stackers has dropped from 3 times a week to 2 times.
3) Saving manpower: Reducing losses, increasing production capacity, and maintaining stable quality in production operations are issues that every company attaches great importance to. Ninety percent of the front-end paper printing process has been replaced by

computer digital inkjet printers, which greatly reduces the demand for manpower. The back-end printing production has also eliminated power-consuming machines and equipment, and strengthened security control and some automation systems, which not only improves the labor shortage problem, but also makes it safer to use and relatively reduces electricity consumption.

4) Green Talent: Focus on saving electricity, energy management, and carbon reduction. Secondly, information skills, communication skills, and regulations are also key skills. Finally, integrate and connect cross-departmental work. Case company attaches great importance to the education and training courses on carbon emissions and net zero transformation sustainability issues. Since 2024, it has started training two employees to participate in the "Low Carbon and Intelligent Upgrading and Transformation of Manufacturing" counseling. Knowledge and skills for energy management; communication training, workplace ethics, and leadership and command courses are also very important general courses.
5) Green procurement: imported environmentally friendly diesel forklifts, battery-powered forklifts, water-based ink, variable frequency air compressors, and digital inkjet printers.

Table 3. The eight wastes of LM

	Traditional intaglio printing	Digital inkjet printing
Ink properties	Oil-based	Organic and water-based
Environmental issues	In order to avoid environmental pollution, wastewater treatment equipment is required.	Pollution-free and environmentally friendly.
Electric power consumption	800 Watt/hr.	20 Watt/hr.
Production capacity	800 Meter/hr.	4000 Meter/hr.
Manpower	3 persons.	2 persons.
Warm-up time	4-8 hours.	0.5-1 hour.

From Table 3, it can be clearly seen that the power consumption ratio of traditional equipment is 40:1, and the production capacity is only one-fifth of that of digital inkjet printers, and more manpower is used. In addition, water-based ink has pollution-free and is environmentally friendly.

6) Renewable energy: The existing rooftop solar panels can produce about 20,000 to 40,000 kilowatt-hours per month, which varies depending on weather conditions. We are also considering adding "energy storage system equipment". Energy storage systems usually include charging and discharging control, battery modules and monitoring and management functions. They can integrate energy into the power grid to help regulate electricity, or be used in off-grid systems to meet the electricity needs of specific areas. As the pace of global energy transformation accelerates, energy storage systems have become an important technology for moving towards a low-carbon society. The main principle is to store excess electricity through energy storage devices and power storage systems during off-peak hours, and release electricity during peak hours. Solar power supply combines energy storage benefits. Energy storage equipment can also provide support in a short period of time when the power system trips or there is a power outage without warning, allowing machine operators to have ample time to operate according to the standard operating procedures (SOP) steps to avoid damage to machinery and equipment.
7) Throuth the equipment improvement the production speed of the precision printer reached more than 3000 meter/hr.
8) Throuth the equipment updates, more than 80% of the machines are replaced with 380 V high-voltage power supplies to save energy.

9) The profit margin increased reach to 16% after the improvement.
10) Electricity power consumption reduced by 40%

Suggestions to Peers

The future is not an extension of the present. Abandon the old ideology and reposition yourself. Here are eight suggestions:

1) Innovation ability plus knowledge economy.
2) Review various data to reduce costs and increase net profits.
3) Increase employee salaries and benefits.
4) Continue to improve the production environment and raw materials in order to achieve the net zero carbon emission target as soon as possible.
5) Adopt an open communication culture in the process to maximize the current production process capacity.
6) Increase industry-university cooperation plans to cultivate professional talents.
7) Strive for government resources (eg: Textile Research Institute, Energy Administration, Ministry of Economic Affairs).
8) Conduct detailed analysis of each production line to improve core competitiveness.

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