MANAGEMENT IN THE PORTSMOUTH BLOCK MILL, 1803-1812

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ABSTRACT

The Portsmouth Block Mills' operations are assessed using archival materials showing staff numbers, hours and work assignments, providing insight into scheduling and workload management, capacity availability and use, and overall facility organization and design. A review of production records reveals items made specifically to meet individual production requirements and those made for "stock" and later use, and the Mill's internal lines ran in a relatively"lean" fashion.

INTRODUCTION

The Portsmouth Block Mill was built in 1803 to produce blocks (pulleys) for the Royal Navy. It was implemented as part of Samuel Bentham's reforms in the Royal Navy's operations with machinery designed by Marc Isambard Brunel and built by Henry Maudslay. Cooper (1981-2, 1984) described it as a production line and her analysis can be extended using newly found data on the Mill's production (Anon., 1809C) and operations (Burr, 1812; Anon., 1809B). These show the Mill was well designed and managed. A better understanding of the Mill's management and its operations will have popular appeal as well as academic interest. The Mill's operations may reveal historic management techniques that were more widely used.

Historical Context

The Mill reflected contemporary management understanding applying the idea of tightly linked production processes to producing discrete units in a batch production mode. The mechanization of these processes was innovative, requiring new working methods and management of inter-related processes. The factory was making a simple product in large numbers of small batches of standardized, though somewhat different designs and sizes. These features simplified the factory's management. However, the Mill's management may not reflect wide-spread thinking or practice. Coats (2006, p. 59) observes that Bentham sought to "…enable ***best*** [emphasis added] practice from public and private enterprise to drive reform and innovation…." Cooper (1981-2) observes that although British factories did not directly emulate the Mill its indirect influence was substantial through the three principals. Notwithstanding these reservations, the Mill's management practices would have been more widely useful. During the Mill's first years its capacity was insufficient to meet demand, thereby revealing management's efforts to bring in equipment and obtain materials to function most effectively.

New Data

The volume and detailed archival records reflect the conflicts surrounding the Mill. Coats (2006, p. 63) observes that the Mill was introduced at a time "…while these [Management]

Boards were barely speaking to one another. Perhaps because relations were so bad, correspondence is remarkably detailed… as if all sides realised they might at some future point have to justify every action to a commission." Furthermore, records are unusually detailed since the payments for Brunel were to be based on cost savings *vis-à-vis* older production methods. Additional weekly labour reports (Burr, 1812) identify individual workers, their work assignments to named processes making specific block components; the time individual workers worked in days, fractional days and hours, their weekly pay and its breakdown in quantities (usually hundreds or dozens, or fractions thereof) of components made at given piece rates. These provide information about shop-floor organisation, work rates and output, and allow inferences about the Mill's operations. In addition, Anon. (1808, 1809B) show work-in-progress inventories that allow inferences to be drawn about inventory management, production batch sizes and processing policies.

Actual Production and Theoretical Demand

Although the Mill could manufacture all the blocks that the Navy required, Coats (2005) and Gilbert (1965, p. 1) say that was 100,000 per year, though Gilbert (1965) also claims the maximum output was 130,000. Morriss (2011, p. 181) claims that 150,000 were made annually during the Crimean War. Production records have been found (Anon, 15/Sept/1809C) that detail the types and numbers of blocks made. The Mill produced 130,475 blocks in 1808, with 125,228 completely made on Brunel's machines and 5,247 oversized blocks that likely had some machine-made components, with another 10,321 "deadeyes", machine-made in most sizes; for a total output of 140,796 blocks in 1808.

The Mill was claimed to be capable of fully satisfying the Navy's demand, but having these figures does not fully resolve whether it was able to do so. The case that the Mill could satisfy demand fully will be strengthened by providing an independent estimate of demand. In this unusual case the theoretical demand can be estimated since the Navy was the only customer and it used blocks for clear purposes linked to the numbers of its ships. The concept of dependent demand (Jacobs and Chase, 2013) can be used, then giving estimates of the blocks used each year: an overall total estimated as 800,000 blocks; with about 750,000 of the types manufactured by the Mill. Unsupported estimates that the Navy used one million blocks are repeated (Cooper, 1981-2); this provides a foundation for that. An estimate (1/6 of the 800,000 blocks in active service) of replacement requirements yields an annual demand for 125,000 blocks, roughly matching the number made in 1808.

Machine Loading and Coordinating Production

The data allow an assessment of the factory's design and use: how its equipment and workforce could be most effectively deployed. The first set of machines installed were those with the greatest demand. The next set introduced for small blocks could then satisfy the next greatest demand. The last set for large blocks was installed to supply the rest of demand. The introduction of the machines was rational, delivering the most useful set of machines first.

The overlaps in machine capacity provided flexibility for manufacturing and can be inferred to be a conscious design decision. Both block-making and deadeye machines were very expensive and their design and use would reflect real manufacturing needs. Given the heavier demand and workloads on the large and medium sized block machines this flexibility in allowing production to shift to less heavily loaded machines was sensible.

Capacity, Staff Workloads and Work Patterns

Cooper (1981-2) analyses the production rates for the machines and concludes that they were well-balanced and allowed the close coordination required by a production line. Cooper (1984, p. 206) quotes Brunel saying the Mill could make 700 small, 520 medium and 200 large blocks daily. She does not recognize this equals 440,000 blocks annually, significantly more than the number made or required. Using production rates reveals that meeting demand in 1808 would require roughly 155 days' production of the large blocks required using just the large machines; 83 days of medium machines' time and 92 days of the small ones'. None of the machine sets was needed full-time throughout the year; but all three ***together*** provided a full year's workload. Thus, episodically, each set of machines ***might*** have operated continuously as a line, with workers shifted between them as a team.

Thus, each machine set's capacity was adequate to handle demand; and if, as Cooper (1981-2, 1984) and Wilkin (1999) assumed, an individual worker was dedicated to each machine then labour would have been underutilized. But, if a single workforce was shifted between machine sets as required, labour could then have been fully employed. Management did not maximize machine use. Contemporary evidence supports the interpretation that machines were not individually manned; but, instead, were used by just four workers moving between them.

FLEXIBLE WORK PATTERNS AND CAPACITY

The Mill was commissioned to make more blocks cheaply and quickly than its outside contractors. (Coad, 2005) The critical issue was production capacity and the inability of its vendor to easily increase production from off-peak, peace-time levels to the full scale demands of war-time. Once the Mill reached full capacity it then appears that the Mill's management adjusted output to match demand by varying staff work patterns.

For example, Figure 1 shows a workload profile for the first process in making block shells: the "conversion" of Elm logs into roughly shaped blocks. It plots a stacked area graph for each workman's earnings throughout 1812; with the highest earner on the lowest strata up to the lowest paid on the top. This shows Mr. Chamberlain was employed regularly through the year (with one week off in October) at a constant intensity since the "thickness" of the strata is stable. The next best paid worker, Mr. Drew, worked on a similar basis for the first three months while Messrs Jolliet and Thorne worked alternate weeks, as may be seen in the "saw-tooth" pattern for their earnings: if they worked, it was full time. In mid-year those work patterns for all except Mr. Chamberlain were upset; but from mid-July onwards, Messrs Drew, Jolliett and Thorne worked a rota with each generally working two weeks on and one week off; again shown as a blunted saw-tooth pattern in their earnings. Output for most of the year yielded weekly payments of just under £5 total. Of particular note is the final six week period in which all four workmen and another were fully employed, the Mill then virtually doubled its weekly output compared to the first six months' production. The Mill seems to have regularly underutilized its workers as well as its equipment.

Insert Figure 1 Here

It may seem odd that staff would work half- or two-thirds time as some did for much of the year unless wages were high enough to make such employment attractive. Working practices in the Dockyards had previously been flexible as a policy encouraging labour's loyalty and reliability. Uncertain employment was endemic in the industry and the Mill seems stable by comparison. It appears that dockyard workers were more regularly employed at better wages under an easier regime than were their civilian counterparts.

Materials Control and Batch Sizing Policies

The Mill did not perform all production processes at the time demand arose—a mixed strategy was used sometimes, in which components were made in batches, and the finished block assembled only when an order was received. This make-to-stock, assemble-to-order policy was appropriate for components such as the pins, coaks and sheaves that could be used in a variety of different types and sizes of blocks. The more heavily required and regularly produced items seem demand-driven in that the quantities made do not seem to reflect consistent batch sizes (recurring identical or multiples of fixed quantities); but that variation may be a consequence of variations in process yields or inputs since logs naturally vary in size and have imperfections that create uncertain yields.

These impressions are confirmed by the work-in-progress (WIP) data for 1808 and 1809. The descriptions of the WIP items allow their positions in the processing sequence to be identified. This implies that a batch ran completely through all of the Brunel machines without pause with either one worker moving with it from one machine to the next, or the staff in that area working in a "leap-frog" manner. It is also possible that in 1808 when the Mill is said to have assigned four workers to these machines that they actually did operate as fully manned lines. However, the inherent inefficiencies due to balance delays make that unattractive, and this implies that the line did not run as a smooth flow of single units but instead that each machine and worker handled batches and the flows were intermittent, though the absence of any WIP between the block machines implies that a whole batch was fully processed through all of the machines within each day's work.

These WIP quantities are divided by the average production rates to show the workloads involved. Thus, for example, the 392 small rough shells took an estimated .56 day to make. The numbers of batches of small and medium sized blocks in WIP are small, usually fewer than four batches for rough blocks, and fewer than six in the sheaving and complete stages. Note that there were four workers making block shells and six making sheaves so these batch numbers seemingly reflect worker assignments to specific production batches as they progressed through the processing.

For sheaves there are more WIP "pauses" in processing. The implication is that they are "buffer stocks" used to insulate each process from variations in their neighbours. (Jacobs and Chase, 2013) If one process ran faster than its predecessor it would reduce the WIP built up in front of it rather than run out of material. This maximized labour productivity since workers could work constantly, with variations in output imposed on these WIP stocks rather than affected other worker's productivity. Although there was a linear flow between these activities the pauses signified by these WIP stocks contributed to the Mill's efficient operation, rather than show a loss of control over material flow, or inefficiency in production line design. Variations in production rates would naturally arise when different sized batches of different size sheaves were processed making their workloads naturally vary too. These unavoidable differences made smooth flows through linked processes impossible. Good management would plan and use WIP stocks to accommodate them. Figure 2 illustrates how these processes coordinated output between processes over time, although the correlations of weekly output between them were low,

Insert Figure 2 Here

The WIP stocks shown are relatively small, and seem planned to allow each process to work independently despite being strongly linked to its neighbours. The first process, the converting of lignum vitae logs into blanks processes the greatest number of units. The second process, boring and rounding, may be seen to track that almost exactly until mid-July when both plateau, representing a near halt in production for both and then production restarts in late August through late October when it ceases again until late November. If more staff were used, or if the production rate changed the slope of the line showing weekly output would change. Not only did these two processes start and stop together, but also the slopes of the lines are similar and "parallel", meaning that their rates of production matched. Differences between them arise from a delay in processing materials, shown as a horizontal displacement. The following processes are similarly coordinated.

CONCLUSIONS

The Portsmouth Block Mills were able to satisfy fully the Royal Navy's requirements for blocks and had the capacity to meet any future requirements. The Mill's equipment was designed to allow different size blocks to be allocated between the machines so that demand could most effectively be met, particularly if the most heavily loaded machines' demands increased in the future. The excess capacity of these machines shows that they were not used continuously, as Cooper (1981-2, 1984) and Wilkin (1999) supposed; and that even during 1808 when demand was heaviest staff were moved between them to maximize labour productivity rather than machine utilization. In 1812, when production was reduced from its 1808 levels staff levels were still kept higher than necessary but reduced the intensity with which they were employed through rotating shift patterns or reduced hours. The materials used within the Mill seem to be well managed with small batch sizes and low work-in-process stocks. Raw materials and finished goods inventories seem rather large, but given the slowness of communications and transport that is expected. The Mills were well designed by Brunel and Bentham, and seem to have been well managed by Bentham, Goodrich and Burr. Considering modern management theory and practice the Mills were effectively designed and well used with staff managed to maximize their productivity.

ACKNOWLDEGEMENTS

I would like to thank ***Carnegie Trust for the Universities of Scotland*** for their supporting grant.

REFERENCES

Available upon Request from the author.

FIGURE 1
Converting Elm Workload Profile

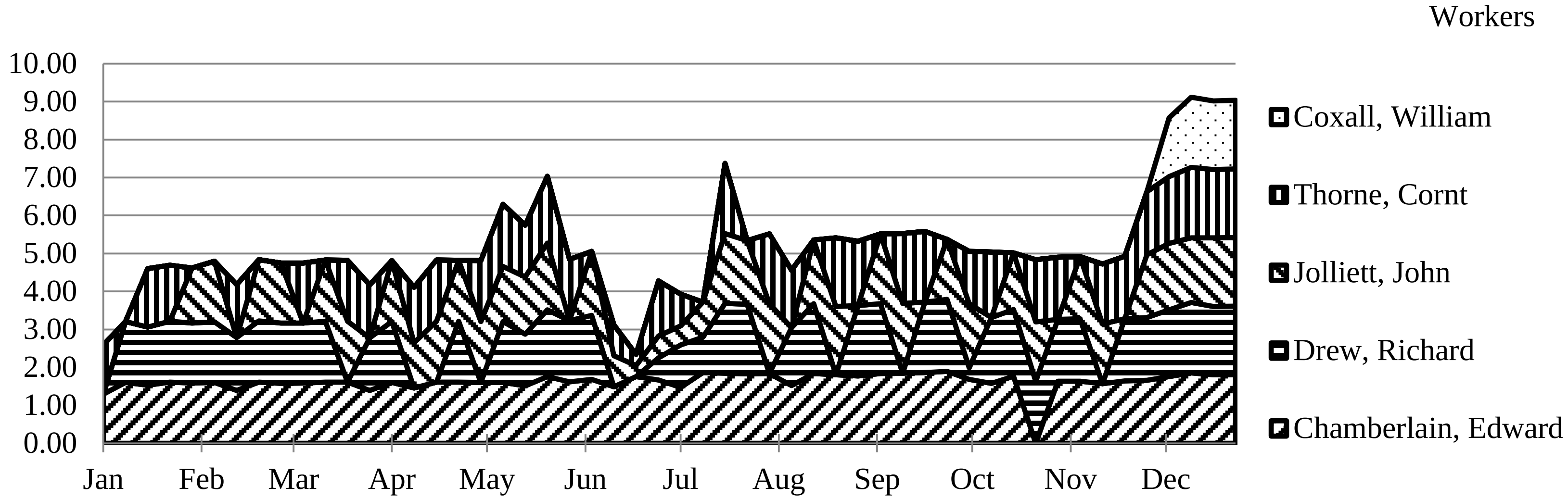
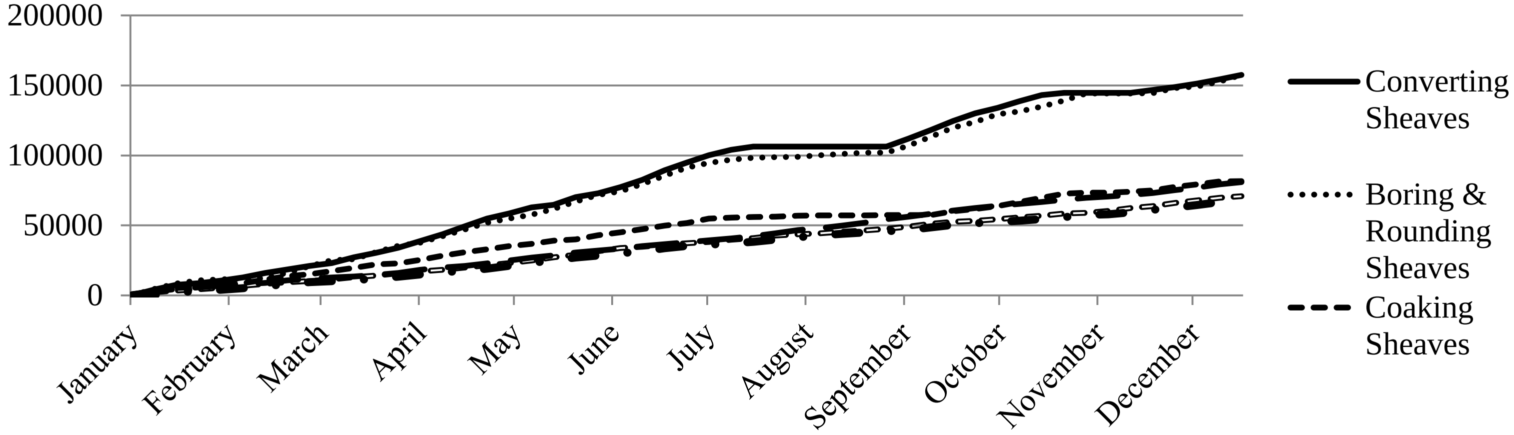


FIGURE 2
Sheave Production Processes Cumulative Output



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