

Plant Layout Selection and Feasibility Study for Bamboo Furniture Factory

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Abstract: The general reasons found to redesign of furniture manufacturing unit are: Low production capacity, conventional machines and operating tools, Nonscientific design ignoring time, motion and work study, erroneous material processing and work flow directions, functional discomforts including facilities & utilities, lack of engineering concepts and ergonomics etc. Therefore, the major objectives in design of bamboo furniture manufacturing unit are: layout design based on modern engineering concepts, contemporary machine tools and tooling, skilled manpower, ergonomically designed utilities & facilities and scope for future flexibility. The factors contributing to the objectives determine final productivity. The present paper addresses the design of factory layout for bamboo furniture manufacturing unit, but not limited to it.

Keywords: Plant layout, bamboo furniture, productivity, working capital, payback period,

I. INTRODUCTION

Bamboo is the common name for member of a particular taxonomic group of a perennial grass with large woody stem belonging to the family Poaceae, subfamily Bambusoideae. It encompasses about 1,200 species within 50 generation [1,10]. India is the major bamboo producing country, possessing about 145 species; the area of bamboo growth exceeds 11.4 million hector surface covered by bamboo and 17% of the country's total forest area.

Interest is growing daily on the utilization of bamboo as a reliable supplement to wood in furniture production to mitigate the scarcity of wood raw material supply. It is increasingly difficult to meet human demand for wood supply for diverse end uses in view of the alarming shrinkage in its supply. There have been deliberate efforts to create supplement or alternative to wood whenever possible from plastics, concrete, steel, aluminum amongst others. The provenance of these non-fibrous materials for high environmental hazards, relatively low strength, high cost of procurement and processing, high technological capacity requirement, need for specialized skill and power requirement were the bane of their patronage in developing countries like India.

Bamboo is an important non-wood species which mostly grows in the tropical and subtropical zone. It has now become valuable and superior alternate for wood composites [3]. Apart from China, bamboo utilization as a supplement for wood in furniture industry appears to be gaining marked interest in other Asian countries like Japan, Indian among others. The Asian exploit is thus spurring the interest of researchers in many developing countries that are making efforts to harness the potential of bamboo in their countries.

Nowadays, there are many kinds of bamboo composites that are produced and traded across the world. However, bamboo and wood differs in characteristics, composition, and properties. For this reason, the methods, technology and machine tools for wood processing cannot be directly applied in bamboo furniture manufacturing unit. Further research is required on the information on bamboo properties, cost-effective technologies and managements[7,9].

With modern techniques and adapted technologies, bamboo can be processed into a wide range of products which successfully compete with wood and other raw materials in the future. Bamboo furniture made from bamboo boards, bamboo timber and round bamboo shall replace wooden modular furniture in near future. It is mainly because mechanical properties and strength of bamboo composite materials are being improved through various processes and treatments [6,8]. In general, bamboo is stronger than wood in bending strength, compression strength parallel to grain and is similar in shear strength parallel to grain. The strength of bamboo in grain direction is extremely high. It might be suitable as the raw material for structural boards which bears unidirectional load. Bamboos have low shear strength parallel to grain. According to the mechanical properties, appropriate for composite products should be considered based on their strength to weight ratio [4,2,5].

As a result, bamboo has a low strength to weight ratio, it is not desirable for some applications because of its high specific gravity. All these complex features must be taken into concern for the bamboo utilization in the wood composite manufacturing. However, its bending strength and availability may compensate this disadvantage.

II. MATERIAL AND METHODS

Laying out a factory involves deciding where to put all the facilities, machines, equipment and staff in the manufacturing operation. Layout determines the way in which materials and other inputs (like people and information) flow through the operation. Relatively small changes in the position of a machine in a factory can affect the flow of materials considerably. This in turn can affect the costs and effectiveness of the overall manufacturing operation. Getting it wrong can lead to inefficiency, inflexibility, large volumes of inventory and work in progress, high costs and unhappy customers. Changing a layout can be expensive and difficult, so it is best to get it right first time. The first decision is to determine the type of manufacturing operation that must be accommodated. This depends on product volume and variety. At one extreme, the factory will produce a wide variety of bespoke products in small volumes, each of which is different (this is called a 'jobbing' operation). At the other extreme it will produce a continuous stream of identical products in large volumes. Between the extremes, the factory might produce various sized batches of a range of different products.

Plant layout is an important decision as it represents long-term commitment. An ideal plant layout should provide the optimum relationship among output, floor area and manufacturing process. It facilitates the production process, minimizes material handling, time and cost, and allows flexibility of operations, easy production flow, makes economic use of the building, promotes effective utilization of manpower, and provides for employee's convenience, safety, comfort at work, maximum exposure to natural light and ventilation. It is also important because it affects the flow of material and processes, labor efficiency, supervision and control, use of space and expansion possibilities etc.

Once the type of operation has been selected (jobbing, batch or continuous) the basic layout type needs to be selected. There are three basic types:

- Process layout
- Cell layout
- Product layout

Jobbing operations (high variety/low volume) tend to adopt a process layout.

Batch operations (medium variety and volume) adopt either a cell or process layout.

Continuous operations (low variety/high volume) adopt a product layout.

1. Process layout

In process layout, similar manufacturing processes (cutting, drilling, wiring, etc.) are located together to improve utilisation. Different products may require different processes so material flow patterns can be complex.

An example is machining parts for aircraft engines. Some processes (such as heat treatment) need specialist support (e.g. fume extraction), while other processes (e.g. machining centres) need technical support from machine setters/operators. So the factory will be arranged with heat treatment together in one location and machining centres in another. Different products will follow different routes around the factory.

2. Cell layout

In cell layout, the materials and information entering the operation are pre-selected to move to one part of the operation (or cell) in which all the machines to process these resources are located. After being processed in the cell, the part-finished products may go on to another cell. In effect the cell layout brings some order to the complexity of flow that characterizes process layout.

An example is specialist computer component manufacture. The processing and assembly of some types of computer components may need a dedicated cell for manufacturing parts to the quality requirements of a particular customer.

3. Product layout

Product layout involves locating the machines and equipment so that each product follows a pre-arranged route through a series of processes. The products flow along a line of processes, which is clear, predictable and relatively easy to control.

An example is automobile assembly, where almost all variants of the same model require the same sequence of processes.

Another is paper making. Although different types of paper can be manufactured, all types have the same processing requirements. First the wood chips are combined with chemicals, water and steam in the 'cooking' process to form pulp. The pulp is then put together through a cleaning process before being refined to help the fibers lock together. The mixing process combines the refined pulp with more water, fillers, chemicals and dyes, after which it is spread on a fine flexible wire or plastic mesh. This is shaken from side to side as it moves along to lock the fibers into the sheet of paper and to drain away the water. The press rollers squeeze more water out of the paper and press the fibers closer together. The drying process continues to reduce the water content in the paper before finally it is wound onto large reels.

It makes sense then to locate these processes in the order that they are required (cooking, then cleaning, then mixing, spreading, shaking, squeezing, drying and winding) and to let materials flow through them in a predictable manner.

DETAILED DESIGN OF THE LAYOUT

Once the basic layout type has been decided, the next step is to decide on the detailed design of the layout to determine:

- The exact location of all facilities, plant, equipment and staff that constitute the 'work centres' of the operation.
- The space to be devoted to each work centre.
- The tasks that will be undertaken by each work centre.

General objectives

The general objectives of detailed design of factory layouts are:

- *Inherent safety.* Dangerous processes should not be accessible without authorisation. Fire exits should be clearly marked with uninhibited access. Pathways should be clearly defined and not cluttered.
- *Length of flow.* The flow of materials and information should be channelled by the layout to fit best the objectives of the operation. This generally means minimising the distance travelled by materials.
- *Clarity of flow.* All flow of materials should be clearly signposted, for example using clearly marked routes.
- *Staff comforts.* The layout should provide for a well ventilated, well lit and, where possible, pleasant working environment.
- *Management coordination.* Supervision and communication should be assisted by the location of staff and communication equipment.
- *Accessibility.* All machines, plant and equipment should be easily accessible for cleaning and maintenance.
- *Use of space.* All layouts should make best use of the total space available (including height as well as floor space). This usually means minimising the space for a particular process.
- *Long-term flexibility.* Layouts need to be changed periodically. Future needs (such as expansion) should be taken into account when designing the layout.

Detailed design in Process layout

The detailed design of process layouts is complex, because of the complex workflow patterns that are associated with this layout to ensure a very wide variety of products can be made. Optimal solutions are difficult to achieve and most process layouts are designed through intuition, common sense and systematic trial and error.

To design a process layout, the designer needs to know:

- The area required by each work centre.
- The constraints on the shape of the area allocated for each work centre.
- The degree and direction of flow between each work centre (for example number of journeys, number of loads, cost of flow per distance travelled).
- The desirability of work centres being close together.

The degree and direction of flow are usually shown on a flow record chart, which records in this case the number of loads per day transported between work centres. If the direction of flow between work centres makes little difference to the layout, then the information can be collapsed

Combined layout

Certain manufacturing units may require all three processes namely intermittent process (job shops), the continuous process (mass production shops) and the representative process combined process [i.e. miscellaneous shops]. In most of industries, only a product layout or process layout or fixed location layout does not exist. Thus, in manufacturing concerns where several products are produced in repeated numbers with no likelihood of continuous production, combined layout is followed. Generally, a combination of the product and process layout or other combination are found, in practice, e.g. for industries involving the fabrication of parts and assembly, fabrication tends to employ the process layout, while the assembly areas often employ the product layout. In soap, manufacturing plant, the machinery manufacturing soap is arranged on the product line principle, but ancillary services such as heating, the manufacturing of glycerin, the power house, the water treatment plant etc. are arranged on a functional basis.

PLANT LAYOUT

Figure 1, shows the plan of proposed plant layout for bamboo furniture manufacturing unit. Table 1, presents the description of the various sections of plant areas.

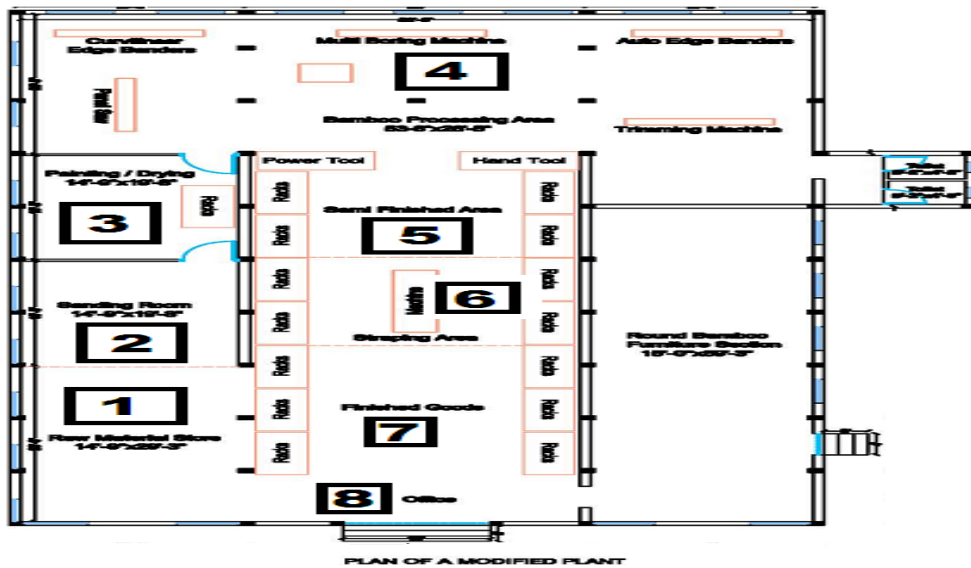


Fig. 1: plan of proposed plant layout for bamboo furniture manufacturing unit.

The flow of raw material received at raw material receiving section (1) as shown in Figure 1, shall be 1 to 7 in sequential manner as shown in Table 1 below.

Table 1: The description of the various sections of plant areas

S.	Name of the sections/Rooms
1	Raw material Stores
2	Sanding Room
3	Painting & Drying section
4	Operation/Bamboo Processing section
5	Section of semi-finished goods
6	Strapping/Packaging Section
7	Finish Goods storage and Display
8	Office section
9	Toilet Blocks/Utility

Bamboo Furniture Manufacturing Machinery

Table 2, presents the list of modern machine tools and tolling required for manufacturing bamboo furniture.

Table 2: Machinery required for manufacturing bamboo furniture.

Sr. No.	Machine Tools/ Operating Tools
01	Panel saw Machine
02	Edge Banding Machine (Curvilinear)
03	Multi bore
04	Edge Trimmers
05	Sander Machine
06	Dust Collector
07	Hi- Speed Router

08	1) Circular Saw m/c 2) Cutter machine 3) Sander Machine 4) Jig saw Machine 5) Router Machine 6) Planner Machine 7) Trimmer Machine 8) Drill Machines 9) Screw Driver 10) Hammer Drill m/c 11) Tooling for Bosch Power Tools
09	Hand Tools
10	T.C.T. Saw Set for Panel Saw Machine (With Main Saw & Scoring Saw)
11	Router bit for High Speed Router Machine
12	Sand Belt for Wide Belt Sander Machine
13	Multi Boring bit

MANPOWER REQUIREMENT

The skilled, semiskilled labor technicians along with the office staff and supervisor are mentioned in Table 3.

Table 3: Manpower required for furniture manufacturing unit

Sr. No.	Personnel: Supervisor/ Operator (s) for a M/c
1	Sanding Machine operators
2	Painting / Polishing Machine operator
3	Panel saw Machine operators
4	Edge Banding Machine operators
5	Trimming Machine operators
6	Buffing Machine operators
7	Multi bore Machine operators
8	Loading Unloading
9	Assembly / stock & display Arrangement
10	Supervisor
11	Accountant

Production Capacity:

Production capacity is calculated based on the total time required to manufacture the individual components of modular bamboo furniture. the time required to complete each of operations like: Unloading/loading, Sanding, Painting /polishing, Panel saw Machine, Buffing/Trimming, Edge banding operation, Multi bore operation, Strapping/Packaging operation, miscellaneous and contingency etc are estimated based on the machine capacity and motion and work study analysis of another furniture manufacturing unit. Total time worked out was about 4070 minutes. A Shift of 8 Hours i.e. 480 minutes is assumed. Based on this following calculation is made:

$$4070 \text{ min}/480 \text{ min.} = 8.47 = 9 \text{ Labours}$$

Therefore, 9 people are directly required for machining related work

Expected Initial Production capacity = 960 pairs or furniture set

= 1920 Units per month

However, after some time (say one month), the same unit is expected to beat these figures and production capacity is expected to be 120 units i.e. 60 pairs per day.

Hence, Expected Production capacity after a month or so =1440 pairs or furniture set

= 2880 Units per month.

WORKING CAPITAL

The working capital consists of direct and indirect expenses. The direct expenses are again distributed in direct material and direct labor. The direct material like a) Bamboo Boards b) Bamboo Timber c) Allen sockets, Barrel nut, right angle connectors/dowels d) Thinner, adhesive, paint e) Edge Banding strip f) Sand paper (belts etc.). Direct labor consists of production labor. The overheads like electricity, water, other facilities, and maintenance and office staff expenses are considered. For a case of exemplified bamboo furniture product the direct expenses were added to produce Rs. 1, 54,100 per day. Cost of Each furniture unit then = Rs. 1, 54,100/40 No. = Rs. 3852.5 per pair.

Selling price (adding 35 % profit) = Rs. 3852.5 + Rs.1348.5 = Rs. 5,201/- per pair of furniture set. In case of Indirect expenses: If the production capacity of the plant is increased from 40 pairs to 60 pairs a day, (i.e. by 33%) then all the above projected costs are likely to be increased by 30%. And hence becomes = Rs. 1, 54, 100 + Rs 46, 230 = Rs. 2, 00,330/-

CALCULATION OF PAYBACK PERIOD

Considering SUPREME TOTAL investments of Rs. 01, 03, 71, 486 only (One Crore three lakh seventy one thousand four hundred and eighty six only)

Following *calculations* are made for and applicable, if and only if demands from market are 100 % favourable:

Total investments = Rs. 01, 03, 71,486/ ----- (1)

Profit per pair (as calculated earlier) = Rs. 1348.5/ ---- (2)

Hence manufacture of total number of furniture pairs required = [(1) ÷ (2)] = 7,692 pairs

With production capacity of 40 pairs each day

Then the days required= 7692/40 = 192.3 days (approx. 7 months)

If the work is only for 24 days a month (considering 6 Holidays a month),

Therefore, 6 holidays each month X 7 months = 42 days (holidays are added to 192 days)

= 234 days/30days ~ 8 months

PAY BACK PERIOD shall be approximately 8 months.

On the safer side,

It is speculated that the PAY BACK PERIOD may be considered to be double and rounded to

About 18 months = 1.5 years

III. CONCLUSION

It can be concluded that bamboo being a special material, both in socio-economic and environ friendly material, is finding a prominent place in modern civilized world. All types are furniture like domestic and industrial furniture including modular furniture can be manufactured from the bamboo board, bamboo timer and round bamboo. Considering the rapidly improving properties of bamboo composite and its advantages, it is likely even to replace some metals and polymer in near future. To cater these requirements bamboo furniture manufacturing units must be strongly favoured by countries in Asia and especially in India. The research case considered in this paper is a demonstration of upcoming era of transformation in tribal and agricultural based industries. The paper demonstrates a strong scope and possibility of establishing successful bamboo furniture related enterprise. The investments if made of order 1 crore can be paid back with a year and half, provided all the design factors are favourable.

IV. ACKNOWLEDGMENTS

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