Applicability aspects of workload control in job shop production

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Chapter 1 Introduction

The title ‘Applicability Aspects of Workload Control in Job Shop Production’ emphasises the three central issues of this thesis with as main element Workload Control (WLC). *Workload Control* is a shop floor control concept especially suited for *Job Shop Production* (JSP), a common manufacturing environment in small and medium-sized enterprises (SMEs). The *Applicability Aspects* relate to the objective of this thesis, which is to add to the WLC concept to be better able to cope with several specific characteristics of JSP.

The term *Job Shop Production* (JSP) describes a manufacturing environment that produces piece goods in small batches. The incoming production orders often differ in the number of ordered products, their design, process characteristics (for example, routeings, operation processing times, and set up times), or urgency (rush-orders). Mostly, general purpose machines grouped into functional units are used to realise this broad range of orders. JSP is characteristic of many SMEs within the make-to-order sector. These companies are of general interest, as they form a relevant part of the industrial infrastructure. Moreover, the complexity of JSP is extremely challenging.

Workload Control (WLC) is a comprehensive shop floor control concept especially developed and suited for JSP. Within the JSP manufacturing environment queues of orders waiting for capacity groups (for example, a group of machines) on the shop floor are inevitable. These queues form buffers allowing a high degree of utilisation at the different machines. The WLC concept aims at controlling the queues. Orders are not sent immediately to the shop floor but are collected in a so-called ‘order pool’ before being released to the shop floor. The collected orders are assessed periodically for release to the shop floor. They can be released as long as a maximum workload per capacity group, measured in terms of operation processing time, is not exceeded. This procedure has direct implications for various performance measurements, such as throughput times, which are necessary to determine realistic due dates.

This thesis focuses on *Applicability Aspects* to facilitate the necessary linkage between specific characteristics of JSP and WLC. In JSP a broad range of shop floor characteristics can be distinguished. These have to be taken into account in the application of the shop floor control concept. Though WLC is developed particularly for JSP, specific aspects of this manufacturing environment require an elaboration of the WLC concept to improve its applicability. This thesis deals with several applicability aspects of WLC in JSP.

1.1 Research themes

Before WLC can be introduced as a suitable concept for a particular company, it is important to know its strengths and weaknesses with respect to the specific job shop characteristics. For classical concepts, such as MRP, a knowledge frame has been generated, which deals with the necessary prerequisites regarding the production environment to guarantee a successful introduction. For WLC those prerequisites have hardly been specified yet.

When a company has opted for WLC, the concept has to be embedded into the production environment. The introduction of a shop floor control concept always has to be case-based. Therefore it is important to consider thoroughly the influences of the characteristics of the manufacturing environment on the functioning of WLC. In this way, several characteristics have already been studied. Oosterman et al. (2000) investigate the influences of the routeing structures within JSP on WLC. Missbauer (1997) discusses sequence dependent set up times, whereas, for instance, Enns and Prongué Costa (2002), Park and Salegna (1995), and Salegna and Park (1996) consider the influence of bottlenecks on WLC. In WLC research there are still numerous aspects of real life characteristics of JSP that have not yet been considered.

One important aspect scarcely considered within WLC research is the availability of shop floor data in SMEs. In order to obtain a good performance, WLC needs data from the shop floor. The timeliness, accuracy and completeness of shop floor data is crucial for the functioning of the order release mechanism (Melnyk and Ragatz 1989). However, due to the complex and dynamic use of capacities on the shop floor, combined with the lack of an appropriate data collection system, which is quite common, it is often difficult to get a view of the actual capacity use. This may lead to a mismatch between the availability of shop floor data and the information need of WLC with respect to the order release decision. Yet, little is known about how to cope with possible limitations of shop floor data in WLC.

Another aspect of the complexity of JSP, which only has been considered to a limited extent, is the influence of machine characteristics. To be able to produce a broad range of products on a limited range of machines, often general purpose machines are deployed, which are grouped in several functional units. Machines in a functional unit may be identical, but they can also differ to a considerable extent, resulting in interchangeability and semi-interchangeability respectively. To make use of the possibilities of (semi-)interchangeable machines within the WLC concept, several decisions have to be made. For example, the decision regarding the routeing of orders across (semi-)interchangeable machines has to be defined within the WLC concept.

The above mentioned considerations have led to a selection of *three themes*, which form the basis of this thesis.

The *first theme* addresses the more general need to explore the applicability of WLC. The elaboration of this theme, based on an investigation of the inherent prerequisites of the WLC concept, provides a framework that can be used to get a first impression of whether WLC fits into a specific JSP environment.

The *second* and *third theme* are founded on two common aspects of JSP environments: (a) the limited possibilities to generate shop floor data, and (b) the interchangeability of machines. These aspects will have to be better facilitated within WLC. The research conducted provides an overview regarding alternative adaptations to the WLC concept on the one hand, and insights into the related implications for performance on the other hand.

Elaborating these themes leads to the main objective of this thesis, which is to add to the WLC concept to be better able to cope with several specific characteristics of JSP.

1.2 Thesis outline

Chapters 2 to 5 of this thesis are based on four individual papers, which have been published, accepted or submitted for publication in various scholarly journals on operations management. They are introduced and concluded in such a way that they can also be read and understood independently of each other.

Chapter 2, based on the paper "*Exploring applicability of the workload control concept*", is the starting point of this thesis. It elaborates on the first research theme as introduced above. In this chapter, the inherent characteristics of the WLC concept and the relevant characteristics of a JSP environment are identified. Confronting indicators of JSP characteristics with the distinguishing elements of WLC results in 'best fit' indicators for the WLC concept. In this way, a framework is developed that can be used to gain a systematic and quick view of the applicability of WLC.

Chapter 3, based on the paper "*Reducing feedback requirements of workload control*", relates to the second theme mentioned above. Here, the possible mismatch between the availability of shop floor data in JSP and the data requirements of WLC are analysed. WLC is adapted on the basis of more realistic assumptions on JSP feedback opportunities. Several alternatives are compared and evaluated in a simulation study.

Chapter 4 is based on the paper *"Grouping machines for effective workload control"*, and Chapter 5 on the paper *"Semi-interchangeable machines: implications for workload control"*. Both these papers deal with the interchangeability of machines. Non-interchangeable, semi-interchangeable, and completely inter-

changeable machines are considered. These chapters investigate the grouping of machines into capacity groups and the different alternatives to route orders among these machines. The influences on shop floor performance are evaluated by simulation studies.

Chapter 6 sets out the overall conclusions of the thesis. While Chapters 2 to 5 contain specific conclusions related to each paper, Chapter 6 endeavours to bring together those conclusions for further discussion and recommends where future research ought to be conducted.