EXPLORING THE ROLE OF VISUAL CONTROLS ON MOBILE CELL MANUFACTURING: A CASE STUDY ON DRYWALL TECHNOLOGY

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ABSTRACT

This paper stresses the impact of using visual controls in a mobile cell implementation in the construction industry, expanding the analysis carried out by Santos, Moser & Tookey (2002) within the same research project. The investigation was carried out using a case study research method and focused on the drywall technology. The whole research was carried out in two phases. Initial phase: a diagnosis on drywall practices in three companies. The observations showed various problems such as improvisation with tools, poor workflow planning and the absence of adequate drywall design plans. Second phase: implementation of a mobile cell. The study showed that developing adequate visual controls on the workstations, packages, and the materials themselves is a key factor to enable a successful implementation of mobile cells in construction. However, the frequent movement of workstations throughout the construction site demands visual controls with higher mobility than current on-the-shelf visual controls, which is in itself an opportunity for further innovation in construction.

KEY WORDS

Visual Control, mobile cell, cellular manufacturing

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INTRODUCTION

Previous research carried out by the authors presented an exploratory study that investigated the application of the mobile cell manufacturing concept within the construction environment (Santos, Moser & Tookey, 2002). The study showed that the concept of "mobile cells" is feasible in construction and deserves further research and dissemination within the construction industry. Its main virtue in terms of lean construction implementation is the fact that it enables (and requires) simultaneous integration of most lean ideas within a single environment.

The present paper discusses the use of visual management practices within the cell manufacturing environment in order to obtain "process transparency". Santos (1999) defines transparency as the ability of a production activity to communicate with people. There are several implementation approaches used to increase process transparency since the operational level in the construction site until broader approaches applied at the organizational level. Santos, Powell, Sharp & Formoso (1998) have already pointed visual controls as a source of innovative solutions on visual management for construction when comparing Brazilian and British construction practices. The present paper reinforces such conclusions and points out its benefit on the implementation of a mobile cell in construction.

WHAT IS A MOBILE CELL MANUFACTURING?

Cell manufacturing (CM) encapsulates most lean production practices within a single environment and, thus, we understand that it can be used as a focus for lean implementation initiatives. Hyer & Brown (1999) define cellular manufacturing as an environment that dedicates equipment and materials to a family of parts or products with similar processing requirements by creating a work flow where tasks and those who perform them are closely connected in terms of time, space and information. Similarly, Steudell & Desruelle (1992:264) understand cells (or work-cells) as a group of closely linked, dissimilar workstations (automatic or manual) that are dedicated to performing a sequence of production on families of similar parts or products

Research carried out by Santos, Tookey & Moser (2001) showed that mobile cells could handle most problems identified in the traditional sequential mode of production observed in construction. Implementing the Cell Manufacturing concept had a significant impact in all problems pointed during the diagnosis phase carried out in the drywall process. There was lesser improvisation on transport and storage locations since now the drywall team was responsible for layout and workflow planning. Previously this was the foreman responsibility and there was little commitment of the workforce to implement his plans.

Additionally, the improvements in ergonomics increased the motivation of workers and their perception on the benefits that cell manufacturing brought to their every day operations. Cycle time was reduced with the reduction on set-up time and improvements in the communication among the drywall team. They now have a walk-talk attached to the workstation. Furthermore, people working in different process stages were now working closer to each other and that is a key factor to promote faster correction of errors (Santos, Tookey & Moser, 2001).

Hyer & Brown (1999) propose an underlying theory to describe the discipline necessary for effective manufacturing cell operation. They differentiate real cells from other types of cells based on the presence of key linkages. In a real cell, operations and those who perform them are connected in terms of time, space and, foremost, information. Factors such as the need for multi-skill operators, reduced set-up times, small transfer batch size, and the presence of visual controls can be viewed as enablers that strengthen the discipline of real cells.

Hyer & Brown (1999) define the information linkage mentioned above as follow: “people and machines responsible for cell activities have access to complete information about the work within the cell”. The information to which the dedicated people and machines must have access may include production goals, order status, specifications, procedures, part availability, equipment function and so forth. The relative importance of each type of information depends on the situation. However, information itself is not sufficient – to be effective, information must be timely, accurate and complete (Galsworth, 1997). A number of enablers related to visual management can help translate information into reduced process cycle time. These enablers must grant operators the authority and responsibility to act on information. Written reports, oral communication, material accumulation at a particular workstation, lights, and even music can be used as calls for operator intervention (Hyer & Brown 1999).

DEFINITION OF PROCESS TRANSPARENCY

“Increase of transparency” means to increase the ability of a production activity to communicate with people (Santos, 1999). This is one of the core principles behind a number of managerial methodologies and techniques such as Visual Management, Kanban, 5S programs, Andon, Poka-yoke, and so on. The way in which information is organised for accessibility is the distinguishing feature of “transparency” as portrayed in modern theories. In conventional communication, information is transmitted in a “push” mode and the user has little or no control over the amount and type of information that is transmitted or received. In contrast, in the new paradigm nothing is transmitted: an information field is created which can be “pulled” by any person at any time (Greif, 1989). This is a fundamental move from the usual silent production process to a more communicative one, more self-explanatory, self-ordering, self-regulating, and self-improving (Galsworth, 1997).

Production systems operating in competitive environments should no longer lead to loss of time with people searching for information. According to Galsworth (1997), information should be part of the process, as physically close as possible, pre-set at the point-of-use, fresh and available at a glance, without the need of people to ask questions or spend time processing it. In short, the process itself should be able to inform its state.

A transparent (or visual) workplace/process is characterised by a certain dualism, existing simultaneously, communication directed toward a group’s internal need and messages to people outside the workplace (Greif, 1989:27; NKS, 1991:4). In an ideal situation, even a lay visitor should be able to understand what is happening in any production process and, consequently, be able to identify problems. This definition goes against traditional ways of thinking, such as the one exemplified in the phrase of Edwards & Peppard (1994:252): “Customers do not recognise much of what goes on within an organisation, nor should they”.

IMPACT ON PRODUCTION SYSTEMS

Transparency can be used as an instrument to increase the motivation of workers for improvement, reduce the propensity of errors and, most certainly, increase the visibility of errors (Koskela, 1992). The manufacturing literature shows a list of other advantages relating to the implementation of transparency, such as (Greif, 1989; AKS, 1991):

- Simplification and greater coherence in decision making;
- Stimulation of informal contacts throughout different hierarchical levels;
- Contribution to introduction of decentralisation policies;
- Helps to broaden employees participation and autonomy in management;
- More effective distribution of responsibilities;
- Increase in employee morale;
- More effectiveness of production scheduling;
- Simplification of production control systems;
- Rapid comprehension and response to problems.

USE OF VISUAL CONTROLS TO INCREASE TRANSPARENCY

Visual controls can give an important contribution to enhance efficiency of production systems. The term "visual" includes messages communicated through any of the senses: tasting, touching, hearing, seeing or smelling. Thus, visual controls could also be understood as “sensorial controls”. The easy and fast identification of waste, or any other process problems, helps enabling and promoting continuous improvement activities. For instance, appropriate visual controls should be able to help people to identify whether or not boxes of a certain item are where they should be, or if they have exceeded the maximum limit of a required quantity. In an ideal situation, anyone should be able to detect or avoid errors like this and, thus, contributing to improve the process performance.

In the manufacturing industry, the pressure for achieving increasingly high levels of process performance has driven the development of a great variety of visual controls. The most mentioned visual controls in the literature are:

- Kanban: this is intensively used in “pull production systems” as a major instrument for communicating orders from downstream to upstream workstations. Kanban is usually associated with cards but, it actually has many different formats such as coloured containers or even limited areas painted on the floor (Steudel & Desruelle, 1992);
- Call Light: this is used when an operator regularly needs to call for a supervisor, maintenance worker or a general worker. Usually there are several different colours of lights and each one is used to summon a different type of assistance (Monden, 1998);

- Andon: this means “lantern” in Japanese. Andon is a nickname for the indicator board that shows when and where a worker has stopped the line (Monden, 1998);
- Digital Display Panels: this shows the pace of production, with information such as the day’s production goal and the unit’s production so far (Monden, 1998);
- Visual Controls in Poka-yoke Devices: (PokaYoke – mistake-proof devices) usually consists of a detecting instrument, a restricting tool and/or a signalling device. The signalling device alerts the operator when it detects an abnormality or defect (Monden, 1998).

Another important visual control often mentioned in the literature is called “bordering”. Bordering is used to indicate the space for the designated location of a production process, making it clear when an item is not at its appropriate location. In world-class companies, factory after factory has shown that a simple floor border offers a positive contribution to increase production efficiency, even in situations where the layout is constantly changing. Such companies use borders in many different ways and for many different purposes, for example (Galsworth, 1997):

- differentiation between walk-ways from work-ways;
- as a trigger for improvement, through the identification of as many forms of movement as possible;
- identification of minimum/maximum supply levels;
- home addressing for equipment (e.g. profile or silhouette painted on the place for storing tools or equipment).

Allied to bordering is the practice of giving address names or numbers for locations and identification labels to materials, tools or equipment. Working together, “borders”, “home addresses”, and “identification labels” ensure item recoil. Galsworth defines “item recoil” as the capacity of an object to find its way back to its designated location (home), solely on the basis of location information built into it. In practice, this means that every item that leaves its designated location is more likely to come back to its original position. These are also crucial requirements for better health and safety conditions in any production system. When there is a need to find a fire extinguisher, for instance, there can be no waste of time (Galsworth, 1997).

Colour is an important consideration for bordering and for transparency in general. Standard specifications such as OSHA and ANSI give guidelines for the adequate use of each particular colour. For example: red is used when meaning stop, to mark emergency stop bars and stop buttons on hazardous machines; green is used when meaning safety and to mark the location of first aid and safety equipment (Galsworth, 1997).

RESEARCH METHOD

The assessment of visual controls in a “mobile cell” was carried out within a single case study. The investigation demanded the development of the study in “real world” conditions to reflect an actual situation faced by practitioners in everyday life. Real world conditions imply little or no control over the events surrounding the observed practices (Robson, 1993). These requirements resulted in the adoption of a case study research strategy. The most widely accepted definition of case study is given by Yin (1994:13) who defines it as ”an empirical inquiry that investigates a contemporary phenomenon within its real-life context and where the boundaries between phenomenon and context are not clearly evident”. The entire case study lasted six months and included a number of activities such as training sessions for the workforce and the development of new equipment for workstations.

RESULTS AND ANALYSIS

The concept of cell manufacturing is an innovative solution for organising the construction process but, as the case study showed, the use of visual management practices such as visual controls is fundamental for obtaining all its benefits. When operators have timely, accurate, and complete information they can use it to reduce operating times and the visual controls are an important driver for reducing or eliminating the possibility of errors or the need for spending time on measurement and control activities in this new work organization model. Some of the examples of visual controls implemented in this case study includes:

- Bordering: prior to cell implementation there was no clear definition of production flows and, as data gathered from process mapping and work sampling showed, that was one of the key causes of disruption on the production flow. In order to tackle such a problem one of the solutions implemented during the case study was the use of indicative “arrows” painted on the floor showing the most efficient production flow. It also helped workers to anticipate the next operations and their correspondent requirements in terms of space usage. All other pathways within this construction site, including those paths for visitors also benefit from this solution as confirmed by interviews carried out at the end of the study;
- Product Label: the speedy understanding of proper positions for materials and equipment as well as measures used to take excessive time from workers and managers. As one of the improvements developed during the case study all components processed on site received labels specifying their exact destination and other complementary process information. For example, labels placed on components such as “studs”, along with the signs on the floor, enabled fast recognition of every component destination;
- Walkie-talkie on the workstation: in order to enable faster communication within the workstation and, also, among all other workstations every operative leader had direct communication with site managers at any time through a walk-talk. This simple device attached to the workstation allowed anticipation of easy solutions, particularly for those problems with potential to disrupt workflow.

One of the lessons from attempting the implementation of visual (sensorial) controls in a mobile workstation in construction was the lack of adequate on-the-shelf mobile visual controls in the market. Visual controls would work better in construction if they were portable and easy to install and update. That is not the case for most on-the-shelf visual controls as they focus mostly on safety aspects of production, and normally offer strictly solutions related to law requirements. Clearly, more visual controls were required in transportation (e.g. borders in storage) and processing activities (e.g. support to measurement activities). That could be a source of innovative solutions for construction.

The study showed that effective application of visual controls on cell environment depends on the degree of responsibility for process improvement shared with the workforce. That was the case in the present study since construction workers were fully involved in the development and implementation of all visual controls. The study also showed that visual control is a supporting approach and works better when it is surrounded by other complementary approaches of lean construction.

CONCLUSIONS

This research project showed that visual controls have to be part of the issues to be discussed in the early phases of mobile cell implementation. The lack of visual controls may result in poor understanding of process anomalies and process status. Process variability alone is a major obstacle for enabling the organisation of production around cells since in such environments there is no space for buffers. Finally, the results also showed that there is great opportunity for innovation by developing on-the-shelf visual (sensorials) controls to be incorporated in mobile workstations and that necessarily needs to consider all human senses in their development.

ACKNOWLEDGEMENTS

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