DIGITAL DATA COLLECTION AND VISUAL PROGRESS PRESENTATION OF BM BUILDING INDUSTRIES ANALOGUE PRODUCTION PROCESSES

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Abstract
The project conducted in this paper is a continuation of a VT1 project [1] conducted in collaboration with BM Building Industries (BM). It was concluded that data collection in a production environment mainly containing analogue processes, is difficult and not being done at present time. This initiated the desire for BM, to bring digital technologies into its production and start collecting data for visually monitoring the production progress, production planning, pinpointing bottlenecks and possible delay origins. BM is a company that produces and delivers complete buildings and enterprise solutions. These buildings are assembled by a set of bespoke pre-fabricated modules. BM's production of pre-fabricated modules is primarily consisting of analogue production processes such as painting, layering floor, inserting windows etc. The difficulty and time needed for completing these processes are subject to large variations because of the customization of the modules available to customers. At present time, planning and decision making is based on intuition and experience. BM would like to make the planning and decision-making in production data driven. The purpose of this paper is therefore to describe the usage of a system able to collect data from an analogue process and facilitate the data to be used to benefit the company in multiple aspects. It is lastly expected to provide usage and implementation guides together with tests and analysis of the implementation of these developments.

Keywords: Analogue Productions , Digitalization, Data collection, visualisation, Production Management, Monitorization

1. Data collection in analogue production companies

Most production companies have over the last half-decade been a part of a new industrial revolution called "Industry 4.0". Where some companies have embraced automation and the big data opportunities that have followed with it. For some companies, the adoption of digitalization and from there the collection and use of data has been easier than for others. Larger and more advanced enterprises have already adopted digitalization and automation to a large degree, but for smaller and less advanced companies is not as straightforward. For these companies, the transition to automated production has either, not been possible because of the economical aspect or type of production processes used. This does not mean that these companies would not benefit from having access to production data and resulting visual progress presentation.

One of these companies is BM Building Industries. BM Building Industries is a production company located in Hobro that produces modular housing solutions. The production facilities at BM Building Industries are primarily using manual and analogue production processes. These processes are the likes of painting, drywall installation, grouting, floor installation, kitchen installation, plumbing, carpentry, and electrical installation.

For a company as BM Building Industries to use data for data analysis and production overview by data visualization, the data must be created since it does not exist. Contrary to automated productions where the data has been collected by sophisticated equipment and only must be extracted, for a company like BM Building Industries the data must be created. It is this creation of the data which will be undertaken through this article.

2. Issues with not collecting production data and using data visualization in analogue production companies

The lack of data collection in a company like BM Building Industries leads to decision-making, production planning, product cost estimations and delivery plan commitments that are based on intuition and prior experience, but not factual data.

It is furthermore hard to justify performance-improving action when no data exists to first, predict if the action has the potential to increase the performance significantly enough to make the investment in this action financially viable.

It is secondly hard to determine the real effect of the action if it can not be seen through data. If big actions are taken to increase performance but the gains cannot be presented through data, this can have a demotivating effect on the personnel of a company. For real performance improvement to be seen the actions must be taken in the right areas. The lack of data used in decision-making will make it difficult to find the areas of a company where improvement is needed, but even more importantly where an improvement will have the biggest effect on the performance of the company.

One of the big objectives of production companies is to increase the throughput of products, enabling more products to be sold, resulting in an increase in revenue. The ability to use production data will open up a vast amount of possibilities to increase production efficiency.

Based on the findings of these issues at BM Building Industries A/S and the realisation that other similar production companies would also have these issues. It was decided to develop a system to help mitigate or even eliminate these issues.

3. Change Management

Going from a current known stage to a new desired state, a company have to undergo a change. In the case of BM Building Industries A/S, going from the current operation where data is not collected to the desired state where data is being collected, they will have to change.

Change is something all companies have to do to improve and remain competitive. but change is not necessarily something that is easy to do. To ensure that change can be implemented successfully in a company, the theory of change management can be used. Within change management, different methods and models exist.

To establish the best conditions for a successful change, the change management method, Kotter's "Eight Steps for Leading Change" [1] and the ADKAR model [2] was used.

These serve two different purposes. Kotter's "Eight Steps for Leading Change" provides a structured approach to change on the organizational level. Where the ADKAR is a model concerned with how the individual within a company can be influenced to lower resistance. Kotter's "Eight Steps for Leading Change" used as the name suggests eight steps to follow. These are from [1] as follows:

1) Establishing a sense of urgency
2) Forming a powerful guiding coalition
3) Create a vision
4) Communicate the vision
5) Empower others to Act on the vision
6) Planning for and Creating short-term wins
7) Consolidate Improvement and produce still more change
8) Institutionalizing new approaches

For the ADKAR model, the purpose is to get the individuals of the company on board with the change. This is done by taking actions to ensure that the individual feels that they possess the following 5 elements [2].

1) Awareness
2) Desire
3) Knowledge
4) Ability
5) Reinforcement

For BM Building Industries A/S a system had to be developed and implemented. To have the best potential for succeeding in the development of a system and the subsequent implementation and long-term use, both these change management levels were used.

4. Data Collection

The use of data can help mitigate or even eliminate these issues. For data to be used it must be created.

In productions where it cannot be collected from a machine, the people who do the production processes have to provide the data.

To do this one has to understand the organization where the change must happen and especially the people whom the change must be done through. For BM Building Industries these people are the project managers and production personnel.
The task has therefore been to develop a data collection and visualization system that is made for this type of personnel, with the purpose of decreasing resistance to use the system. In the case of BM Building industries, the following elements were of main concern for the employees to not reject the system.

- Make the data collection process have as small an impact on their current workflow as possible.
- Create an intuitive process of creating the data.

Before determining how the data is to be collected, it must be determined what data needs to be collected. From the work with BM Building Industries, it was found that the data needed to be collected for them was:

- Individual process times.
- Overall module takt times.
- Department-specific module takt times.
- Individual employee's time on individual processes.

It was found that by collecting the individual employee's time on individual processes, the result of the desired data could be calculated from this.

But how is this done? It is important to remember that this data must come from the employees, and people have a natural reaction to new things and change to what know in the form of resistance. One of the actions taken to reduce resistance to the system developed for BM Building Industries was to ensure that the data collection process had as small an impact on the normal workflow. In Figure 1 the difference in workflow between the workflow without data collection, with manual data collection and with data collection through the system developed.

The goal was to collect data through a digital system but keep the workflow processes as close to the one without data collection. Some sacrifices had to be made to get the data, otherwise, the data could not be collected. To make it as easy, it was decided to do the data collection through mobile devices, in the form of smartphones or tablets.

The developed system made it possible for BM Building Industries to collect the desired data, by facilitating the following steps for the employees to go through when using the digital system:

1) Login to the system.
2) Choose the module to work on or scan the QR-code on the module where work is to be done.
3) Select the task to work on.
4) Select either start the task, stop work on the task or complete the task.

By having each individual employee go through these steps for all individual processes they put in work for, BM Building Industries will be able to collect all necessary data from their production facilities.

5. Use of Data

When data has been collected and obtained from the different production processes around a facility, what can it then be used for? An how can the data be specified, sorted and directly targeted such that unnecessary data is not being used?

5.1 Data Visualization

Data visualization refers to the visual representation and display of data. The importance of data visualization comes as it helps the human mind to process and understand data. How clearly the data is communicated to the recipient, depends on showing the right data and the right amount of it, the use of shapes and colors.[3]

The use of data visualization in industry can be used to support faster decision-making, and furthermore, base the decisions on data. It will enable a real-time overview of the production, to be used by personnel, but also give the rest of the company an overview of where the production is at, thereby establishing easy and faster communication between departments. The data visualization will showcase trends and abnormalities like bottlenecks.

5.1.1 Dashboards

A type of visualization that can be used in manufacturing facilities is a dashboard. A Dashboard

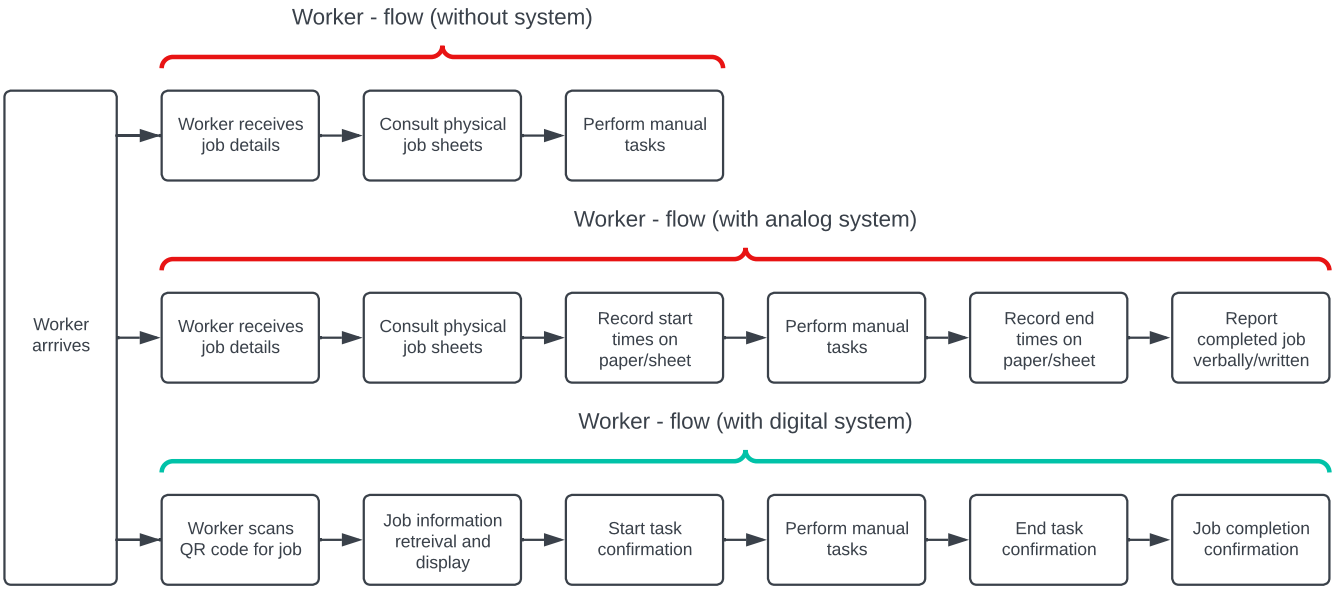

Fig. 1 Workflow processes in the scenarios: without data collection, analogue data collection and digital data collection.

is a visual representation of company data, shown on a single screen with the purpose of providing information in a way that is fast and easy to understand. The information on a dashboard should be specific to the facility it is containing information about.[4]

A survey was done in [4], where it was found that for the visual monitoring in the production facility, the manufacturing personnel voted on the status of individual processes and the queue of processes and jobs as the most important information. For management personnel, the most important information to be shown on a dashboard was process cycle times, reliability of delivering on time, the efficiency of production facilities and the quality of the produced products as a measure of the number of warranty-issues received on the product. For the development of the solution in this paper, the data collection approach, data visualization and monitoring tools and key performance indicators (KPI's) used.

In the solution developed for BM Building Industries A/S, data visualization was only done for the representation of production process status. The solution was therefore developed based on the parameters, production facility status of individual processes, and the queue of processes and jobs, as they were also said to be of most importance to the employees at the company. The result is seen in Figure 3.

The illustration in Figure 2 is an example of how KPIs could possibly be presented. This dashboard design is aimed at the management personnel at BM Building Industries A/S. Here the production overview has been compressed into eight numbers giving the most important information from the production.

Both of these visual representations of production data are currently being used at BM Building Industries A/S on a daily basis.

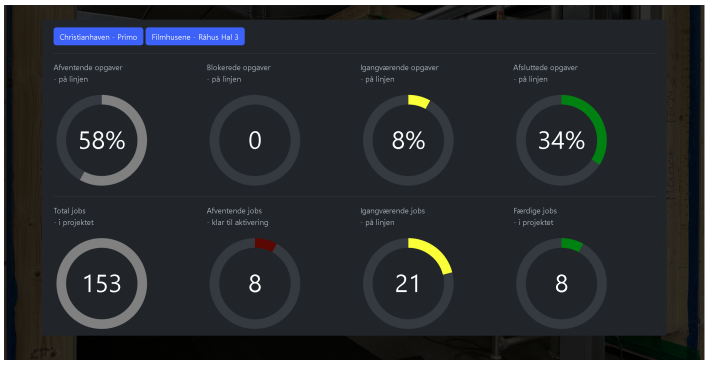

Fig. 2 A figure showing the visualization dashboard interface containing KPI's. This screenshot is also taken at 18.05.2023 at 14:51, and this is an actual overview at the time.

Fig. 3 A figure showing the final visualization interface. This screenshot is taken 18.05.2023 at 14:51, and this is an actual overview at the time in the facility called PRIMO.

5.1.2 Table Displays

A second type of visualization which can be utilized in a production facility, is a table display showing the entire production as a table with each row representing a job, and each column representing a task. This table is then filled dynamically with colors in order to represent the individual statuses of tasks in a job. Thus a quick overview of the entire production facility can be obtained. It can also be defined as type of visualization with higher resolution, since more data is visualized and provided.

5.2 Data Analysis

The collected data can be used to calculate different types of KPI-values (Key Performance Indicators). These can be the following and are not limited to:

- OEE (Overall Equipment Efficiency) based on availability, down-time and performance
- Cycle Time
- Production Costs
- Energy Consumption

In the case of BM Building Industries A/S the wanted information was cycle time, process times and production costs. The production costs KPI would improve BM in the sales process for future projects, since a badly estimated production cost, would lead to the wrong pricing of projects. The process time and cycle time are interesting values for the company, since estimated production completion times can be calculated for future projects. This allows BM Building Industries A/S to predict with better precision when a project can be delivered.

In order to do this a simple and unfiltered example is provided. The data collection shown in Figure 4 is from a task called "laying floor" at BM Building Industries A/S. As can be seen in the x-direction multiple different jobs are shown with a job name. In the y-direction the used amount of hours between the start and completion of the task is shown.

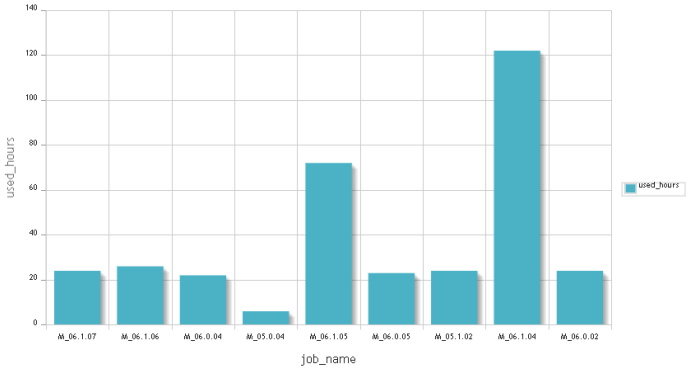

Fig. 4 A chart showing the used amount of hours on a specific task on nine different jobs.

The chart in Figure 4 depicts nine different jobs, each with an individual task time for laying down floor. Since the chart is unfiltered, there is two large spikes primarily showing the weekends and holidays. If this is taken into consideration, an average of 22,11 hours are used to complete this task. If this average value is moved across e.g a week or a month, the results of improvements and changes can be visualised.

In the second example shown at Figure 5 another task has been selected. This collection of data is started four days later than in Figure 4, and thus the two spikes showing weekends and holidays are again present. Again the average process time can be calculated to 23,4 hours. This is generally positive since BM aims to ouput products once a day, meaning that the process time cannot exceed 24 hours. In the case of the two charts ,the process is completed when it is finished and not during the night nor weekends. Optimally the process time should only include used hours, and not standby-time.

6. How is data collection implemented

As the data collection is happening through the employees, the successful implementation is highly dependent on the individuals in the production. Therefore a large emphasis was laid on managing the change and the individuals in the development of the implementation approach.

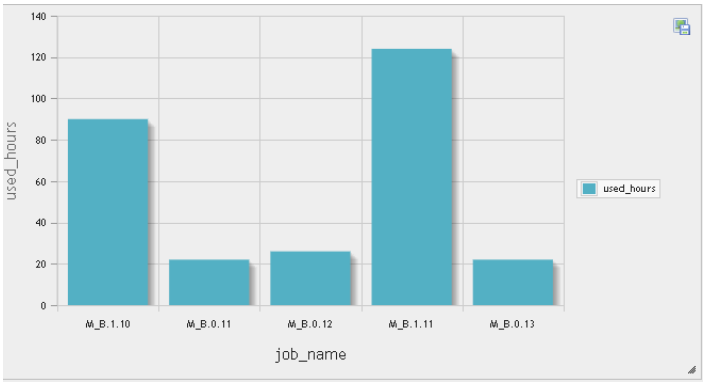

Fig. 5 A chart showing the used amount of hours on a specific task on five different jobs.

This resulted in the approach where the employees were given information about the implementation, the vision for using the system and the expected benefits from the system. The purpose of this was to provide the individuals with awareness and a desire for the system prior to its implementation.

On the day of the implementation, the employees were given a presentation of the vision for the change by the CEO. This showed that the change had backing from the top of the company. This was followed by a presentation about the functions and use of the system, provided by the creators of the system. This provided the employees with knowledge about the system. The final part of the implementation was one-on-one training in the system. This was in the form of a relevant real use case, supervised by one of the creators of the system.

This first implementation was carried out in the facility called PRIMO. The result was a successful implementation where 12 employees ended up with the desire and ability to use the system on a daily basis. With an average status registration from the employees of 21 per day, the implementation has deemed a success. The number of status registrations in the system following the implementation is illustrated in Figure 6

As a result of the successful implementation at the first production facility of BM Building Industries A/S, it was decided that the system was to be implemented in additional 2 facilities. For the implementation at these facilities, the same approach was used as the one used for the first facility. This resulted in the successful implementation of the system in these facilities.

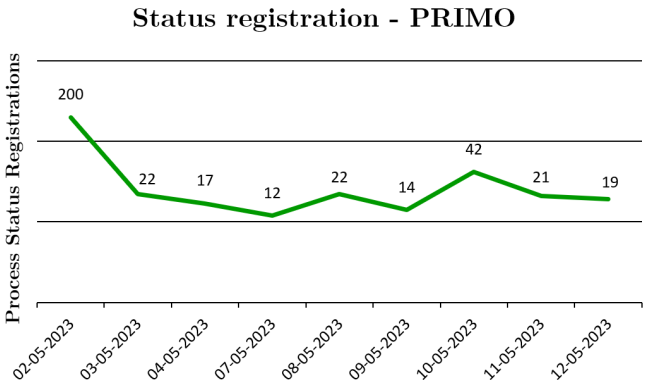

Fig. 6 Graph illustrating the number of process status registration on working days from 2.May to 12.May

7. Conclusion

A system facilitating the collection and visualization of production data has been developed and successfully implemented in 3 production facilities BM Building Industries A/S.

BM Building Industries A/S have voiced that they are very pleased with the system, the functions it provided and the values it has given and has the potential of giving in the future. It is expected that the system will be implemented company-wide within the next month.

Acknowledgement

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