Optimizing Schedule In Furniture Planning

Abdul Talib Bon

Technology Management – Universiti Tun Hussein Onn Malaysia
talibon@gmail.com

Abstract. The methodology for developing the production system schedules from a project management perspective is being investigated. System orders are considered to be potentially parallel projects that share the same resources. The mechanics of manufacturing controls are discussed in an existing project management package. Order input to the network is envisaged via the web and, after generation or re-generation of schedules, the estimated fulfilment period and delivery date for each order should be accessible via the internet again. Both ideas were described on the basis of real data from a security door supplier operating a make-from-stock, process-oriented production program. The system provides, on the one hand, the approximate (calculated) completion time of each task and, on the other, the assignment of daily work to assets. Nonetheless, it would have trouble performing more than 3000 activities with concurrent asset scaling.

Keywords: Scheduling, Flow Shop, Levelling, Flexibility

1. Introduction

The main research hypothesis of this work is that the Project Management (PM) methods, based on critical path principles, with a focus on resource balancing, are an efficient and effective production scheduling method when the form of output is acceptable, i.e. the product does not vary much, the pattern of material flow does not differ too much, and lead times are also predictable. Japanese have discovered that PM software is well suited to production control — especially when performance and delivery dates are significant. For two companies, these systems as complements to MRP systems are provided. [1]

Onwubolu describes an integrated visual flow-shop scheduling system using scheduling techniques such as lower bound, automated generation of near-optimal process sequences and schedule optimization[2]. Outputs are in the form of a Gantt graph. Material requirements preparation can be achieved more efficiently in a laboratory setting using a resource-restricted project scheduling method. This model improves MRP models by adding power constraints and using adjustable lead time lengths[3]. A full overview of the issues and perspectives of flow shop scheduling.[4]

Martinez suggests a technique to integrate a performance perspective into production planning[5]. The definition of project-oriented development is used to demonstrate the hierarchical structure of research and decision-making. Based on a new form of resource workload model, the technique is used to estimate the speed-up of each project for the different levels of resources allocated to it. Leverage utilization allows an optimal level of resources to be identified for each task, which minimizes peak demands by varying aggregate operation intensities.

Thierry points out that make-to-order development is often structured into projects with their own goals[6]. These programs use strategic and essential tools that must be allocated at the level of
strategic or tactical planning. Following the development of the initial medium-term plan, the scheduling process consists simply of reviewing the current project schedule when unexpected events occur.

Aurich is implementing the idea of development programs[7]. Under this definition, either a single production line or an entire production site can be planned and run as a company. The Master Schedule of the Production Project consists of uniform phases for the life-cycle-oriented development and function of the production system.

Baek suggests an immersive human-computer scheduling solution in which the system provides a computerized Gantt map comprising a variety of assistance features in static laboratory environments [8]. The optimization behavior of computer-aided human schedulers in scheduling tasks is also observed in the experiment.

PM-based scheduling is simple and intuitive compared to other scheduling strategies, but when the number of tasks / jobs to be scheduled is large software support is needed. The importance of scheduling in the operation of manufacturing systems is illustrated by the sheer number of references which have dealt with the subject in the last 40 years [9]. Apart from PM, the most common scheduling techniques studied are [10]: integer programming for small problems, heuristics-based on major problems and, more recently, meta-heuristics that direct the application of small problems such as simulated Annealing, Taboo Search and Genetic Algorithms.

Evergreen Fibreboard Berhad is engaged in the manufacture and sale of engineered wood products. It provides medium density fiberboard for use in a variety of applications, including furniture, speaker boxes, windows, moldings, flooring and PCB back-up panels, as well as for high-humidity applications in bathrooms, kitchens, flooring, doors and window frames. The company also manufactures particle board for use in veneer, high or low-pressure laminates, melamine and paper cover applications, as well as for use as a core material for the construction of homes and office furniture, shelving and kitchen cabinets and industrial and institutional fixtures. It also sells furniture items for living room, bedroom, work area and storage. In addition, the company manufactures and sells glue, resin, urea formaldehyde concentrates and adhesive products; trades and maintains plantations; and specializes in manufacturing, trading and selling wood products. It exports its services to Asia, Australia, North America, Europe and Africa. The business was founded in 1972 and is based in Batu Pahat, Malaysia.

2. Methods

Figure 1. Typical door structure without metal cover, wooden panels and some accessories.
The manufacturing that my group going to optimize the scheduling is a security door with its complementary casing process. The door consists of the following parts, see Figure 1: door frame, door covers, door panels, vertical reinforcements, horizontal reinforcements, windshield, lock plate, lock bars, lock bars, safety locks, tubes, hinges, aluminium profiled bars, rubber sealing pads, door handles, glass panels (if required), door-eye, small screws, large screws, plastic caps for hinges and tubes. The door housing consists of the following parts, see Figure 1: the left and the right beams, the horizontal beam, the casing bolts, the splays and the sills.

The type of manufacturing system used for the production of doors and housings is essentially a flow shop consisting of a stable series of operations for all product variants, modifications of the process plan relating, to a large part, to the duration of the operation. The test case used is a manufacturing system that produces safety doors. The original production system consists of five departments, namely metal construction, welding and assembly, painting, final assembly and casing production.

In the metal construction factory, the door frame, the steel board, the housing and the reinforcement are made. Wind blockers, safety boxes, lock plates, etc. are manufactured or purchased separately and stored until necessary at the assembly stage. Both the wooden panels and the metal structure are processed in the paint shop. The assembly shop deals with the welding of the door structure and the housing as well as the assembly of all the auxiliary parts, e.g. glass, handles, rubber insulators, etc. The door housing is assembled on the customer's premises.

The metal construction department consists of a CNC punching station, which mainly makes all the openings necessary on the metal sheet for locks, hinges, rams, etc., a shearing station for cutting to size all the sheets that need to be bent and welded to make the door frame, and a press brake, which forms the door frame elements, including the reinforcement struts.

The welding and assembly unit consists of three welding stations. In the first example, welding is used for initial mounting of reinforcements and hinge bases as well as for welding of door cover to door frame and glass frame to door cover as required. The second one-point welding and the Gas Metal Arc Welding (GMAW) are used for the seam welding of reinforcements and for the welding of lock bars on the lock as well as for the seam welding of the door cover on the door frame. In the sixth, GMAW is used to weld the bolt, the hinges and the wind blocker. There are also three intermediate storage stations for locks / reinforcements / wind blockers / hinges (first station), door frames shaped prior to welding (second station) and ready doors (third station). Painting department cuts, sands down and paints and varnishes wooden door panels in three phases as needed. Varnished panels are processed immediately before being fed to the assembly unit.

Accessories as well as wooden beams and wooden panels were mounted in the assembly unit. The gate is taken to the finished goods shops. The development department of the casing consists of a calibre-bench on which the casing pieces are cut and positioned in their final position before welding on site. The casing is then sent to an external paint shop for electrostatic painting. To maintain the output of the casing. Regardless of the production of doors, a large inventory of them is retained, which led this analysis to focus on the production of doors alone. Preparation of accessories such as locks, hinges, glass frames for special doors is carried out in auxiliary workstations which are not considered to be necessary for production planning. Remember that the brand variants come in variations of two categories: first, single reinforcement, double reinforcement, glazed.

3. Result and Discussion

For each material model, a production flow diagram is drawn and the corresponding Program Evaluation Review Technique (PERT) analysis shows serial and parallel processing, as well as priority constraints, as required, and offers an understanding of critical pathways using the Critical Path Method (CPM) and related graphical tools [9] provided that all appropriate resources are available. This phase is directly comparable to infinite capacity planning.
Accurate processing times as well as auxiliary process times at each workstation should be required for the creation of PERT diagrams. This is best achieved by doing an evaluation of the stages of research and then conducting time measurements accordingly. According to PERT diagrams for each product version, the design model is initially built and then completed at a later stage by assigning the necessary resources. This is an ‘instanced’ project model further improved later with order-specific information to become an Order Input File (OIF).

In order to construct a full schedule for all current and expected future orders, the models of the project to progress for all applicable orders are compiled into an aggregate plan. Constraints resulting from relative priorities between orders are entered at this point. In addition, existing restrictions, such as set release phases or completion time, may also be entered. The last step that accounts for a practical schedule is the so-called resource levelling, which allows use of the corresponding algorithm that inevitably occurs in computer scheduling systems. This step is directly comparable to that of finite capacity planning.

Table 1. Part of an Order Input File. Grey cells represent user input. White cells represent standard template values

| TYPE             | ANALYSIS | ID | NAME | TIME | PREDECESSORS | OUTLINE_LEVEL |
|------------------|----------|----|------|------|--------------|---------------|
| ARMOUR           | DOUBLE   | 1  | CNC  | 2.3  |              | 1             |
| CLOSING          | 17       | 2  | CNC sk | 2.3  |              | 2             |
| EXT.MATERIAL     | ANIGRE   | 3  | CNC kap | 2.3  |              | 2             |
| EXT.DESIGN       | NAUSIKA  | 4  | CUT   | 3.6  |              | 1             |
| INT. MATERIAL    | ANIGRE   | 5  | Koph sk | 1.2  | 2            | 2             |
| INT. DESIGN      | NAUSIKA  | 6  | Koph kap | 1.3  | 3            | 2             |
| HANDLE           | TWIN     | 7  | Stranza | 2.2  |              | 1             |
| DATE             | 26/8/2018| 8  | Stranza sk | 2.2  | 5            | 2             |
| REPRESENTATIVE   | 1        | 9  | Syg-1-a | 9.8  |              | 1             |
| CODE             |          |    |       |      |              |               |
| DOOR NUMBER      | 19       | 10 | Syg base  | 9.8  | 8            | 2             |
| DOOR HEIGHT      | 2.10     | 11 | Syg-2 | 22.6 |              | 1             |
| DOOR WIDTH       | 1.00     | 12 | Syg medesa | 22.6 | 10           | 2             |

The delivery times for each order and for each workstation in the process can now be exported to the shop floor via the intranet, while the estimated fulfillment date of the order can be exported to the customer via the internet. The steps outlined above are further analysed, and descriptions of their implementation are given.

All data relating to the construction of PERT diagrams leading to the construction of project templates are collected for each of the product variants flowing through the system. A production flow diagram is constructed for each product variant. All-in-all nine flowcharts were created in the test case used. A corresponding PERT diagram was constructed on the basis of each flow diagram, the duration of each production or auxiliary stage shall be measured by means of a standard stopwatch-based continuous time measurement and a table shall be constructed containing all such processes and corresponding time durations.
Figure 2. Excerpt from flow diagram for variant with single reinforcement without panel

| ID | Stage                     | Duration (min) | Starting conditions | Process | Transport | Control | Delay | Store |
|----|---------------------------|----------------|--------------------|---------|-----------|---------|-------|-------|
| 1  | Frame punching            | 2.29           | -                  | ○       | □         | □       | D     | ▼     |
| 2  | Frame cutting             | 1.21           | after 1            | ○       | □         | □       | D     | ▼     |
| 3  | Frame bending             | 1.24           | after 2            | ○       | □         | □       | D     | ▼     |
| 4  | Transporting              | 0.60           | after 3            | ○       | □         | □       | D     | ▼     |
| 5  | Cover punching 1          | 4.46           | after 1            | ○       | □         | □       | D     | ▼     |
| 6  | Cover cutting 1 (3 point) | 0.80           | after 2, 5         | ○       | □         | □       | D     | ▼     |
| 7  | Cover bending 1           | 1.05           | after 3, 6         | ○       | □         | □       | D     | ▼     |
| 8  | Hinge base welding        | 5.78           | after 4            | ○       | □         | □       | D     | ▼     |

Figure 3. PERT diagram corresponding to variant presented in Figure 2.

PERT diagrams contribute to the identification of essential pathways for the processes of each product type, i.e. the time of completion of the product can be determined, assuming that all the assets necessary to carry out each process are available when appropriate, which is obviously a fictitious situation.

Note, too, that, in some cases, the constraints deemed to apply were not correct. For example, painting activities have been observed to occur in a particular order, i.e. panel followed by an event, although this is not appropriate. Therefore, the constraints of the project have been re-examined and mitigated as required. In contrast, certain duties, which were evidently unnecessary to keep separate from others, were adequately represented in them. Usually, this occurs when a part is transferred by a network after the same part has been processed. Such an embodiment simplifies data and saves on the need for computing power.

Each of the output flow diagrams is represented in a spreadsheet format and is complemented by all the information required for the full order processing to become an Order Input File (OIF). This additional information relates to the name of the order, the type of reinforcement, the number of keys, the type of door, the type of handle, the date, the customer code, the brand identification and the measurements (width X height) and the time of issue of the order.
Figure 4. Task information in PM system as imported from the OIF

Figure 5. Gantt chart corresponding to OIF.

Many other macros have been written to encourage the creation and display of Gantt and CPM maps, to write results in a correct order in the resource job allocation output document, etc. The PM system requires two types of production information: the approximate (calculated) completion period of each order and the allocation of daily work to assets. The first type is classified as a standard document in the PM system and can be used as a ready-to-use report, see Figure 7. The file representing the second type of information is compiled by exporting asset names, jobs and start-up
and completion times from the unsorted PM system to the spreadsheet in which form it is then sorted as appropriate, see Table 2.

![Figure 6. Sample report excerpt referring to a particular order](image)

| ID  | Project                  | Name    | Initials | Scheduled_work | Start_date   | Finish_Date  |
|-----|--------------------------|---------|----------|----------------|--------------|--------------|
| 1361| C:\gd\2900500046ID.mpp  | PAINT 1 | BAF1     | 9 mins         | 29/8/2005    | 29/8/2005    |
| 1337| C:\gd\2900500041JT.mpp  | PAINT 1 | BAF1     | 9 mins         | 29/8/2005    | 29/8/2005    |
| 1241| C:\gd\2900500001JM.mpp  | PAINT 1 | BAF1     | 9 mins         | 29/8/2005    | 29/8/2005    |
| 1289| C:\gd\2900500026JM.mpp  | PAINT 1 | BAF1     | 9 mins         | 29/8/2005    | 29/8/2005    |

A complete 120 orders (approximately 3000 tasks) exercise was carried out on the real-world data system sponsored by the organization. The results show some idle periods, especially in sheet metal cutting and sheet metal bending stations, which typically achieve lower utilization compared to other stations where the utilization rate is 100 per cent.

The completion time report for each order is intended as a response to the customer, forecasting reasonable delivery dates. The resource loading document (daily) is intended to be used for both allocation and control purposes. Resource loading may be compressed (aggregated) or extended according to perceived needs, as all information provided by the PM system is at the lowest resolution (minutes) level, see example in Figure 8. Remember that although Gantt charts help to visualize the schedules, the documents also provide more accurate information.

The concept of creating a master plan consisting of individual projects corresponding to orders was appropriate as long as the number of projects was relatively small. The system did not seem to manage levelling correctly for a large number of projects, leaving lengthy idle time intervals between many tasks. The notion of master plans was therefore discarded. It has been verified that the individual sub-project files corresponding to the respective order levelling procedure have been well performed by keeping them open. This system also allowed for better control of orders to be scheduled.
4. Conclusion

Based on the experience gained by developing a PM-based scheduling system for a real-world production environment, it has become clear that the sheer volume of data to be handled brings the system to its computational power limits, particularly as regards resource levelling. This is especially true when the product process plan requires repeated storage at the same workstation.

One approach is to divide tasks into larger chunks in order to reduce the number of tasks that the PM system handles simultaneously. This would certainly involve some loss of precision, but it could be tolerable if aggregation parameters were properly established. Order import into the system could be further automated by allowing the customer to fill in product data directly into forms that would be transparently transformed into database tables that would be automatically fed into the PM system.

5. References

[1] (Aurich & Barbian, 2004; Martínez, Duje, & Pérez, 1997; Reza Hejazi & Saghafian, 2005; Rom, Tukel, & Muscatello, 2002; Thierry, Lamothe, & Galvagnon, 2004)
[2] Aurich, J. C., and Barbian, P. 2004. Production projects - Designing and operating lifecycle-oriented and flexibility-optimized production systems as a project. International Journal of Production Research. https://doi.org/10.1080/00207540410001696348
[3] Martínez, E. C., Duje, D., and Pérez, G. A. 1997. On performance modeling of project-oriented production. Computers and Industrial Engineering, 32(3), 509–527. https://doi.org/10.1016/S0360-8352(97)00005-3
[4] Reza Hejazi, S., and Saghafian, S. 2005. Flowshop-scheduling problems with makespan criterion: A review. International Journal of Production Research. https://doi.org/10.1080/0020754050056417
[5] Rom, W. O., Tukel, O. I., and Muscatello, J. R. 2002. MRP in a job shop environment using a resource constrained project scheduling model. Omega. https://doi.org/10.1016/S0305-0483(02)00033-6
[6] Thierry, C., Lamothe, J., and Galvagnon, V. 2004. Re-planning support system for make-to-order production with reserved resources. International Journal of Production Research. https://doi.org/10.1080/00207540412331282042

Figure 7. Sample resource loading results