Production Planning in Dynamic and Seasonal Markets

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Summary. In chemical engineering, pinch analysis holds a long tradition as a method for determining optimal target values for heat or mass exchanger networks by calculating an optimal alignment of available flows. A graphical representation of the time-material production relationship derived from the original pinch analysis can be used for aggregate production planning. This can deliver insights in the production planning problem as several production strategies can be compared. The approach is applied to a case study on bicycle coating.

1 Introduction

The problem of planning the future production capacity of a company can be addressed in numerous ways and has been extensively discussed in literature. A good overview of standard methods is given in [4]. For more recent approaches, the reviews of [5] and [9] are recommended, with the latter focusing on high-tech industries. When companies face a seasonal demand, the problem of capacity adaptation can become even more challenging, as there may be a constant need for capacity adaptations. Forecasting such seasonal demands is possible using various statistical methods, mostly aiming at identifying a seasonal component in historical demand data (see for example [8]). Given a prediction of the upcoming seasonal demand, a company still has to choose its production strategy, i.e., when to operate at which production rate. [6, 7] propose a graphical method that represents demand and supply data as composite curves and derives inspiration of pinch analysis. This approach is a classical method from the chemical process industry that aims at optimizing a system's performance by analyzing the process streams, i.e. mass and energy flows, and possible interconnections. The same methodology can be applied to product streams and the time-material production relationship. The application of the analysis is shown for a Chinese bicycle company facing seasonal changes throughout the year and different production planning strategies are compared based on cost criteria. In this application, the dependence of the planning outcome on the starting season and the occurrence of stock-out using the pinch planning method were identified as shortcomings of the method for which solutions are proposed.

2 Production Planning Applying the Pinch Analysis Approach

The Classical Pinch Analysis for Heat Integration

The basic idea of the thermal pinch analysis is a systematic approach to the minimisation of lost energy in order to come as close as possible to a reversible system (see [3, 2]). In its first step the pinch analysis yields the best possible heat recovery at the thermodynamic optimum. Thus, the pinch analysis requires the combination of hot and cold process streams to composite curves and the description of the respective temperature-enthalpy relationships. However, there exists a trade-off between the savings in operating costs for the hot utility and the investment in the heat exchanger. The result of the pinch analysis is the energy savings potential for the considered set of processes.

Translation of the Thermal Pinch Analysis to Production Planning

An analysis of intra- and inter-company production networks on the basis of product streams is also possible in analogy to the classical pinch analysis. The *time-material production* relationship can be used for a pinch analysis approach for aggregate production planning [6, 7]. Based on material balances, a time versus material quantity plot can be derived in translation of the original thermal pinch analysis. The quality parameter in the production planning pinch is the time of production (in analogy to the temperature level T). The quantity parameter is the demand of units to a certain time (in analogy to the enthalpy ΔH, describing the sum of internal energy of a thermodynamic system. One demand composite curve and one production composite curve can be constructed on a time basis (cf. Figure 1).

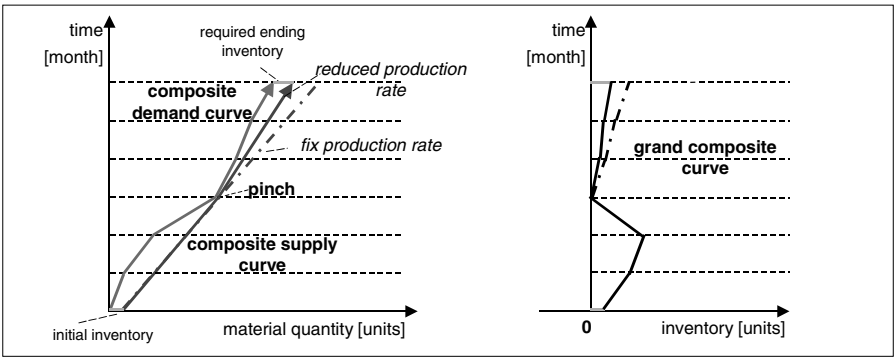

Fig. 1. Production Planning [6]

In this context aggregated production planning is defined as the identification of an overall level of production for an individual company. The focus of the analysis is the evaluation of seasonal changes on the demand side and its consequences for setting the level of production during the whole period considered. The central issue