The Impact of Manufacturing Execution Systems on Labor Overheads

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***Abstract*— The advantages of Manufacturing Execution Systems have been well documented. One such advantage, reduced labour overheads, has been tested at an agile manufacturing facility to determine the extent of this capability. A review of literature is initially presented from which a hypothesis is developed. The methodology and research stages are then described, followed by the findings. The paper concludes with the results of the findings and the limitations of this research.**

***Index Terms*— Cost-benefit analysis, justification analysis, labor overheads, manufacturing execution systems.**

I. INTRODUCTION

With economies in recession, manufacturing is under ever more pressure from global markets to produce high quality products at low costs and short lead times. An injection molding plant faces these same market pressures, and, coupled with a marked decrease in demand leaving machine and labor capacity unutilized, efforts are being continually made to improve the financial and operational capabilities of the company. This paper will describe one such study conducted to evaluate opportunities to reduce labor overheads attributed to manufacturing execution and control.

Manufacturing at the company is a combination of make-to-order and make-to-stock. With high product variety, low volumes and unpredictable demand, the manufacturing and planning systems have been designed to cope with such high volatility. The company has been using a software package which processes orders and manages materials and stock, however falls short of manufacturing planning and control. Thus, activities such as machine and labor resource planning and scheduling, works orders processing, data recording and acquisition, and performance monitoring have been performed using a plethora of labor and time intensive paper- and spreadsheet-based procedures.

Potential for savings in labor overheads being recognized, the company wished to evaluate opportunities to reduce the labor-dependency of administering its manufacturing execution systems (MES). This evaluation has been described in this paper which begins with creating a profile of MES from literature from which a hypothesis is proposed. The methodology used for this research is then described, followed by an explanation of the research stages. Finally, the information obtained from this examination is consolidated to test the hypothesis. This paper concludes with the findings of the research and its limitations.

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II. LITERATURE REVIEW

Computer Integrated Manufacturing (CIM) appears to possess the relevant capabilities to provide an efficient and flexible manufacturing system, capable of producing high quality products at low costs, and short lead times [1]. MES are a part of CIM supporting the information link between production planning and production process control [2], and are seen as an intermediary between high-level planning by ERP systems and operational-level manufacture of physical goods. The National Institute of Standards [3] defines MES as a collection of hardware/software components that enables the management and optimization of production activities from order launch to finished goods. The scope of MES includes, but is not limited to [3]:

- Resource allocation and tracking
- Scheduling
- Data Collection
- Labor Management
- Quality Management
- Process Management
- Maintenance Management, and
- Product Tracking

There exists a high degree of agreement in literature for the benefits of MES. MES has reduced the cost of production in several discreet manufacturing industries [2]. Plants using MES are found to be able to reduce costs more dramatically than plants not using MES [4], improving the return on operational assets, on-time delivery, inventory turns, gross margin and cash flow performance [5]. These benefits are not only restricted to profitability, but extend to include improvements in productivity, process improvement and personnel development [4]. MES may also improve resources planning and allocation [6], and allows for supervision of process execution using current and accurate data [5], making it possible to promptly identify abnormal, deviant or critical states in the production process [7]. In essence, the benefits of MES are summed up as codifying best practice, empowering employees and reinforcing management systems – as conditions change [8].

Promotional material from suppliers of MES support these findings suggesting that MES can improve utilization and efficiencies, information timeliness and accuracy, and reduce

scrap and labor overheads via real-time machine monitoring, reporting, live scheduling, identification of process abnormalities and automatic data acquisition and interrogation.

The advantages of MES ranging from improving operational to financial performance have been identified in this literature review. It stands for companies to identify opportunities for improvement and present a suitable justification for investing in MES. These systems can be justified based upon fulfilling purely financial, strategic or operational aims, by using faith alone [9], or a combination of these. The basic problem with justifying new manufacturing technologies is that their advantages lie not in the areas of cost reduction, but rather in more nebulous, strategic areas such as shorter lead times, simpler scheduling, and more consistent quality [10]. This has been recognized in the current study, however reduced throughput has left machine and labor capacity unutilized and, *ceteris paribus*, employees have fewer tasks to manage and more time to manage them. Justifying investment on the basis of shortening lead-times, expanding capacity and controlling rejects, in an environment where lead-times have been met due to availability of resources, capacity has been left unutilized and rejects have been under control, seems fruitless. It has thus been left for such an investment to be justified based upon a reduction in labor overheads. To this end the following hypothesis is proposed.

Hypothesis: Reduced labor overheads alone can justify investment in MES.

III. METHODOLOGY

Due to the growing frequency and magnitude of changes in technology, operations management researchers have been calling for greater employment of field-based research methods [11]. A case study at an injection molding Small & Medium Sized Enterprise has been used to test our hypothesis. The research instruments used to facilitate this evaluation have been described below.

Face-to-face interviews

Face-to-face interviews have been conducted with experts at the company to identify current manufacturing execution procedures, and later, to validate findings.

Sampling

Primary data collection requires suitable sampling. Calculating the labor overheads of selected activities in the study has been conducted using a suitable set of samples.

Online & On-site demonstrations

Online demonstrations of MES software have been conducted to ascertain an initial profile of the capabilities of MES, followed by on-site demonstrations to provide a more comprehensive view of capabilities.

Structured Questionnaire

A structured questionnaire has been used to create a profile of each MES evaluated.

Simulations

Simulations on demonstration software have also been conducted to identify the labor overheads for administering an MES.

IV. RESEARCH STAGES

From interviews with experts at the company a current state map for the entire process of order execution has been created. For each activity, sampling studies ascertained the time and labor resource required for successful execution, and each activity's impact on the performance of successful order fulfillment has been identified. This has created a holistic picture of the lead-times for current order fulfillment procedures, the labor overheads incurred for administering this procedure and the relative importance each activity has on successful order fulfillment.

A survey of suitable MES software has been conducted, and with online demonstrations and e-mail correspondence, a suitably realistic future state map of order execution has been created. On-site demonstrations by different system suppliers were followed up with a questionnaire probing those capabilities of their MES which were found wanting in the current system; thus in effect ascertaining whether MES could fill the necessary gaps identified in the current system. Simulations of planning, works orders processing, manufacturing execution and data acquisition and reporting have been conducted using demonstration software to identify the scope of generic MES capabilities and quantify the extent of labor overheads required to administer such systems.

V. FINDINGS

Four functional areas, consisting of a total of ten separate activities formed the basis of the analysis comparing the costs of the current system with an MES. Based upon this comparison we have tested the proposed hypothesis.

Hypothesis: Reduced labor overheads alone can justify investment in MES.

It was found that there was a marked reduction in labor overheads required to perform most of the activities. Across the board the labor overheads required to administer the software system was 50% less than the overheads needed to administer the current systems, though these reductions were not equally distributed among the activities studied (Fig. 1).

It was apparent that there would be a reduction in labor overheads to administer manufacturing execution at the company. However, the crucial question regarding when the company would be able to realize these benefits still remained. There exist a number of formulae and approaches

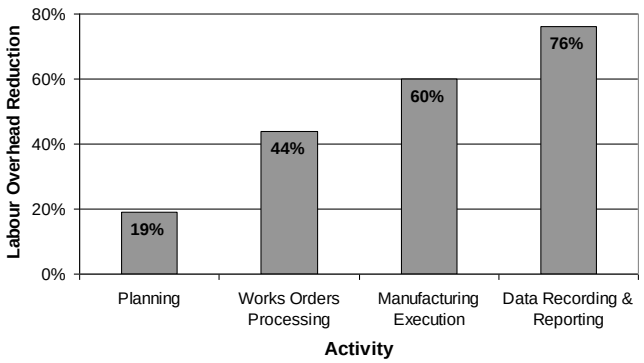

Figure 1. Reduction in Labor Overheads for Different Activities

that firms use for the economic justification of equipment [10], however, an overwhelming majority of firms (91%) use only the payback and return on investment approaches [12]. In addition to these two approaches, the internal rate of return approach has also been used in this study.

Based upon the intent to reduce labor overheads, a positive cash flow from the investment would only be realized by either reducing current production personnel, or, once reaching higher capacity utilization levels, to invest in technology as against employing more staff. It has been observed that the reduction in labor overheads was spread across different functional areas relating to numerous employees at the company. No single role at current capacity utilization levels could be wholly replaced with an MES, effectively mitigating the possibility of a positive payback, return on investment or internal rate of return at current levels of capacity utilization.

It has thus been left to identify a level of capacity utilization at which current labor resources would not be able to cope, and where investment in the MES may be favored against employing more staff. Using extrapolated calculations, an MES investment would show a positive payback only on exceeding 80% of capacity utilization. At 100% capacity utilization the payback period of the investment has been found to be in excess of 2 years. Return on investment calculated [10] at 100% capacity utilization has been found to be 17% with depreciation netted out and 37% without depreciation. A positive return on investment with depreciation netted out is only realized on reaching 89% capacity utilization, as below this level cash inflows are unable to offset initial capital expenditure and operating costs for the life of the asset. A similar result, for similar reasons, is realized using the internal rate of return approach, though the investment offers a 25% internal rate of return at 100% capacity utilization (Fig. 2).

VI. CONCLUSION & DISCUSSION

Based upon this evaluation and considering the criteria used for it, the hypothesis does not hold true at current levels of capacity utilization. A definite reduction in labor hours can be realized by replacing current systems with MES, though as found, these benefits would merely reduce the time taken to perform tasks, rather than reduce the number of employees needed to perform them. Savings in labor overheads by replacing employees with MES start to become realizable only after exceeding 80% of the factory's capacity utilization. Though, considering the feasibility analyses conducted and the numerous other criteria used for investment decision making, the economic feasibility of such an investment would be seen to require higher capacity utilization from the factory to justify the investment.

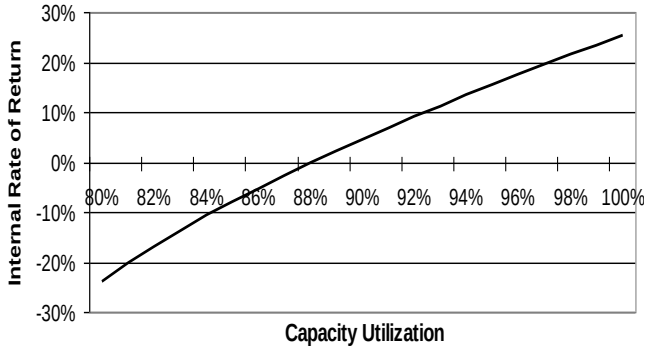

Figure 2. Internal Rates of Return at Different Levels of Capacity Utilization

This study has been conducted with appropriate rigor and impartiality, and within the boundaries of the research constructs, however it is in no manner a complete evaluation of the capabilities of MES. The study has been conducted within a narrow scope due to numerous factors, and as such, generalizations from the findings should be made with caution. The economic feasibility analyses have not been complemented with analytic and strategic justification approaches. Only one of the numerous benefits of MES identified in literature have been tested, and more so, those core advantages of MES which lie in the strategic areas of shorter lead times, simpler scheduling and more consistent quality [10] have not been evaluated. Such evaluations would be more justifiable to conduct once capacity utilization reaches levels where MES would facilitate realizing these benefits.

To survive in an environment of economic recession, organizations must seek new ways to improve competitiveness and reduce waste at all levels of the organization. MES are sometimes regarded as monolithic, insufficiently configurable, and difficult to modify [13], where installing such software and integrating it with current systems is found to be a challenging and costly undertaking [14]. When organizations, like the one studied, may find it difficult to justify such investment with gaps in their order books and capacity in abundance, it is left for MES suppliers to develop solutions which tackle the immediate need for organizations to reduce costs and improve cash flow. Affordable point solutions that strengthen localized capabilities such as energy and waste management may be easier to justify than full product suites. To weather the storm and land near the pot of gold at the end of the rainbow, manufacturers too need to reevaluate their strategic direction and pursue business objectives aggressively [15], filling gaps in their capabilities via small but strategic investments.

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