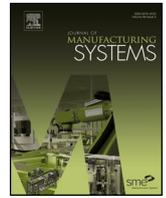




Contents lists available at ScienceDirect

## Journal of Manufacturing Systems

journal homepage: [www.elsevier.com/locate/jmansys](http://www.elsevier.com/locate/jmansys)



# Graphical tools for production planning in small medium industries (SMIs) based on pinch analysis

Joseph S.H. Lim<sup>a,b</sup>, Dominic C.Y. Foo<sup>c,\*</sup>, Denny K.S. Ng<sup>c</sup>, Ramlan Aziz<sup>b</sup>, Raymond R. Tan<sup>d</sup>

<sup>a</sup> Adirondack (M) Ptd. Ltd., 54A, Jalan 19/3, Petaling Jaya, 46300 Selangor, Malaysia

<sup>b</sup> Institute of Bioproduct Development, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

<sup>c</sup> Department of Chemical and Environmental Engineering/Centre of Excellence for Green Technologies, University of Nottingham Malaysia, Broga Road, 43500 Semenyih, Selangor, Malaysia

<sup>d</sup> Chemical Engineering Department/Center for Engineering and Sustainable Development Research, De La Salle University, 2401 Taft Avenue, 1004 Manila, Philippines

### ARTICLE INFO

#### Article history:

Received 16 August 2013

Received in revised form 16 March 2014

Accepted 2 June 2014

Available online xxx

#### Keywords:

Production planning

Pinch analysis

Targeting

Small and medium industries

### ABSTRACT

Small medium industries (SMIs) routinely face supply variations in their production cycle. Such firms are typically characterised by limited resources and insufficiency of funds. Thus, SMIs need simple solutions to cope with the production planning issues. Pinch analysis has been proven as a strategy for planning of efficient use of scarce resources. Recently, it has been extended to various production planning problems. In this paper, a simple novel graphical approach is proposed to address two common production planning problems in SMI's, which are warehouse space allocation and production capacity planning. Two industrial case studies are shown in this paper to illustrate the proposed approach.

© 2014 The Society of Manufacturing Engineers. Published by Elsevier Ltd. All rights reserved.

## 1. Introduction

Most companies, especially small medium industries (SMIs), face seasonal demand and production problem, which lead to the emergence of lean and peak periods. Such variation in demand and supply is normally beyond the manufacturer's control. In current practice, the approach to the problem is to plan based on production capacity, machine capacity or storage space, in order to accommodate the varying demand. Production planning issues are often addressed through the use of mathematical model or systematic quantitative decision support techniques. For example, linear optimisation models are used for multi-site production environment [1,2]; while Gunther et al. [3] integrates production planning and worker training considering machine and worker availability, operation sequence and multi-period planning horizon. Besides, analytical approaches where uncertainties are described as probability distributions have also been presented [4]. Various models and techniques for production and distribution are recently reviewed by Fahimnia et al. [5]. However, most of the

techniques require specialised technical knowledge that may not always be available in the staff roster of SMIs. Therefore, simple, intuitively appealing techniques are required to aid in production planning and coordination especially in SMIs. Furthermore, in many cases, graphical displays may be useful to facilitate decision-making (as evidenced, for instance, by the ubiquitous use of Gantt charts).

*Pinch analysis* techniques have been widely used as systematic design tools in the chemical process industry over the past decades. The techniques were initially developed for the design of heat-recovery systems for industrial energy conservation [6]. This methodology was later extended into various mass integration techniques [7–9] for efficient use of *mass separating agents* for pollution prevention. Later, pinch analysis techniques were developed for general resource conservation networks, focussing on efficient use of process water [10–16] as well as industrial gases [11,14,16–18]. Aside from the traditional applications, pinch analysis has also been extended into a variety of non-conventional areas such as financial management [19], supply chain management [20,21], “emergy” analysis [22], carbon-constrained energy planning [23,24], carbon capture and storage [25–28], short-term scheduling of batch processes [29] and human resource planning [30]. However, there has been very limited work on the use of pinch analysis in the area of production planning.

\* Corresponding author. Tel.: +60 3 8924 8130; fax: +60 3 8924 8017.

E-mail addresses: [joseph@orifera.com](mailto:joseph@orifera.com) (J.S.H. Lim),

[Dominic.Foo@nottingham.edu.my](mailto:Dominic.Foo@nottingham.edu.my) (D.C.Y. Foo), [Denny.Ng@nottingham.edu.my](mailto:Denny.Ng@nottingham.edu.my) (D.K.S. Ng), [Ramlan@ibd.utm.my](mailto:Ramlan@ibd.utm.my) (R. Aziz), [Raymond.Tan@dlsu.edu.ph](mailto:Raymond.Tan@dlsu.edu.ph) (R.R. Tan).

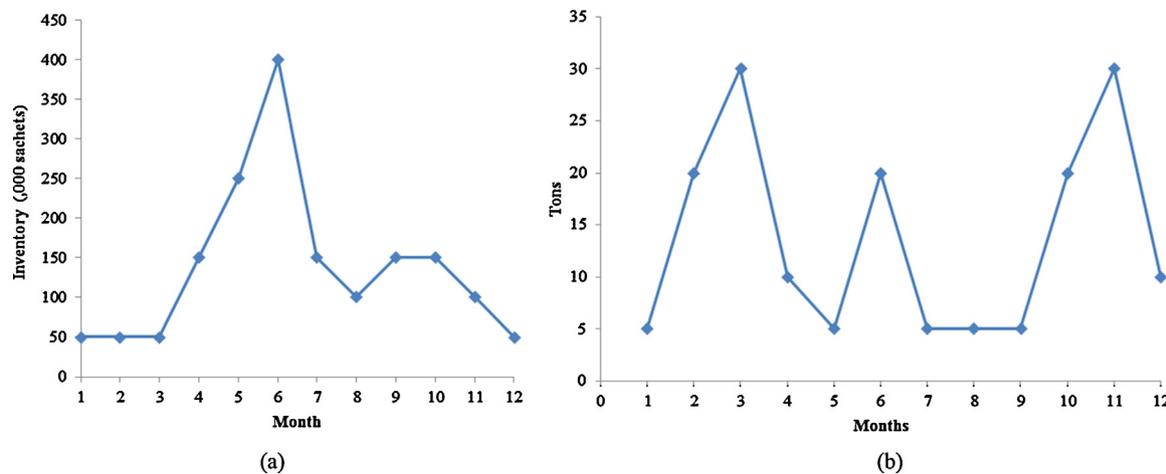


Fig. 1. Single and double peak demand.

An earlier attempt to use pinch analysis approach for production supply chain has been developed by Singhvi and Shenoy [20]. The authors later extended the work to cover for multiple products manufacturing [31]. In these earlier works, graphical targeting tools are proposed to determine the minimum production rate for known customer demand across a given planning horizon. Subsequently, Ludwig et al. [32] extended the techniques for production with seasonal demand, where different production strategies were evaluated based on cost parameters. The work also presented a compromise between inventory and capacity adaptation costs. Foo et al. [21] in turn proposed an algebraic-equivalent tool to determine the minimum production rate, and incorporated the consideration of maximum and minimum inventory limits. In these previous works, the main objective is to determine the production rate based on the seasonal forecast for the planning horizon. However, none of the above techniques address the minimisation of outsourcing of resources, nor do they explore opportunities for operational changes.

The underlying principle of pinch analysis is the use of information about stream “quantity” with data about the stream “quality” of those systems to optimise the overall system. In the context of pinch analysis, “quality” refers to any quantitative index that imposes directionality on the transfer of streams. Depending on the application, stream quality may be defined by key process variables such as temperature for heat recovery [6] and concentration for material recovery [16]. In many management extensions of pinch analysis, time is used as the quality index [20,21,29–32]. On the other hand, “quantity” refers to the amount in the transfer streams; for instance, enthalpy for heat recovery [6], and mass flowrate in mass recovery [16], etc. Once the quantity and quality aspects of a system are identified, graphical or algebraic targeting tools are used to determine the system performance based on first principles, e.g. mass and energy balances. In all cases, the targeting tools provide good insights (as compared to other tools such as optimisation techniques), which can be used by the users to identify areas for improvement for a given problem.

In this paper, two novel graphical tools for production planning are proposed. These newly proposed tools can be used to optimise warehouse space and production capacity for production machinery, which are common challenges in most SMIs. The problem arises when a company/facility seeks to maximise use of its internal resources, such as storage space or the capacity of its machinery, while minimising outsourcing requirements. This goal is equivalent to reducing idle space and/or excess machines capacity. Note that the problem is more serious in SMIs as compared to large industries due to the typical lack of access of such firms

to adequate financing for expansion of facilities. Thus, SMIs often simply rent readily available industrial space for storage, and likewise purchase off-the-shelf equipment that are readily available in the market. Therefore, proper production planning is extremely important for SMIs to survive in the market. Furthermore, production planning in such companies is often done in a relatively ad hoc manner by production staff, who may not have the adequate technical training to use sophisticated planning techniques. Therefore, simple graphical tools that are appealing and intuitive in understanding the key planning issues are needed. With these newly developed tools, SMIs will be able to handle the production planning problems more effectively.

## 2. Problem statements

As mentioned earlier, fluctuation of product demand and supply of raw materials are common challenge faced by SMIs. Thus, it creates a peak and lean periods in the planning horizon. The peak period may occur once or even twice in the case of seasonal demand, for instance the demand of a summer and winter cream (see Fig. 1).

In most cases, supply and demand of goods are beyond the manufacturer’s control, even if they may be estimated from history. Thus, from the vantage point of any given company, such conditions may be regarded as being exogenously defined. On the other hand, to certain extent, control of time and capacity adaptation is still possible. Note that machine capacity and warehouse space can either be fixed or variable in most cases. For instance, if factory or warehouse is a standard industrial lot with fixed dimension; or packaging machine is available in standardised capacities, this is classified as *fixed-capacity with variable time problem*. On the other hand, in case where factory, warehouse or packaging machines are available at a continuous range of capacities; i.e. manufacturer could acquire them according to their exact requirement, those units can then be classified as a *variable-capacity and variable time problem*. For example, such cases usually occur in pharmaceutical and allied (herbaceutical, cosmeceutical, bioceutical, cosmetic, herbal and traditional medicine) industries. Both cases are illustrated in later sections with two industrial case studies.

In order to address the problem, we first identify the *production sinks* and the *sources* of the planning problem. In this work, sinks are defined as the internal units/sections (within the company) that demand resources; while sources are referred as units or sections that contain the necessary resources. For instance, finished product to be sent for storage is treated as a sink because it requires

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات