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FOREFRONT MANUFACTURING: PRODUCTION PROCESSES AND CHANGE MANAGEMENT IN MAINLAND CHINA

Nigel Goodwin wrote this case under the supervision of Professor Chris Piper solely to provide material for class discussion. The authors do not intend to illustrate either effective or ineffective handling of a managerial situation. The authors may have disguised certain names and other identifying information to protect confidentiality.

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FOREFRONT MANUFACTURING

ForeFront Wood Products (Manufacturing) produced high-quality wooden doors and doorframes in Shenzhen, in China's southern Guangdong province. In July 2005, the company grappled with capacity constraints and inefficiencies that threatened both its financial survival in the immediate term and the viability of an initial public offering (IPO) planned for 2007. Returning from his first tour through the factory, Michael Li, the recently hired operations manager, considered the actions that he could take to quickly turn things around.

THE COMPANY

Business Model

Manufacturing produced customized doors and doorframes, which were collectively referred to as door-sets. ForeFront's door-sets were installed in large residential properties, such as apartment and condominium blocks, and in commercial properties, such as hotels, resorts and office buildings. Most of these properties were located in Hong Kong, and to a lesser extent, on the nearby island of Macau.

The company made an essential product. As one executive explained:

> There will always be demand for what we do. The other features and fixtures in a building may vary — the floors may be wood or marble or carpet, for example. . . . But every single building in the world needs doors.

Manufacturing worked in tandem with its sister company, Hong Kong–based ForeFront Contracting (Contracting). Both companies were wholly owned subsidiaries of Hong Kong–based ForeFront Holdings.

The Contracting division tendered bids to provide interiors for new construction projects in Hong Kong and Macau. About 10 to 20 per cent of each bid was for the manufacture and installation of door-sets. Prior

to submitting a bid, Contracting consulted with the project's architects to decide on the materials, dimensions, colors and style of the door-sets required. Each property development was unique, and since door-sets had to be consistent with a given property's style, each order for door-sets was likewise unique. Contracting's bids were based on each job's architectural characteristics, construction, materials, labor and other factors.

Manufacturing produced the required door-sets in Shenzhen to capitalize on lower labor costs.[1] Manufacturing then sold the door-sets to Contracting at a standard cost plus an agreed-upon mark-up through an inter-company transaction. Finally, Contracting delivered and installed the door-sets at the construction site. Manufacturing recorded turnover of RMB 97 million[2] in the financial year ended March 2005, up from RMB 80 million in the previous year.

The arrangement between the two sister companies was not exclusive. Although Contracting purchased most of its door-sets from Manufacturing, the contracting company was free to purchase doors from other manufacturers, which happened occasionally when Manufacturing was too busy to fill all of Contracting's orders. Also, the non-exclusive nature of the arrangement reminded the management of Manufacturing that its costs needed to be competitive.

Roughly 90 per cent of Manufacturing's door-sets were installed in Hong Kong and Macau. The company had recently begun exporting to international markets as well, with door-sets going to Europe and the Middle East. Some other wood products, such as decorative paneling, were exported to North America. International orders were generated by a new export division under ForeFront Holdings.

The business was built on securing and delivering large orders. A single property development might require thousands of door-sets. For example, a recent order for a 4,000-room hotel and casino in Macau required 20,000 door-sets.

A single project could have as many as 20 different types of door-sets, including several door-sets each for the lobby, restaurant, health club and back office; dozens of door-sets for stairwells and exits; and hundreds or thousands of door-sets for guest rooms, in-room bathrooms and in-room closets.

Door delivery was typically phased over three or four months according to Contracting's installation schedule. There was little or no storage space at building sites, so doors were either made just in time to meet the installation schedule, or were stored as partially completed work-in-process or as finished goods inventory at the factory. Doors were the only item manufactured by ForeFront Holdings, which assured customers that the doors would be supplied when specified. The other components of the buildings' interior, such as floors and walls, were supplied by independent subcontractors engaged by Contracting.

Each type of door-set would be different in terms of wood variety, height, width, thickness, moldings, features, wood variety, color and finish, as well as holes for locks, handles and windows. Manufacturing had to change machine set-ups for each new type of door.

History

ForeFront Holdings and its subsidiaries were established in 1992, by two entrepreneurs who had been classmates in university. Each owned 20 per cent of the company, and a private investor owned the

[1] The trip between Hong Kong and Shenzhen took about two hours by road, including time spent at the border crossing, although extended delays were not unusual.
[2] In July 2005, one Chinese Yuan Renminbi (RMB) equaled approximately 0.121 U.S. dollars.

balance. The two founders were still active in the company when Li toured the plant and each still held his original share of the equity.

ForeFront Holdings prospered and grew during the Hong Kong property boom of the 1990s. When the property market cooled off in 2001, orders for door-sets decreased and margins thinned.

Hong Kong investor Andrew Chan purchased 55 per cent of the ForeFront equity at that time from the original private investor. "I invested in ForeFront because I could see its potential for growth and profitability," he explained. "I did this when the market was in a slump because that was the smart time to buy in." With the purchase, Chan assumed chairmanship of the company's board of directors.

Chan believed the company would require additional capital to fully realize its potential, and planned to issue an initial public offering in 2007.[3] In his opinion, the preparation required for this IPO, which he referred to as "getting our house in order," was the most significant influence on the company's actions in the interim. The company would have to develop a profitable track record, tighten its corporate governance, streamline its operations and reduce investor risks.

The preparation for the IPO included the financial and managerial separation of the two operating entities, Contracting and Manufacturing. The two had been intertwined for nearly 15 years, but in March 2005, their financial statements were separated. From that point forward, the two entities were treated as separate divisions with common ownership and a common board of directors. This change was made to simplify the management of the two entities and ensure good decision making.

The separation of the financial statements confirmed what had long been suspected: the manufacturing division was barely profitable. The door-sets were not produced efficiently enough to preserve the margins on the prices paid by Contracting. Prior to March 2005, Manufacturing had reduced its parent company's profitability. Now that Manufacturing stood independently, its pre-tax earnings of three per cent were well below Chan's target of 10 to 15 per cent.

Li had been hired in the newly created position of operations manager to improve Manufacturing's operations and increase its profitability. He had 16 years of operational experience with a major producer of carbonated beverages. He had worked at one of the company's bottling plants in mainland China and had risen to the position of operations manager there. He had joined Manufacturing with the intention of applying the techniques, processes, structures and management systems of a world-class company to this medium-sized enterprise.

THE PLANT TOUR

Li learned that Manufacturing began operating out of a leased building in Shenzhen in 1992. As the company grew, it leased additional nearby buildings. Currently, the company leased seven factory buildings in two groups, located several hundred meters apart. Exhibit 1 shows the layout of these facilities. These buildings housed the activities of approximately 500 workers and 80 management and administrative personnel, including 20 factory supervisors. Exhibit 2 provides a list of the staff and activities performed by each department. Some workers were considered skilled and operated machinery. A few of these skilled workers had specialized training while most had been trained on the job.

[3] *The IPO would include ForeFront Manufacturing and possibly ForeFront Contracting as well.*

As Li walked around the facilities, examining the various equipment and operations, he asked many questions and took mental notes. He knew he would soon be expected to improve the company's operations.

The Engineering Department

A small group of builders and owners was responsible for most of ForeFront Holdings' business. The small number allowed Contracting to maintain close contact with its clients and gain early notice of planned building starts. Although discussions commenced several months before contracts were awarded, there was not much time between the issue of a firm order and the required start of deliveries. As a consequence, Manufacturing's Engineering Department frequently had to begin production planning before orders were received. Consequently, some production plans were produced for orders that were ultimately awarded to ForeFront's competitors. Less frequently, a contract award was delayed to such an extent that materials had to be ordered in advance just in case ForeFront won the contract. ForeFront's continuing relationships with builders and owners and its problem-solving role made it difficult to refuse late orders or charge extra for the costs incurred in accelerating their completion. However, advance material orders would only be placed when Contracting was confident that it would eventually receive the order. In those cases, Contracting compensated Manufacturing when material was purchased and ForeFront did not win the contract.

Each project began with product development activities. Manufacturing's product development team coordinated with Contracting, property developers and architects to make sample door-sets. The product development team did most of its work in the sampling area with simple wood-working and finishing tools. Occasionally, machines on the regular production line were used. Ideally, this work was restricted to lunch hours and nights when the machines were not in use. In practice, however, the development work during operating hours often delayed production.

The production plan specified materials, dimensions, colors and finishes, as well as the exact sequences of operations (routing) to be performed. Given that thousands of doors would be made and installed with limited opportunities for on-site adjustment, the specifications — particularly the dimensions — needed to be precise.

A desired result could be achieved by specifying various combinations of raw materials and manufacturing processes. For example, the use of a higher quality varnish for a door's base coat might reduce the required number of subsequent face coats from three to two, thus trading off material for capacity and labor. Similarly, applying a higher quality face varnish might require fewer applications than a lower quality face varnish. Also, some veneers might require less sanding, less filling and fewer coats of varnish than other veneers. The engineers took such factors into account to develop production plans that first met the delivery schedule, and second met the material yield targets.

In the plant, operators regularly varied from the production plan to cope with defective or missing materials or unavailable equipment. Sometimes insufficient materials were ordered to supply the needed number of door-sets. Other times, material was damaged during storage or processing. A shortage would set off a chain reaction in which operators "borrowed" material that was being held for other orders, thereby causing yet another shortage. Material substitutions were sufficiently frequent to make it difficult to know exactly which material was used to produce a given order. The changes further complicated production scheduling and forced continual juggling of priorities.

Raw materials, such as wood and varnish, were ordered based on the production plan using standard material usage factors. Wood was imported from North America or Europe and usually took two to three

months to arrive. Upon arrival, the materials were delivered to an outdoor receiving area, and then sorted and held in temporary storage. The cores, surfaces and moldings of the doors, as well as their frames, were then prepared in four parallel processes diagrammed in Exhibit 3.

In spite of many differences, almost all door-sets had the same four component types: outside surfaces, an inner core, decorative trim and a frame to which the door would ultimately be hinged and locked. The outer surfaces covered the core. The core provided strength as well as separation of the two outer surfaces, which, in turn, provided the desired door thickness and fire-resistance. Once the outer surfaces were fastened to the core, they were often decorated with wood molding to achieve a desired aesthetic profile. Hinges were then screwed to the door, and holes were drilled in the frames for the screws that would fasten the door hinges to the frames after they were installed at the construction site.

The Cutting Department

In the cutting department, rough lumber was cut and planed into boards of the specified length, width and thickness. These boards would provide the interior structure, or core, of each door, as well as appropriately sized lumber for the trim and frame components. Skilled workers operated the machinery while unskilled workers assisted by placing lumber on the equipment and moving it between machines. Workers selected lumber with the needed dimensions and freedom from splits and other natural defects. Careful lumber selection and cutting at this early production stage was the most important way of avoiding defects in later stages and improving wood yields. The boards were stockpiled, and then sent in batches to carpentry to be shaped and assembled into larger components.

The Carpentry Department

At the same time as the lumber was being prepared by the cutting department, the carpentry department also prepared batches of door surfaces. Workers took medium-density fiberboard (MDF)[4] or high-density fiberboard (HDF) sheets from the sorting area and cut them into the correct height and width for the doors. The workers then applied a wood veneer to provide the outer surfaces of the doors. Veneer was wood that had been peeled or sliced from tree trunks in sheets less than three millimeters thick, and came in different varieties, such as cherry and oak. The outer layer of veneer gave the impression that the entire door was made of that wood. Once the batch of surfaces was complete, it was sent to the finishing department to be varnished.

Li noticed batches of varnished door surfaces were returned to carpentry and fastened over the waiting cores.[5] The assembled units, known as door leaf, then underwent more detailed cutting in carpentry. Holes were cut for required handles, locks and windows. Wherever possible, this detailed cutting was done by a programmable, computer-numerical-controlled (CNC) machining center. The completed units were loaded back on carts and sent to the assembly and packing department.

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[4] Medium-density fiberboard (MDF) is an engineered wood product produced by combining saw dust with wax and resins, then forming this mixture into sheets by applying heat and pressure. MDF tends to be more resistant to warping than raw wood or plywood. High-density fiberboard, or HDF, is heavier, but otherwise is produced in the same way.

[5] ForeFront Manufacturing built most doors with veneer-covered MDF or HDF. A small number of doors were made of solid wood. In the manufacture of solid-wood doors, there was no separation of core and surface processes, and the entire door went from general cutting directly to finishing.

The Forming Department

While the cores and the surfaces of the doors were being prepared, batches of moldings and frames were produced in the forming department. Depending upon the design, edges could be beveled, square corners could be rounded and other details and embellishments could be added.

The Assembly and Packing Department

After being sanded, filled and coated, the components were sent to the assembly and packing department where they were accumulated in kits. Here the moldings were fastened to the doors, the frames were assembled and the doors were combined with their matching door frames to make complete door-sets. Finally, the door-sets were packaged and stored in the packing area to await shipping.

The Finishing Department

To retain the appearance of freshly machined wood, a door normally required one or two base coats of varnish, followed by two or three face coats. The type of veneer, the quality of varnish, the number of base and face coats and the types of equipment that were used all influenced the outcome.

Carts of partially completed door surfaces were sent to the finishing department where they received the specified number of coats of transparent or opaque varnish, and were sanded multiple times until they were smooth. These activities were performed by a series of automated machines that were connected by conveyors. Since the wood pieces for the moldings and door frames were not flat like the door surfaces, they could not go through the automated finishing line. Instead, the sanding, filling and coating actions were performed with hand-held equipment in the finishing department on the second floor above the carpentry shop. Although this manual work consumed the bulk of the department's labor, it was the automated line that limited Manufacturing's output.

Li spent the most time examining the finishing department — especially the automated door surface line. Finishing was the most complex manufacturing process, and it had the least capacity.

Exhibit 4 provides a map and a photograph of the automated line, and Exhibit 5 describes each activity on the line. On average, door surfaces required one pass through all but the last four machines, and required two passes through the last four machines, starting at fine sanding. Door surfaces could be loaded at the beginning and the middle of the line, and removed at the middle and the end. It was possible for one batch to go through the first half of the line while a different batch was processed in the second half of the line. Each door occupied a three-meter length of the conveyor, including some space between doors. There had been a trend towards finishing most doors with ultraviolet (UV) varnish, so the infrared dryer was infrequently used.

Some machines on the line could be set up for more than one operation. For example, a coating machine could be used to apply either base or face coats by changing its applicator roll. The adhesive application machine normally used to fill holes could also be used to apply varnish with an applicator roll change. Roller changes typically took about one hour.

While such flexibility was useful, it was not free. Sandpaper rolls could be changed in a few minutes to achieve different sanding qualities. It was much more time-consuming to change the coating equipment, however, since the rollers and tanks had to be washed before they could be reused. In addition to an hour's lost time during a coating change-over, the varnish or stain left on the rollers was lost, costing between RMB 2,000 and RMB 3,000.

Challenges and Concerns

If the leaf's surface was not perfectly flat when it reached finishing, the sanding step might not reach the lowest level of the surface. The result would be an uneven surface. The affected leaves could be run through the coating process one or more additional times, but the additional coating would cause lost capacity and lost coating material.

The Maintenance Department

Machine breakdowns occurred regularly in the finishing department, and replacement parts that were not on hand had to be shipped from Italy. Earlier in the year, both the fine-sanding machine and the laser-textured roller[6] failed at the same time. It took nearly five months for replacement parts to arrive and for the machines to be repaired. While waiting, the department improvised using the other less precise sanding equipment. The textured roller continued to be used in spite of the fact that its deteriorating condition caused the finishes to be defective on one door out of five. Defective doors had to be run through the process one or more additional times, consuming more scarce capacity and expensive coating materials. While the company continued production while waiting for replacement parts, efficiency and quality suffered and costs rose.

Manufacturing kept some spare parts on hand, but it was hard to predict which parts would fail. There were so many parts and so many possible problems that it was impossible to prepare for all eventualities. Li realized:

> If the finishing department were to carry enough spare parts to be prepared for all possible problems, the department would practically have a full set of redundant machines on standby.

Furthermore, some machines were very expensive. The fine-sanding machine, the most expensive piece of equipment, cost the firm RMB 1.5 million. The textured roller cost RMB 10,000.

Some of the department's problems were simpler, but still troublesome. For example, the pipes that carried dust away from the sanding machines would become clogged. This reduced the extraction power and the quality of the finished surfaces since even tiny sawdust particles would be visible after the varnish had been applied. When this happened, the pipes had to be cleaned and the coated doors refinished, causing delays and consuming more material and labor.

Manufacturing employed eight full-time maintenance workers and spent an average of RMB 100,000 on parts and other maintenance costs each month. Maintenance was constantly under stress. In a recent six-month period, two successive maintenance managers quit. The pressure for immediate restoration of equipment after breakdowns was enormous. Maintenance was expected to respond around the clock. There was little time available for preventive maintenance. When the equipment was working, factory supervisors were reluctant to release it for inspection or service. When the equipment eventually broke down, the dominant priority was to get it back in operation as quickly as possible.

[6] *The Italian supplier used a laser to etch fine lines in the roller that resulted in a finish that had an attractive texture and apparent depth.*

PRODUCTION CAPACITY

Production capacity varied with product mix and hours of factory operation. A basic shift ran from 8:30 a.m. until 5:30 p.m. from Monday to Saturday, with no work on Sundays. During busy periods, which seemed to be most of the time, the shift was extended until 10:00 p.m. from Monday to Saturday, and sometimes even on Sunday.

In an extended shift, with a typical product mix, the cutting department could cut enough wood for 350 door-sets per day with relative ease. Most of the other departments could match this pace. However, the finishing department could only process 300 pairs of door surfaces per day through the automated line. The line operated at eight meters per minute. Although the equipment on the line was rated by their manufacturers at 17 meters per minute or more, operators found that operating it at higher speeds resulted in uneven sanding by the bottleneck fine-sanding machine. Even at the slower speed, rework typically averaged 20 to 30 per cent.

Adding a second shift to the extended day shift allowed the finishing department to keep pace with the rest of the factory at 350 door-sets per day. The second shift operated at nights and on Sundays. The second shift was less productive since it was staffed with less skilled and less experienced casual workers. Under these conditions, Manufacturing could produce at least 8,750 door-sets per month.

Eleven-hour days and seven-day weeks were welcomed by the workers, who were paid 50 per cent overtime premium after working 40 hours in a week. They received a 100 per cent premium for working on Sundays, resulting in wages double the minimum wage. The mostly migrant workers appreciated the extra wages of extended or extra shifts since most lived in Manufacturing's dormitories, separated from their families who often lived hundreds of kilometers away. Extra shifts did pose some managerial challenges because the workforce had to be reassigned. Some skilled operators needed to transfer to the night shift to supervise and lead the less experienced casual workers. As might be expected, the plant was not as productive during the extra shifts, resulting in increased rates of scrap and rework.

NEW FACTORY

As Li toured the current manufacturing facility, he was struck by the inefficiency inherent in its layout. Fortunately, Manufacturing was on the verge of relocating to a new purpose-built, 60,000-square-meter production facility. The new facility, which was nearly ready, consisted of five single-storey production buildings, a multi-story administration building and showroom, and a multi-story dormitory for workers.

Li was looking forward to the installation of several pieces of additional finishing line equipment, including an initial-sanding machine, a dust-extraction machine, a coating machine and an ultraviolet drying machine. Manufacturing would transfer to the new factory in December 2005. Door production would be halted for the entire month as equipment was moved and set up at the new location.

MANAGEMENT SYSTEMS

Even as Li studied the company's facilities and manufacturing processes, he wondered whether additional factors also contributed to the company's capacity and efficiency challenges as yields were 10 to 15 per cent below expectations. Li suspected that workers were cutting corners everywhere they could in order to make their work easier, and believed guidelines and procedures were required to ensure work was carried out properly.

On his factory tour, Li stopped several times to speak with skilled workers and supervisors. He asked them how they used their raw materials, tracked their work-in-process inventory and followed production plans. He discovered that the workers did not properly document their work before, during or after a given project. Furthermore, there were no guidelines for handing off work-in-process inventory between departments, so it was difficult to track the yield of each process.

Upon further enquiry, it became apparent that workers were anxious to avoid the appearance of making mistakes. The culture was to avoid blame at all costs — even if something outside one's control was at fault. Many of the errors occurred during the initial cutting operations, but were not noticed or reported. Later, when the door surfaces reached the automated finishing operation, finish imperfections became obvious when the sanding and coating rollers failed to touch low-lying spots on the supposedly flat surfaces. Supervisors, as well as workers, were reluctant to assess blame or even acknowledge the defects. The workers would simply run the defective door surfaces through the automated line again. Although this second finishing might be enough to repair the defects, it resulted in unreported capacity and coating losses. Often, defects were spotted late in the production process, long after an easy repair would have been possible. When this occurred, the defective surfaces had to be repaired by hand or even scrapped.

Li noted that the process routings and bills of material developed by engineering were not always followed, which almost always led to extra time and extra materials being consumed. One reason for deviations was the need to adjust for earlier cannibalization (i.e. unauthorized substitutions) that occurred when a worker made a mistake by either choosing the wrong material or making the wrong cut. Unfortunately, there was no information available for Li to measure the extent to which this occurred.

Work-in-process inventory was sometimes transferred between departments without being inspected properly. In other instances, it was not delivered on time. Yield variability and scheduling issues made it very difficult to store and manage inventory properly. In fact, as Li walked back and forth between the buildings, he saw large stacks of raw materials and work-in-process inventory under tarps along the side of the public road.

WORKFORCE TURNOVER

Passing by the workers' dormitory as he walked between the factory buildings, Li considered the impact of the workers themselves. Turnover was very high, with as many as 40 factory workers leaving and being replaced each month. Even the department heads turned over quickly, with seven of 14 managers leaving within a recent six-month period. Chan had told him that he thought that the quality of the workforce had been declining. This was a major problem. Good machines were not sufficient if their operators did not know how to use them properly.

Manufacturing, like other employers in Guangdong province, was largely dependent upon migrant workers from China's less affluent rural provinces. In 2005, an estimated 95 million Chinese lived and worked outside their native provinces, and the number was expected to grow to 115 million by 2007. In Guangdong province, migrant workers accounted for more than one-quarter of the province's total population of 110 million. Nevertheless, there was a labor shortage, so it was relatively easy for workers — both migrant and local — to find or switch employment.

Employers usually provided housing and meals for migrant workers, although the living conditions were tough. The housing units were typically old, small and overcrowded. Furthermore, there was little for the workers to do in their leisure time.

The Guangdong provincial government had instituted a minimum wage standard in 1994 and had raised it six times since then in an effort to attract more workers and improve their livelihoods. Despite these increases, wages remained low, and there was a growing perception among workers that they could find higher wages at newly opened factories in the emerging industrial hubs in the eastern provinces.

Chan had told Li that he believed that the wages at Manufacturing were competitive with the wages at other Shenzhen factories, but were lower than wages in other regions. Manufacturing had recently increased its wages to keep pace with the market and with the minimum wage legislation. Unskilled workers were paid RMB 900 to RMB1,000 per month, while skilled workers received RMB 1,400 to RMB1,600 per month. When workers left the company, they usually went in search of higher wages in other provinces.

Even considering the low wages, Li was surprised by the high turnover rate. Apart from the turnover, he felt that the work pace could be improved upon. One option that he contemplated was the adoption of output incentives. He thought the company would have to demonstrate that it valued its workers and saw them as being essential to its success. In his opinion, success should be reciprocal: the company needed its workers to produce its door-sets, and the workers needed the company for their income.

THE CHALLENGE

Chan had challenged Li to present recommendations for improving the company's operations. Li set four objectives, in order of importance, to help him focus his work:

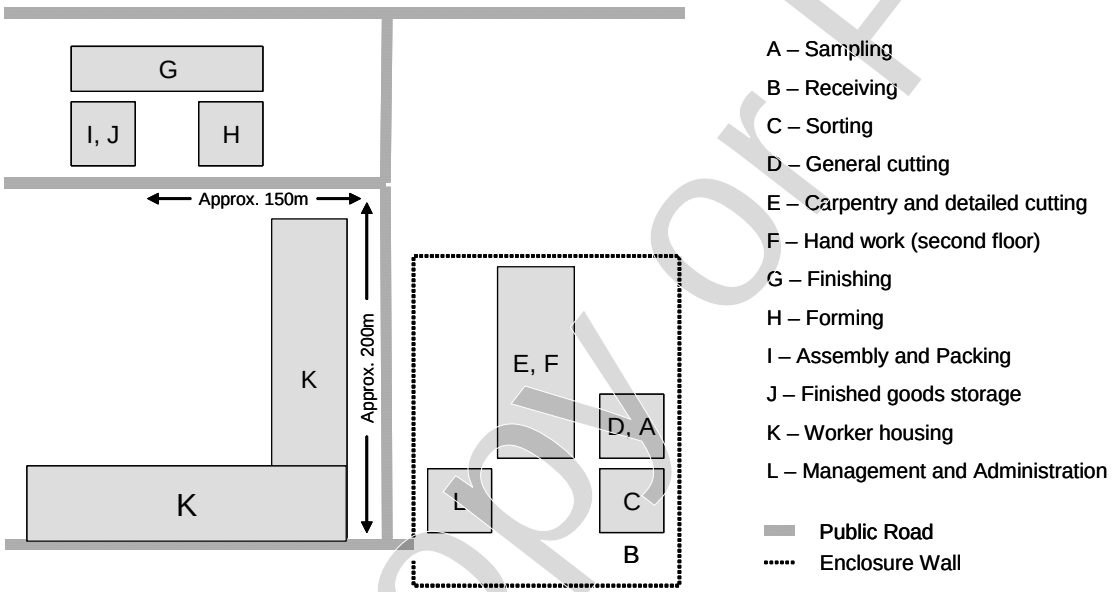
1. Improve Manufacturing's profitability.
2. Establish two management systems: one that would drive operations automatically, instead of depending on constant supervision, and one that would continue to work even if Li or other key managers left.
3. Be responsible to the local society; having signed a 13-year rental contract on the new facility, Manufacturing was compelled to be a good corporate citizen and to pay fair wages.
4. Become a leading wood door manufacturer in China; Li believed this goal would follow automatically if the first three priorities were met.

As his tour of the facilities concluded, Li sat down at his desk in the management and administration building and began to draft his recommendations.

The Richard Ivey School of Business gratefully acknowledges the generous support of the Lee Foundation in the development of this case as part of THE LEE FOUNDATION ASIAN CASE SERIES.

Exhibit 1

FOREFRONT MANUFACTURING CURRENT FACILITIES



Source: Plant tour, case writer analysis.

Exhibit 2

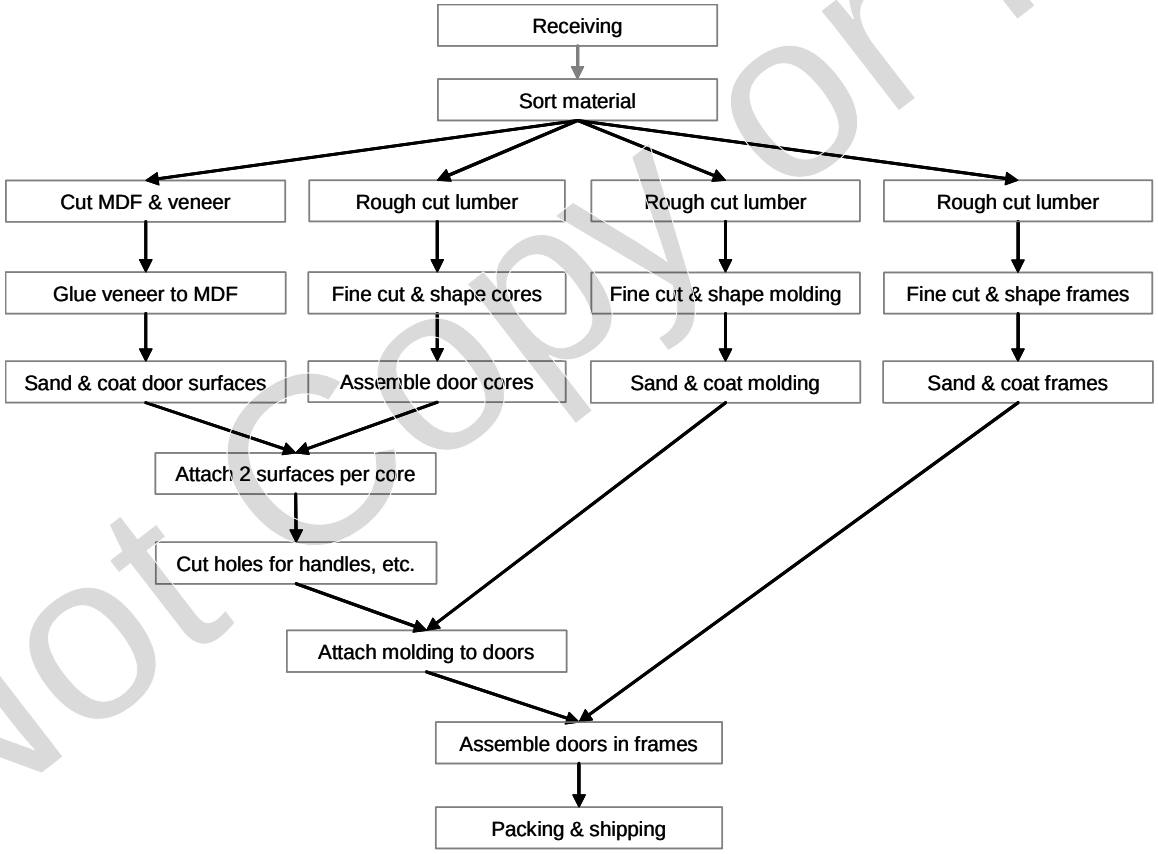
FOREFRONT MANUFACTURING STAFF AND THEIR ACTIVITIES BY DEPARTMENT

Department	***Activities***	***Skilled Workers***	***Unskilled Workers***
Product Development	*Coordinate with Contracting and with property developers and architects to make sample door-sets*	*16*	*0*
Engineering	*Prepare production plans*	*5 engineers*	*15*
Rough cutting	*Cut lumber into basic shapes*	*30 machine operators*	*40*
Carpentry	*Cut MDF and HDF into correct dimensions*	*70 basic cutting machine operators*	*20*
	Apply veneer to MDF or HDF to create door surfaces		
	Assemble surfaces and cores to create door leaf	*30 detail cutting machine operators*	*20*
	Detail cutting (for various holes)		
Finishing	*Sand and apply coats of varnish or stain to door leaf, frames and molding*	*80 machine operators*	*60*
Forming	*Shape and sand moldings and frames*	*35 machine operators*	*25*
Assembly and Packing	*Attach moldings to doors*	*20 assembly operators*	*30*
	Assemble doors and frames to make complete door-sets		

Source: Company files.

Exhibit 3

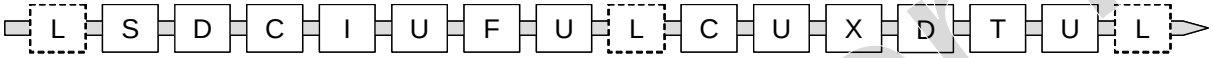
MANUFACTURING PROCESS MAP



Source: Plant tour, case writer analysis.

Exhibit 4

OPERATIONS ON THE AUTOMATED FINISHING LINE (CURRENT FACILITY)



L = Loading / unloading / inspection area

S = Initial sanding machine

D = Dust extraction machine

C = Coating machine (base & face varnish)

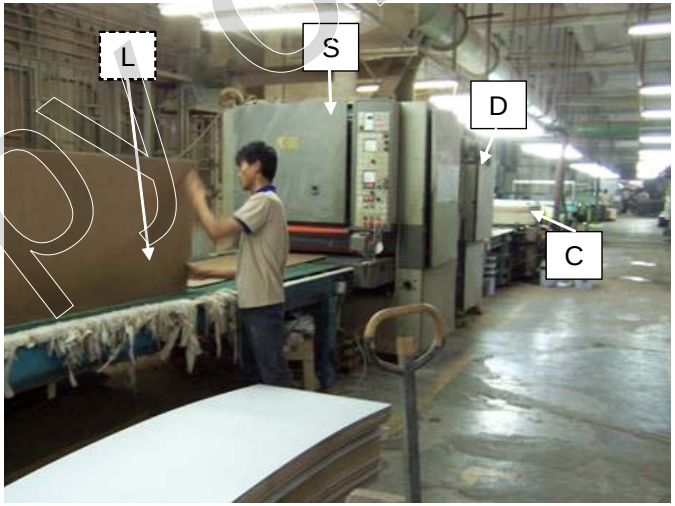
I = Infrared drying machine

U = Ultraviolet drying machine

F = Filling machine

X = Fine sanding machine

T = Textured coater



Source: Plant tour, case writer analysis.

Exhibit 5

ACTIVITIES ON THE AUTOMATED FINISHING LINE

Station	*Operation*
Load / unload /inspect	*Load and unload door surfaces from the production line and visually inspect for defects.*
Initial sand	*Sand door surface veneer smooth with large sandpaper belts.*
Dust extraction	*Remove dust created by previous sanding step with a vacuum.*
Coat	*Coat door surfaces with transparent varnish.* *Apply one base or face coat each time a door surface passes through the coating machine.* *Use a thick roller for base coats and a fine roller for face coats.* *The numbers of base and face coats depend upon the specifications.*
Infrared dry	*Infrared light heats varnish to smooth and even the coat.*
Ultraviolet dry	*Ultraviolet light dries varnish in seconds.*
Fill	*Apply inexpensive, adhesive filling material with a roller to fill holes and imperfections on door surfaces.*
Fine sand	*Sand dry face coats of varnish or stain to a smooth finish.* *Able to sand off fine increments; e.g., 0.1 mm, 0.05 mm, etc.* *Three adjustable sanding belts provided door surfaces with a progressively finer finish.*
Textured coat	*Apply thick textured coating with a laser-etched roller.*

Source: Plant tour.