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Genetic Programming For Scheduling And Lot Sizing In Brewery Production

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**Abstract**

Scheduling with Lot Sizing is one of the most important problems in any manufacture industry. Therefore, the problem has been study extendedly. Since, the scheduling and lot sizing problem is classified as NP-hard problem, which mean the time required for finding the optimal solution of the problem is grow exponentially with the size of the problem. Therefore, it is unrealistic to find optimal solution for the scheduling and lot sizing problem in the contact of real world industrial case, even with today advanced computer system.

There are many heuristic algorithms have been proposal to solve the problem. They are beam search (a derivative of branch and bound technique), local search technique, tabular search and genetic algorithms, to name a few.

In Brewery industry, the fermentation process is the most crucial part, it will decide the quality, taste of the products as well as the productivity of the production line. Since, the fermentation time can take up to 41 days, and the requirement time is varying a lot between different types of beers.

Therefore, finding a good solution for the scheduling and lot sizing problem is important for beer manufacturers. This research will propose a genetic algorithm to solve the scheduling and lot sizing problem in beer production. The algorithm can serve as a planning tool for brewery manufacturers.

**Keywords:** scheduling and lot sizing, brewery industry, two-stage production, genetic algorithms.

Table of Contents

[CHAPTER 1 Introduction 5](#_Toc472347148)

[1.1 Motivation 5](#_Toc472347149)

[1.2 Objectives 6](#_Toc472347150)

[1.3 Research Framework 7](#_Toc472347151)

[CHAPTER 2 Literature Review 8](#_Toc472347152)

[2.1 Scheduling And Lot Sizing Problem in Beverage and Brewery Industry……………………………………………………………...8](#_Toc472347153)

[2.2 Genetic Algorithms 9](#_Toc472347154)

[CHAPTER 3 Genetic Algorithms For Brewery Industry 10](#_Toc472347155)

[3.1 Beers Production Process 10](#_Toc472347156)

[3.2 The Problem Context and Notations 11](#_Toc472347157)

[3.3 The Model 12](#_Toc472347158)

[3.4 Genetic Algorithms Approach 13](#_Toc472347159)

[CHAPTER 4 Results And Conclusion 14](#_Toc472347160)

# Introduction

Vietnamese beer market past, current, and trend.

## Motivation

## Objectives

## Research Framework

# Literature Review

## Scheduling And Lot Sizing Problem in Beverage and Brewery Industry

The lot sizing scheduling problem have been received great attention literature for a long time. (Clark, 2003) proposes a MIP model for canning line at a beverage manufacturer. They discus and compare several heuristic procedures to solve the MIP model, the discussion method include: branch and bound search, backward-then-forward pass, forward pass with linear setup approximations, hybrid heuristics with local search and mathematical programming.

The planning problem of beverage and brewery industry is characterized by two level of production. First, the liquid is prepared in the tank and then it will be used for filling the bottle in the filling. This problem is called the Synchronized and Integrated Two-Level Lot Sizing and Scheduling Problem (SITLSP) in literature. Toledo (2005) has proposes a MIP model to describe the characteristic of a typical beverage production line. According to Toledo, the idea is to combine the issues from the General Lot-sizing and Scheduling Problem (GLSP) and the Continuous Setup Lot-sizing Problem (CSLP).

(Ferreira, Morabito, & Rangel, 2009) Ferreira *et al.* (2009) have also propose other MIP model that integrates the lot-sizing and scheduling decision of a typical beverage manufacturer. This model is considered as a simpler model compare to the one proposed by Toledo, since it base on more simplifying assumption. However this model still describes or considers the synchronization between the two stage of liquid preparation and bottle filling. (Ferreira et al., 2009) have also propose several heuristic procedure to solve the problems. It includes the relaxation approach, relax-and fix.

## Genetic Algorithms

Computer scientist has been dreaming about one type of algorithm that can solve different type of optimization problem. The genetic algorithm has been born from that desire and it try to mimic the natural evolutionary process. Indeed, the genetic algorithm has been applied to many fields such as Finance, Supply Chain Management, and Information Technology. (Orito, Jun, Takeda, & Yamamoto, 2006) use genetic algorithm solve Index Fund Optimization Problem, which is a very useful tool for hedge trading strategy in Financial Market. (Leu & Namatame, 2008) use genetic algorithm to solve optimize network design problem, which help to find the network design which to important character that are resilience and cost.

As mention above, Genetic Algorithm can be use as optimization solver for a wide range of problem in many fields. In Industrial Management, Genetic Algorithm has been use extendedly in many type of problem.

# Genetic Algorithms For Brewery Industry

## Beers Production Process

The main ingredients for making beers include: barley, hops (responsible for the bitterness of beer), water and yeast (responsible for transforming sugar to alcohol and C02).

The manufacturing is varying between different manufacturers, however the core production process is the same for all brewery industry. There are four major steps for beers making.

The first step is malting. The grains (mainly barley) are harvested and processed through a process of heating, drying out and cracking. The main goal of malting is to isolate the enzymes needed for brewing. The second step is mashing in which grains are steeped in hot (but not boiling) water for an hour. Then, water is drained out from the mash. This activates enzymes in the grains that cause it to break down and release sugars. The result of mashing is sticky water which contains sugar extracted from the mash, called *wort*. The thirst step is boiling in which wort is boiled for about an hour while ops and other spices are added several times. The fourth step is fermentation. After the boiling step, the wort is cooled, strained and filter. t’s then put in a fermenting vessel and yeast is added to it. At this point the brewing is complete and the fermentation begins. The beer is stored for a couple of weeks at room temperature (in the case of ales) or many weeks at cold temperatures (in the case of lagers) while the yeast transform the sugar in the wort.

The final step is bottling. The ready liquid will pour to the bottle in a filling line.

## The Problem Context and Notations

The lot-sizing and scheduling problem in this research presents the brewery production process considering demand requirement, machine capacity, and other features to provide a feasible planning solution and minimize the production cost.

The model considers only the bottleneck in the production line. They are fermentation in the tank and filling the bottle in the filling line. The model and assumption of this research will be build base on (Baldo, Santos, Almada-Lobo, & Morabito, 2014). The assumption as flow:

The ready liquids may stay in tanks while waiting for bottling.

There are no holding costs of the ready liquids in the tanks because of the relatively short periods of time that they remain in the tanks.

There is no sequence-dependent setup costs in filling lines (a penalty cost is considered every turn, denoted as a, regardless of which items are part of this changeover).

There are no setup costs in the tanks since in each liquid exchange, the tanks need to be washed, consuming a mean time known in advance, therefore the tank setup times are included in the definition of fermentation/maturation times.

The validity of the liquids is not considered due to the high rotation of the tanks, which avoids the liquid spoiling.

The brewery production process can be described as two-stages production process includes liquid preparation (includes Malting, Mashing, Boiling, Fermentation) and bottling. To characterize the behavior of the beer manufacturing process, the model in this thesis only considers the bottleneck of each state. The first bottleneck is the fermentation in tanks. The second bottleneck is filling the bottle in filling line. The company has a set of tanks and filling lines, which are different in size and capacity. One tank can produce any type of liquid however a filling line can only produce a set of products due to the specific size and type of bottle. A filling line can only receive the liquid from only one tank. On the other hand, One tank can supply the liquid for multiple filling line as long as it is filling the same liquid.

## The Model

## Genetic Algorithms Approach

# Results And Conclusion

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