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# A Plant Layout Design for a Bamboo Furniture Industry

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**ABSTRACT**

The general reasons found to revise the design of furniture manufacturing unit are: Low production capacity, conventional machines and operating tools, non-scientific 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, production capacity, 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 genera (Ahmad, 2011; Zhang et al., 2002). 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, aluminium 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 (Bauchongkol et. al. 2009). 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 (Malanit et. al., 2011, Sumardi et. al., 2008).

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 (Latif et. al., 2002, Nugroho et. al., 2001). 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 (Freeman et. al., 1959, Anwar et. al., 2005, Judziewicz et. al., 2007).

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. 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.

### A. General Objectives of Factory Layout

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.

### B. 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

### C. 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.

### D. 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.

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.

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

| Sr. No. | 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 |

### E. 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

| S. 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<br>2) Cutter machine<br>3) Sander Machine<br>4) Jig saw Machine<br>5) Router Machine<br>6) Planner Machine<br>7) Trimmer Machine<br>8) Drill Machines<br>9) Screw Driver<br>10) Hammer Drill m/c<br>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 |

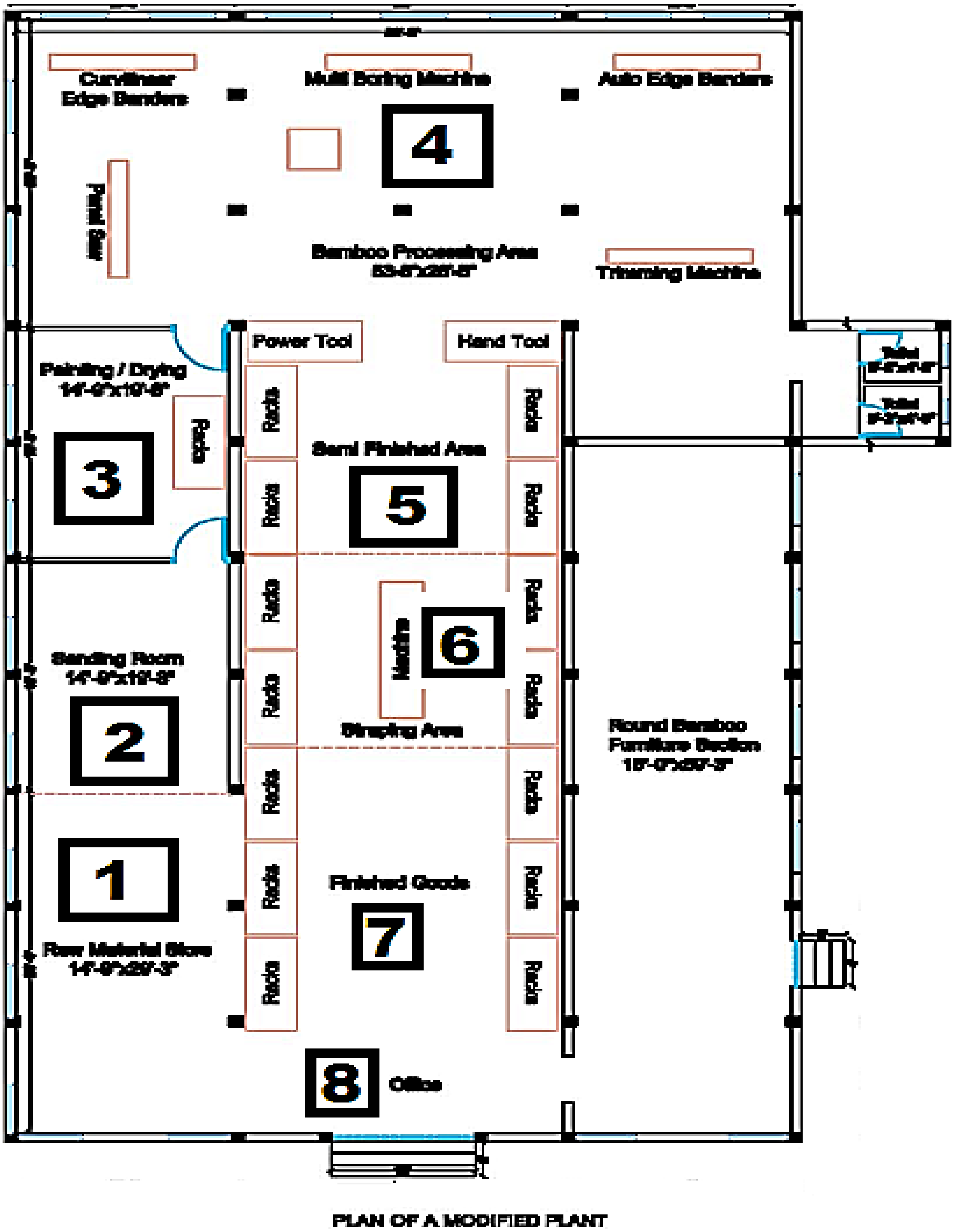


**Figure 1 :** plan of proposed plant layout for bamboo furniture manufacturing unit

### F. Manpower Requirement

Since bamboo inherits typically specific mechanical properties, unlike the wood processing operations, it requires trained artisans and machinists for final form conversions. In general, bamboo preservation, processing and treatments needs skills developed through training and experience. Further, office staff like supervisors, accountants, riggers and helpers constitutes the complete bamboo factory unit. The skilled, semiskilled labor technicians along with the office staff and supervisor are presented in Table 3.

**Table 3:** Manpower required for furniture manufacturing unit

| S. 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 |
| 10 | Supervisor |
| 11 | Accountant |

### G. Production Capacity

The production capacity depends on fullest utilization of production equipment, floor space, advanced technology, and organization of manpower. The estimate of production capacity uses the production-measuring units. The produced units are the simplest and most accurate measures. The production capacity determines the capacity of a production unit or factory. Measures designed to eliminate bottlenecks are accounted in calculating the 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 min/480 min. = 8.47 = 9 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.

### H. Working Capital

Working capital is a common measure of a financial liquidity, efficiency, and overall financial health. Working capital includes cash, inventory, accounts receivable, accounts payable, the portion of debt due within one year, and other short-term accounts. It reflects the results of inventory management, debt management, revenue collection and payments to suppliers. Positive working capital indicates that a company is able to pay off its short-term liabilities almost immediately. Negative working capital generally indicates a company is unable to do so. This is why analysts are sensitive to decreases in working capital. Increases in working capital, on the other hand, suggest the opposite. There are several ways to evaluate a company's working capital further, including calculating the inventory-turnover ratio, the receivables ratio, days payable, the current ratio, and the quick ratio. One of the most significant uses of working capital is inventory. The longer inventory sits in the warehouse, the longer the company's working capital is holds up.

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 labour 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/-

## III. CALCULATION OF PAYBACK PERIOD

Payback period is the amount of time required for the return on an investment to return the sum of original investment. 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

## IV.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.

## V. ACKNOWLEDGMENTS

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