AUTOMATIC CONTROL OF A MEAT LOADING AND MIXING LINE

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INTRODUCTION

Some thoughts will be devoted to how meat technology should be applied to meat processing. One distinguished line will be discussed in particular:
- flexible production (with about 50 or more different meat products) in plants disposing of several meat processing lines provided with equipment that usually has evolved from traditional techniques.

FLEXIBLE PRODUCTION OF PROCESSED MEATS

Flexibility must be maintained with respect to
- the application of different raw materials of variable composition
- the ability to manufacture a broad range of sausage and meat products
- the ability to exchange units in a short period of time, and
- the commitment of people.

Recent developments in meat technology and the adaptation to packaging materials with new properties make it possible to optimize flexibility in meat processing.

Formulation in the production of sausages should provide, at the least cost, products meeting present quality standards of water, fat and protein. Accordingly as the prices and availability of raw materials fluctuate, recipes and procedures must be adapted (a program of Recipe Optimization has been developed).
How to achieve a plant with optimum flexibility can be approached as follows.

1. Sausage line (Figure 1)
- Principle of total line

Raw meat ingredients (fresh and frozen meats) are transferred to a tempering room to reach a temperature of -5 to -6 °C. After being tempered the raw materials are ground in a grinder; without a tempering unit the frozen meat is broken in a cleaver unit and partly thawed by microwave. The meat is then conveyed to blending tanks for standardization. Depending upon the type of sausage the desired quantities of meat ingredients are blended to obtain a predetermined fat content and protein/water ratio. A sample of this mixture is then taken for determination of fat and protein percentages. After any necessary adjustments of chemical composition have been performed to achieve the predetermined level the blender is turned on again while water is added and then the mixture is discharged into carts for further processing. The mixer should have well tested Z-shaped intermittent arms or mixing paddles with forward and reverse motion so that a thorough mixing and ideal binding of the raw meats are guaranteed. For the sake of a flexible use of the mixer for dry-sausage production the speed of the mixing arms should be adjustable. If air removal is required for a compact, meat-coloured emulsion without wrinkles being formed on the sausages a vacuum mixer should be used.

A set of carts holding, for instance, 100 kg of mixture (fat and lean) can be fed to high-speed vacuum choppers or to continuous cutters. Dry ingredients, curing material and starter cultures for dry sausages are added to the chopper. For Bologna-type sausages the chopped mixture is pumped into a colloid mill for "emulsification" and into stainless steel surge hoppers. If flexibility is required the batter is transferred into carts for the production of different kinds of batters.

Salami batters are not emulsified: after chopping these batters are discharged into carts and with a stainless loading hoist transferred to stuffers which feed sizing and clipping machines.
The most important element of the automated sausage line is the mixing/blending part (see figure 2).

2. Mixing/blending

For small scale production a meat loading and mixing line is used. For this loading and mixing line a flexible production automation program has been developed. This program gives the possibility to change rapidly from one mixture to another. The composition of the mixture can be varied by using different amounts of the raw materials or different raw materials. Between two batches it is possible to clean the mixer with foam, but that is not always essential. The cleaning should be cleaning-in-place (so other parts of the apparatus will not be in contact with foam).
The composition of the mixture (water-fat-protein) can be controlled with NIR (near infrared) analysis. If necessary the composition of the mixture can be changed.

The meat loading and mixing line (see also the drawings) consists of:
- three storageloaders (capacity of 400 litres each)
- one storageloader (capacity of 130 litres)
- a transportconveyor
- a (vacuum)mixer (capacity of 280 litres).

All these elements are placed on loading cells (figure 3). The mixer has the following possibilities:
- continuous mixing
- intermittent mixing
- vacuum mixing.

3. Parameters

During the mixing process the following parameters can be measured and recorded:
- temperature of the batch
- the couple of forces of the mixing paddles.

The installation is used for Flexible Production Automation (FPA). At the same time four different raw materials can be used.
The control of the installation has been fully automated (see figure 4). The program controls the following parameters:
- the amount of raw material used from each storageloader
- the way of pressing up (quick or slow, separately or together)
- the way of mixing (vacuum or not, continuous or intermittent, controlling on time, temperature or rotation speed)
- the way of emptying (the amount emptied, one or two doors).

4. Method

The formulation program provides many possibilities. A mixture with a certain water-fat-protein composition is desired. For example, with three raw materials (A=lean meat, B=cheeks, C=meat rich in connective tissue) we can choose to produce a luncheon meat with circa 20 % A, 40 % B and 40 % C and a smoked sausage with 50 % A, 30 % B and 20 % C. With the recipe optimization program it is possible, within certain limits, to keep the costs of the product low with respect to the water-fat-protein composition. For example the composition of the luncheon meat may have to be changed to 10 % A, 40 % B and 50 % C to reach the desired water-fat-protein ratio.
When the optimal solution of the problem has been found the flexible production automation program will start to make the first batch. When the first batch is finished, the production of the second batch will start, using the same raw materials.
When the storageloaders are filled with (enough) raw material and the variables have been given one batch can start. Pressing up the desired

amount of each raw material, transport with the conveyor, mixing and emptying will be proceed in the right way. The variables of each charge can be recorded. The temperature and the couple of forces of the paddles during the process can be recorded as well.

During the production of a batch the temperature or composition of a mixture can be changed by adding ice, water or CO_2 or one of the raw materials. If the temperature is changed by adding ice or water the composition of the mixture is also changed. In this way the premixing process will be controlled.

The next step in controlling this process is an on-line analysis of the water-fat-protein ratio by NIR-analyses. If this ratio is not as desired, the program should instruct to add an extra amount of one (or more) of the raw materials. A mixture with the desired water-fat-protein ratio, the desired temperature and a homogeneous composition can be produced this way.

The results of some experiments are presented in Table 1. Two different products were made using the same raw materials. Three batches of smoke sausage and three batches of luncheon meat were made with lean meat, cheeks and pork rind. The batches of smoked sausage were made with circa 50 kg lean meat, 37.5 kg cheeks and 25 kg pork rind. The batches of luncheon meat were made with 70 kg lean meat and 35 kg pork rind. The composition of the batches is homogeneous and equal to the desired composition.
When one batch has been made, another one can start. This means that the production of different charges can be controlled (Flexible Production Automation).

Table 1

Product		Water (%)	Fat (%)	Protein (%)
Luncheon meat	1	50.5 ± 1.6	34.2 ± 2.1	16.1 ± 0.5
	2	52.4 ± 2.9	32.3 ± 4.4	16.4 ± 0.7
	3	53.5 ± 2.2	30.6 ± 2.9	15.9 ± 0.3
Smoked sausage	1	61.1 ± 0.7	23.5 ± 0.7	15.5 ± 0.5
	2	60.5 ± 1.8	23.5 ± 1.1	16.7 ± 1.4
	3	60.9 ± 1.1	23.4 ± 0.7	16.0 ± 1.1

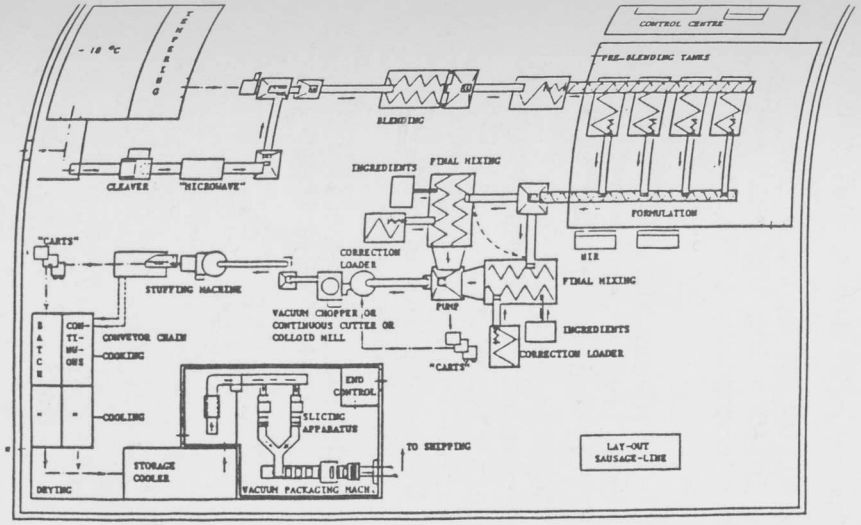

FIGURE 1. SAUSAGE LINE

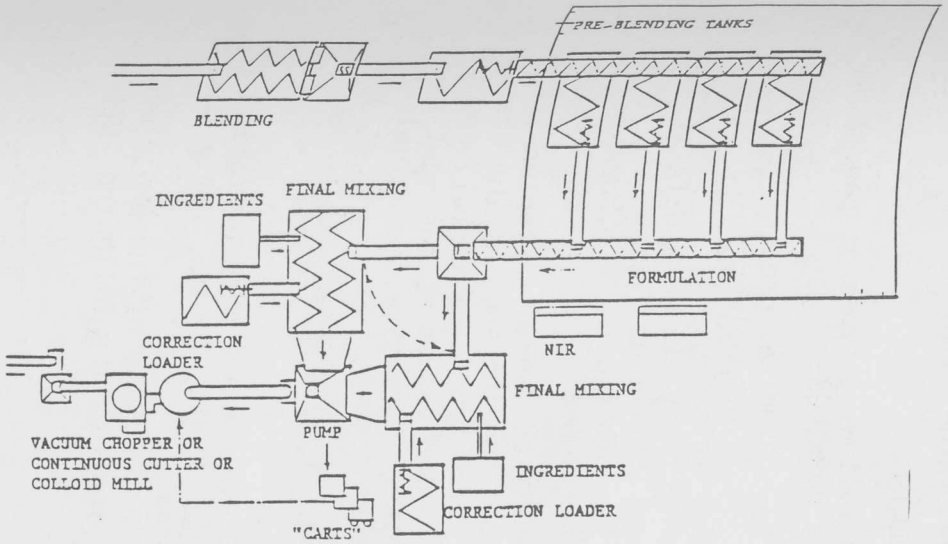

FIGURE 2. MIXING/BLENDING ELEMENT

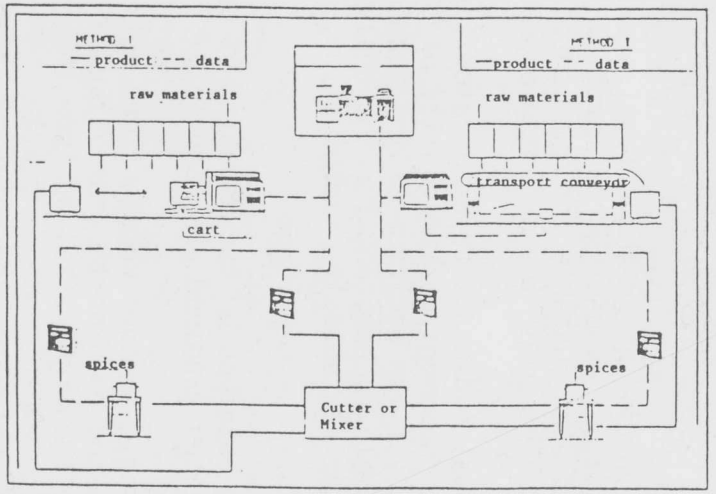

FIGURE 3. COMPUTER-CONTROLLED LOADING CELLS FOR SAUSAGE PRODUCTION

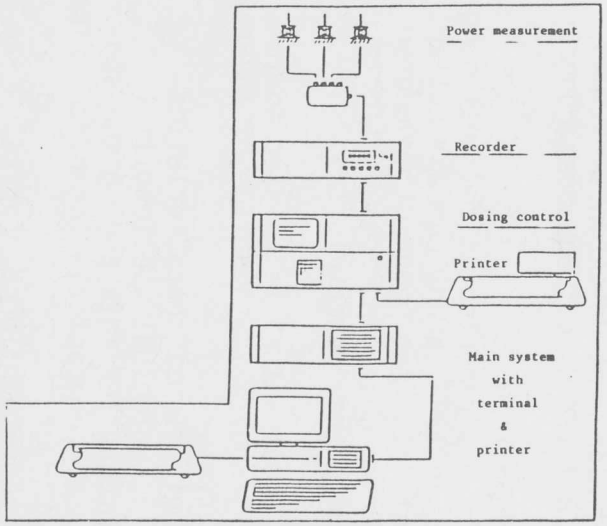

FIGURE 4. CONTROL SYSTEM