MSSI - Problem Identification & Scope Definition

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1 Introduction

The first assessment is about setting and characterizing a problem of certain domain. I chose a production of Brněnská pivovarnická společnost s.r.o.[1] and by using experiments I will try to come to conclusion how to make the production more efficient. All the information comes from an owner **Petr Hauskrecht** who gave me the real data while making a tour in his brewery – because every brewery has its own secret how to make the beer and it is very hard to find detailed information on the Internet.

In the section 2, I will characterize the domain of the problem. In section 3, I will discuss different scenarios. The last section 5 will be about scheduling the plan of my work of this project.

2 Domain characterisation

The topic of the project is the simulation of beer production in the Czech company mentioned in introduction. Four basic ingredients are needed for beer production: malt, water, hops and brewer's yeast. Beer is then produced in batches, where 20 hl of beer is produced from one batch. During one twelve-hour shift, one batch of malting, mashing, lautering, hopping and cooling takes place and then the batch is transferred to a fermentation tank, where fermentation begins several days before the tank is ready for bottling.

2.1 Mashing

During the brewing process, malt is crushed and mixed with water, the mixture is in the brewing vessel and heated to a temperature of 40-50 degrees. Subsequently, a mashing process occurs, in which the starch is split into simple sugars by enzymes contained in malt. The two-mash method of mashing is used to give the beer its golden color.

2.2 Lautering

Lautering is the separation of the wort (the liquid containing the sugar extracted during mashing) from the grains.

2.3 Hop boiling

After lautering, the beer wort is boiled with hops. Then The wort is cooled down to a fermentation temperature and pumped to the fermentation tanks.

Fermentation takes place without the access of air, that would carry yeast, mold, pollen and dust particles and would infect fermenting the beer. There is a total of 23 fermentation tanks each of a capacity of 48 hl, so two batches enter each tank and the remaining space is used for foam. Although there is a place for two batches in the tank, two batches of the same type of beer are always brewed one after the other.

The brewery produces a total of 4 different types of beer. Each type is fermented for a different amount of time. It also forms a different percentage in total production:

- 10° - 30 days fermentation - 13 % of total production
- 11° - 35 days fermentation - 70 % total production
- 12° - 45 days fermentation - 10 % of total production

[1] https://www.hauskrecht.cz/kontakt

- 16° - 90 days fermentation - 7 % total production

After the fermentation is complete, the entire tank is ready for bottling.

Barrels are bottled daily from Monday to Friday and are operated by one shift. It is bottled to kegs and then from the kegs bottled into bottles and glass (the process takes about 6 hours). Every time the tank is emptied it is necessary to wash the tank, this process takes 4 hours before it can be used for new filling. A new batch will only be started if there is at least one clean fermentation tank or a tank waiting to be full.

There are two shifts for beer brewing per weekday. On Saturday, there is just one morning shift and on Sunday there is an obligatory tank cleaning. Shifts for bottling are are once every weekday.

3 Simulation scenarios

It would be very hard to simulate all the process of production because it is very complicated and same parts of it are set and can not be changed (as for example mashing or lautering) so it is not worth to simulate them as a single process. I will concentrate on the part when beer is brewed, lies in fermentation tanks and is bottled. Brewing beer will mean for us a time of mashing, lautering and brewing for simplicity.

The aim of the experiments is to find out how to **increase the total amount produced of beer per year**. To achieve it, it will be aimed at:

1. increasing fermentation tanks
2. decreasing shifts that have nothing to do
3. counting the optimal number of shifts for washing and shifts for brewing

It will be necessary to find to optimal number of tanks and the number of shifts to make the production effective. It can happen that shifts have nothing to do (for example a shift for washing has no tanks) or on the hand hand that there no clean tanks and the production is paused.

As a first test I would try to count how many tanks would increase the most the amount of beer in condition of constant (current) amount of shifts and then increase the number of shifts for bottling (or the number of shifts for washing the tanks).

4 Related work

I was doing some research on simulation connected with beer production. The most of the simulations are focused on fermentation process.

1. **Multi-objective process optimisation of beer fermentation via dynamic simulation** (University of Edinburgh)
   URL: `https://www.research.ed.ac.uk/portal/files/24789868/FBP\_03\_2016.pdf`
   – this article is focused on beer fermentation modelling because this process is time consuming, energy-intensive, so there is an effort to shorten its duration and cost while maintaining high product quality.
2. **Modeling, simulation and optimization of a beer pasteurization tunnel**
   URL: `https://www.sciencedirect.com/science/article/abs/pii/S0260877405004942`
   – this journal introduces a general computational model for beer pasteurization tunnel
3. **Modelling and control of beer fermenting technology process**
   URL: `https://ieeexplore.ieee.org/abstract/document/467034`
   – the proceeding of 1994 IEEEE Interenation Conference is focused on controlling a curve for beer fermenting technology

5 Work plan

The end of academic year is in May 29.

- 26. 3. – 2. 4. 2020 Problem Identification
- 2. 4. – 9. 4. 2020 Formalization of the problem (depends on the deadline)
- April – implementation in C++
- May – doing experiments, verification, validation and documentation