Scheduling and Lot-Sizing in the Dairy Industry:

The Yoghurt Production Case

Georgios M. Kopanos, Luis Puigjaner, Chemical Engineering Department,
Universitat Politècnica de Catalunya - ETSEIB, Barcelona, Spain
Michael C. Georgiadis, Department of Engineering Informatics and Telecommunications,
University of Western Macedonia, Kozani, Greece

Yoghurt production could be considered as a particular case of a batch or a semi-continuous production process. The Process Systems Engineering (PSE) community have addressed and studied these types of production processes during the last 20 years. One of the usual features of batch processes is that a large number of products are produced from a few initial product recipes. This is the case of yoghurt production too. Concretely, final yoghurt products may differ in at least one of the following features: (i) fermentation recipe type, (ii) total cup weight, (iii) number of cups per piece, (iv) labeling depending on their customer destination, (v) flavors, and (vi) packaging cup type (material, shape, etc.). Packing rates may significantly vary from one to another product. The short yoghurt shelf life precludes a "make-to-stock" production policy, since products inventory has a finite storage time. Therefore, yoghurt production is performed into a "make-to-order" environment.

In literature, a production environment where a continuous production stage is followed by a packaging stage is called "make-and-pack production" (Méndez and Cerdá, 2002). Lot-sizing and scheduling constitute the major issues in this type of production environments. There are two approaches to deal with this kind of problems: i) the sequential approach; wherein first the lot-sizing problem is solved and afterwards the scheduling problem (two-stage procedure), and ii) the holistic approach; wherein lot-sizing and scheduling problems are simultaneously solved (single-stage procedure).

A plethora of contributions addressing production scheduling problems can be found in the Operational Research and PSE communities' literature (Méndez et al., 2006). However, the use of optimization-based techniques for scheduling dairy plants is still in its infancy. This can be mainly attributed to the complex production receipts, the large number of products to be produced under tight operating and quality constraints and the existence of batch and semi-continuous production modes.

In this work, a continuous-time Mixed-Integer Linear Programming model (MILP) is developed for the short-term scheduling and lot-sizing problem in a multi-product yoghurt production line of a real-life dairy plant. The problem under question is mainly focused on the packaging stage considering though accurate timing and capacity constraints with respect to the fermentation stage. Packaging units are operating in parallel and share common resources. Sequence-dependent times and costs are explicitly taken into account and optimized by the proposed framework. Daily production line shut-down and setup times are also introduced, as a production policy to guarantee high quality of final products.

To the best of our knowledge, the proposed approach is the first systematic attempt to explicitly address all the aforementioned issues in tandem. Several cases of a large-scale Greek dairy plant have been considered using the proposed model. Solutions obtained are presented, criticized and assessed in a real industrial environment. A number of benefits due to the use of optimization-based techniques are revealed. Finally, concluding remarks are drawn.

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References

Méndez, C.A., Cerdá, J., Grossmann, I.E., Harjunkoski, I., Fahl, M., 2006. State-of-the-art review of optimization methods for short-term scheduling of batch processes. Computers and Chemical Engineering 30, 913-946.

Méndez, C.A., Cerdá, J., 2002. An MILP-based approach to the short-term scheduling of make-and-pack continuous production plants. OR Spectrum 24, 403-429.