Summary of bread production and review of new methods for estimating process parameters

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Abstract: Nowadays the signal processing offers a good theoretical start in the field of industrial processes. This area can give a good feedback of the process and also offers a real time image of the entire production flow. This article presents a study on the engines systems in a grinding wheat system and also the possibility of connection of all the mechanical and electrical parts of the system. Another perspective of the article offers a view over the entire grinding process and also to the possibility of monitoring the engines and offers quick intervention possibilities. First part of this study is related to the grain analysis lab and the updated grinding system on a local producer and how the new technologies can influence factors such as consumption, the life of the machines and also provides better overall performance for the whole system. The second part refers to the software system used for this process and to the real time measurements and the improvements on the power factors. The last part of the article presents an integrated proposal all flow processes, starting to the grinding flow to the finite products. This article can offer a new perspective in the efficiency of the production and also in the production costs.

Keywords: Signal processing, Power factor, Grinding systems, Industrial data management

1. INTRODUCTION

Grain milling is one of the oldest jobs that has been undergoing a number of engineering changes over the years and is still at the industrial level today in the researchers' concerns. According to (Alban J. Lynch, Chester A. Rowland, 2005), along the time there were proposed a lot of mechanisms that updated the empirical mills and keep up with new technologies and provide an optimal grinding process.

This study presents all the grinding process starting from the laboratory for sampling the quality of grains used by a local partner, "Moara Calafatului SRL" and gives a perspective of how the grain parameters, the basic factors influence all the electrical process and the consumption.

Also this article is based on 3 components:

1. The cereals parameters determinations.
2. The mill updated system in the terms of electrical monitoring.
3. The impact of process parameters in the final products with visible results within the monitored bakeries.

Starting with this entire process, it can be said that at every level were offered improving solutions and current technology that influence the production and consumption parameters. All the production flow is represented in the next chart. This scheme gives a perspective of all these three levels. It must be said that the production flow from the cereals products to the final bakery products is a complex system and involves a lot of measurements factors.

According with this scheme, a lot of changes in all the processes were done in the project ADCOSBIO (University of Craiova, Automation department, 2017). In the next sections there will be presented the updates and the improvements that gives such solution for optimizing all those levels of production. Another part of view will be the differences between the old systems and the new ones.

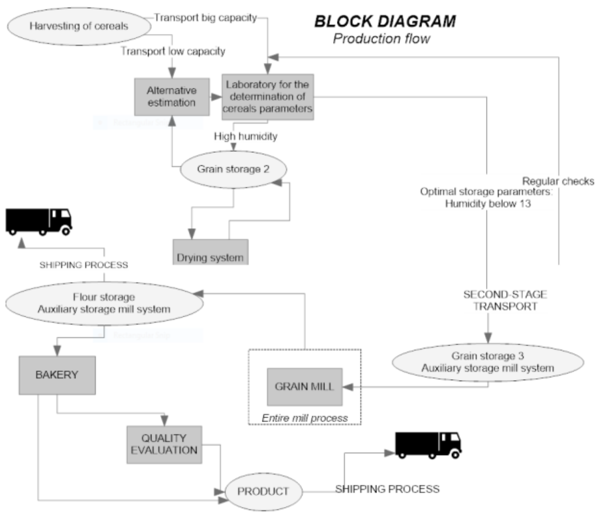

Fig. 1. Chart of the production flow

2. THE GRAIN ANALYSIS LABORATORY

One of the starting points in the bread production consists in the quality of the grain. It must be said that along the project there were used a lot of new measurement instruments for the production of cereals in 2016. This production will influence all the production from the second part of that year. This influence can be reflected in the production costs. A lot of factors was observed during this study:

1. The Humidity influence the power consumption of the grinding mill and the quality of storage.
2. The gluten factor that influence the percentage of flour production around.
3. The protein percentage that influence the bread quality.
4. Another unusable parts of the grain stock production.

All those factors had an impact of process parameters in the final products with visible results within the monitored bakeries. Knowledge of the mechanical properties of cereal grain is indispensable in the design of machines and technologies for the harvest, transport, storage, husking, grinding and flaking (Dziki et al. 2014, Andrejko et al. 2011, Laskowski et al. 2005). One of the most important parts of the study was the acquisition of modern tools to equip the laboratory to determine the grain parameters. The first old model on the right of the previous image, a mechanical estimation model specific to the technology of the 90's with the mildness deficiency and the temperature at which estimates are made. The optimal temperature for work must be at 20 degrees and this is a big inconvenient because in the summer atmospheric temperatures far oexceed these values. Another parameter difficult to obtain for a non-error estimate is the weight of the 140 gram sampling. In the middle of the Figure 2 is presented the intermediary method of measurement according with the SAMAP model H 40 made in France and the Multi-grain tool from the Dickey-John company from USA. Figure 2 represents the analysis laboratory for determining the grain parameters.

Fig. 2. Laboratory with tools for measuring the parameters of cereals

On the left side of the Figure 3 is presented the last model that was involved in laboratory tests, the Pfeuffer HE 50 model which works on the basis of estimates as an electrical impulse for broken or crumbled cereals. Thus, this model offers higher accuracy, giving the humidity in grain compared to the other models that made a general estimate. Also, there are a series of sieves for estimating the nature of broken grains and those that do not meet the standards, as well as deformations. Another point is the balance that is very useful for estimating test samples.

The measurement results for 2016 for wheat production are presented in the following charts. One of the defining parameters for the entire harvesting, storage process is made by the humidity of the wheat. Thus, over a day, more determinations can be made until it reaches the parameters. For example, humidity is directly influenced by several factors:

1. Atmospheric humidity
2. The grain maturity
3. The maturity of the plant
4. Daily climate conditions
5. Soil moisture
6. The culture of the crop, which directly influences the harvesting process, by pressing the green impurities (with a large amount of water)

Fig. 3. The Pfeuffer HE 50 tool

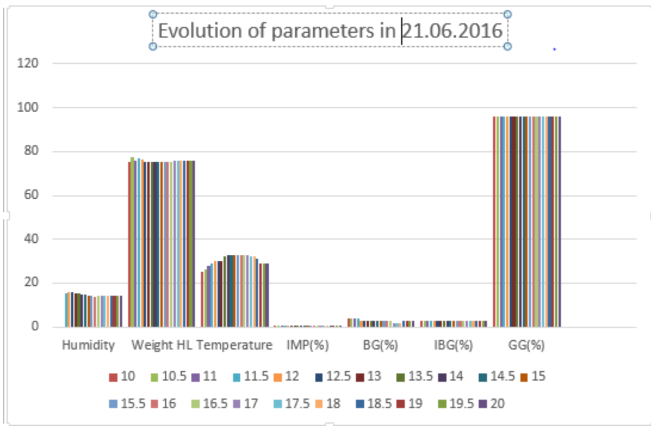

Fig. 4. Evolution of parameters in time over the day

In Fig. 4 are presented a series of specific analyzes for the wheat culture, in the first analysis, the moisture, it can be easily noticed that in the morning, the production lots, measured, have a higher humidity, and during the day this measure decreases, having a great influence in terms of sun exposure. The second parameter, hectoliters weight, is a quality factor of the grain; this factor is influenced by the harvested wheat variety, its evolution, the quantities of fertilizer provided, and the treatments used during the development of the plant, with this parameter reaches closer to the 80th, it means that the wheat is of a better quality in terms of the bakery process.

The third factor, the atmospheric temperature, directly influences the field culture, the harvesting process, but also the calibration of real-time temperature measurement instruments. The evolution of this parameter is specific to sunny summer days. It can be seen, in this example no specific temperature is observed, 40 degrees, as it is a moderate summer from this point of view.

The fourth factor is the impurities of the selected lots, being made with the help of high-precision balances and balanced scales, but also with the help of various forms. Generally, depending on the type of harvesting combine, based on the specific setting a tolerated factor, the impurities in the harvesting process are, as seen, very low. These impurities also influence the other parameters in the analysis, such as humidity or hectoliters weight, if they are not removed during the tests.

The last 3 parameters presented:

1. BG - defective, grained berries, berry grains, burned grains.
2. IBG - deformed grains
3. GG - degree of germination (important parameter for the project that we want to discuss)

In 2016, from a climatic point of view, there was a problem that severely impeded the production, but also the quality of several wheat farms, this being the combination of two major problems.

1. Abundant precipitations have resulted in collapsing more plant areas, which are largely compromised.
2. The presence of hoar days in the spring, which also had a major impact on plant evolution in some areas, affecting several parameters.

It can be seen that grain germination is approaching 100%, being an important factor in seed crops that will provide planting material for next year. The most common defects that may occur in the cereal grain are: frozen berries, shrimp grains, wheat grains attacked, grains with foreign smell and taste, black embryo grains, mycotoxic beans, pearled grains, damaged grains by drying, self-tanning grains, moldy grains, pesticides.

Also there is a great challenge to keep the cereals in optimal condition and also to offer betters products year by year. In Fig. 5 we can see an analysis of the evolution of the hectolitre weight between 80 and 82 and the humidity between 14 and 12.5, it can also easily be observed that starting at 12 o'clock measurements are made for another area and finally, after 22 o'clock, determinations are made for samples already harvested, this process having a difference between direct harvest and measurements, a few hours depending on the distance and the conditions of travel. But towards sunset, the humidity parameter stabilizes, being very low after exposure to sunlight. The other parameter induces the idea of a quality production, and it is very difficult to obtain a parameter of nearly 80 for hectolitric weight in 2016 atmospheric conditions.

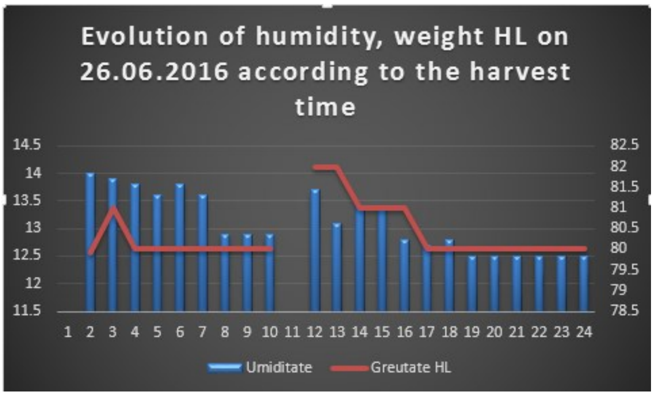

Fig. 5. Evolution of parameters in time over the day

The quality indices of the wheat seeds to be processed must be in accordance with the normative acts in force regarding:

1. Aspect: characteristic;
2. Color: yellowish and reddish;
3. Taste: characteristic;
4. Hectolitrical mass: minimum 75 kg / hl (76 kg / hl for white flour production);
5. Foreign bodies: maximum 3%;
6. Maximum humidity: 14% (15% of the new crop until October 1);
7. Wet gluten: minimum 22%;
8. Glutenic index: minimum 25%;
9. Glassiness aspect: at least 30%.

Starting with the year 2016 and according to the new measurement tools, it can be said that the errors were reduced in this type of determinations.

It is preferred that, for example, for wheat, the wetting factor is less preferably than 14%, the lower this factor, the better. One of the storage reports should take into account that the first process within the next level of processing is made up of wetting and that through this step, consistent energy factors are consumed to climb grain humidity to values around 16% humidity. This is one of the challenges of the process itself.

3. THE MILL'S UPDATED ELECTRICAL SYSTEM FOR MOTORS

It is obvious that, depending on the initial humidity, in which the raw material and especially the wheat enter the milling process, it is taken several percentages for wetting, but the finished product, the end also loses a few percent moisture relative to the wheat humectant. This has been noticed in the process. Grinding is the fundamental operation in the processing of cereal grain (Dziki 2008). One factor, expected to significantly influence power consumption during flour milling is kernel hardness. In fact, several hardness tests have been described that are based on the energy required (Anderson et al 1966, Blum et al 1960, Greenaway 1969) or the time required to grind wheat kernels (Kosmolak 1978, Stenvert and Kingswood 1977). The most common control of an AC motor is based on a motor starter. This device connects the motor to the commercial AC power line. It is rated to operate with the typical high starting (inrush) current that occurs when a motor is directly connected to the utility line (Eaton Corporation. February 2011). As a result of the percentage distribution of flour quality, it is estimated that 75% is attributed to wheat quality parameters and 25% to the milling process. Even if only 25% of the quality of the flour is due to milling, processors in the milling industry have the obligation to improve the quality of the flour so that it is optimal for the bakery and confectionery products (R. von Ow, B. Gerhard. 2010). Another important factor is the percentage of flour, 25% tars and 5% loss in the grinding process of wheat. Maximum input power allowed at the mill is 175kW. Natural power factor was estimated at 0.8, and the improved is 0.95. To achieve this result requires a 118kW battery; is provided equipment for three-phase low voltage capacitor banks, with 3 steps with a rated power of 120 KVAR and power on stage 40 KVAR. All consumers of electricity from the mill are connected to the electrical distribution panel equipped with control and protection equipment for electric as well as reading and recording devices of different voltages and currents.

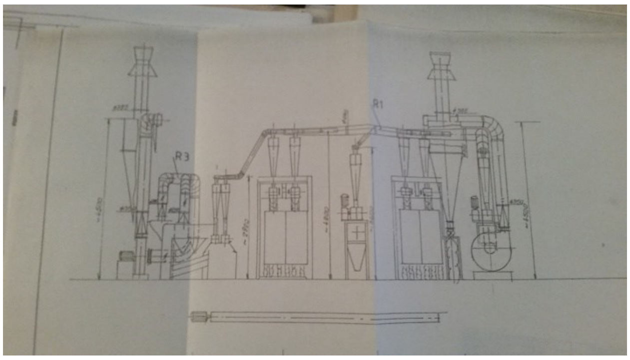

Fig. 6. The complete flow scheme for the mill

The electric motors control is manual, and buttons are mounted on a insulated panel. Pneumatic conveyor and roll fan for corn (high power: 22 kW 11kW respectively) were designed with star-delta-star scheme. In the next table, there is presented the list of power motors involved in the grinding system used in the location. Each of the motors consist in a part of the grinding process for different products. According with the next table, there was proposed the solution to change the starting of the Fan pneumatic conveyor – 22kV (involved all the time) and for the Corn roll – 11kV (involved just in the corn mill process) and also for the monitoring this engines. In this project there was selected the Soft Starter technology to be implemented and to offer new electronic soft used for the slow starting of the engines. There is proposed another starting method an electronical one. The main difference between a soft starter and a drive system is that the first one not change the speed or the frequency. But it ramps up the voltage applied to the motor starting from the initial voltage to the full voltage. In the first step, the voltage of the motor is too low and it is only able to adjust the play between the gear wheels or stretching driving belts and to avoid sudden shocks during the start. Slowly, the torque and the voltage increase so that the motor starts to accelerate. The main advantages of using a soft starter is that it reduce the starting current and thereby avoid voltage drops in the network. It will also reduce the starting torque and mechanical stress on the equipment, resulting in reduced need for service and maintenance (R. von Ow, B. Gerhard. 2010). To achieve system startup / monitoring were used. This information is useful in the planning production management as a reactive power consumption that is significant for the entire process. Starting the torque method is used significantly to limit the engine of 22KW by the mechanical shocks. Those are the biggest engines, the first one having a major influence for the whole process of grinding and transportation.

Table 1: List motors involved in grinding mill

Name	Power (kW)	Revolution (rot/min)
Screw conveyor	0,75	1000
Simple elevator	0,75	1000
Double debarking	4	1500
Suction fan 1	4	1500
Roll	5,5	3000
Plansifter	3	3000
Battery lock	0,75	1500
Maize meal	0,37	1500
Bran finisher	4	3000
Fan pneumatic conveyor	22	3000
Suction fan 2	3	1500
Double conveyor	0,75	1500
Double elevator	0,75	1500
Separator vacuum cleaner	0,75	1000
Fan system	3	1500
Corn roll	11	1500
Sieve with oscillation	0,37	1500

It has purchased and installed a system to ensure their startup using Soft Starter specific type modules according with the specific motors parameters (Popa B., Popescu M. 2017). The implemented system ensures:

1. Start slowly and avoid shocks for motor protection;
2. Monitoring in the first stage engine of 22 kW;
3. Reporting errors;
4. Security and stability of the system for a longer period of time.

For the complete implementation of the new startup system it was used:

1. IF96002 - Module RS232, RS232-C for MF96421 analyser
2. Cable, communication CABLE Length 5 meters
3. ATS01N125FT - Schneider soft starter, 400 Vac, 11 kW, 25 A
4. ATS22D47Q - Schneider soft starter, 400 Vac, 22 kW, 47 A
5. MF96421 - Network Analyser, RS485 communication
6. Current Transformer 100 / 5A AC (6 pcs)
7. Safety-pole 100

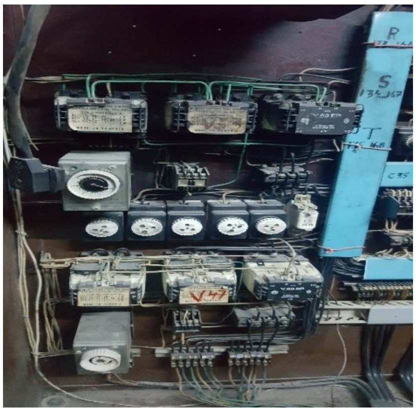

Fig. 7. Old electrical panel

Fig. 8. New electrical panel

After the new system has been fully installed, a number of factors have been improved and system parameters are currently monitored through the software IME – Device Manager Software Evolution 2.5. This software uses a good interface for the visualization and for saving in a txt file the values of the parameters. In the next chart, there is presented an example of the starting for the 22KV engine. There must be said that the Soft Starters were installed for a 20 seconds start-up to the nominal parameters of the motors.

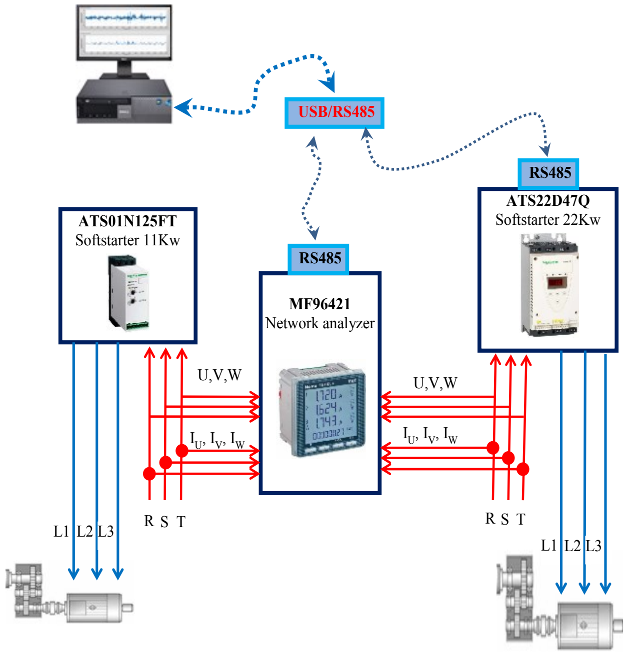

Fig. 9: Complete block diagram application monitoring electrical parameters

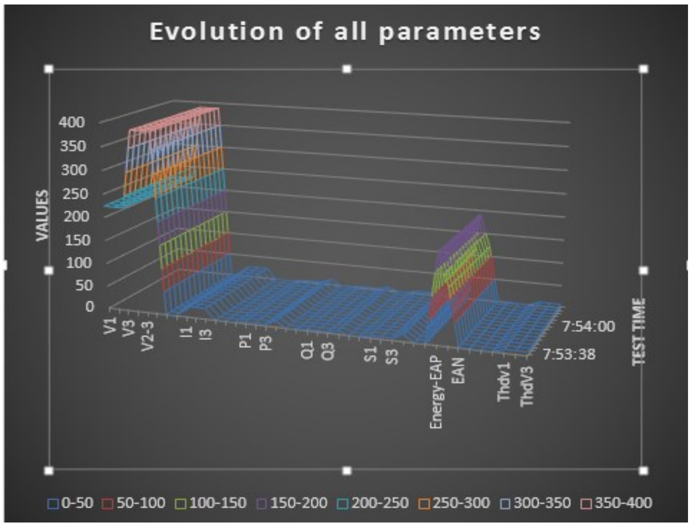

Figure 10. Evolution of all parameters

Several parameters were monitored such as:

1. Measuring currents at startup
2. Evolution of current intensity (load)
3. The evolution of active power at startup
4. The evolution of active power (load)
5. Evolution of reactive power at startup
6. Evolution of apparent power at startup
7. Evolution of apparent power (load)
8. Voltage Total Harmonic Distortion
9. Energy

At this level is processing, the study (Gheorghe Voicu, Sorin-Stefan Biris, Elena-Madalina Stefan,Gabriel-Alexandru Constantin and Nicoleta Ungureanu. 2013), which deals with all aspects of wheat grinding, should be mentioned.
Moreover, starting from the following graphs, which shows the impact of different wheat varieties on energy consumption for grinding, it can be said that in our case such a determination can be made. Starting from the previous study on the “flamura” and “trivale” varieties presented, it can be said that the evolution of energy consumption in our industrial system has also been monitored. 3 wheat varieties were used in these determinations, based on the produced ones, they are "renan" -15%, "arezzo" -10% and "glosa" -75%.

The first aspect of the different evolution of consumption is given by the use of soft starters that alter the startup type of motors to nominal capacity. However, total consumption is influenced by a number of factors, as mentioned above, such as moisture, hectolitre weight, gluten percentage and initially established parameters of wheat grains.

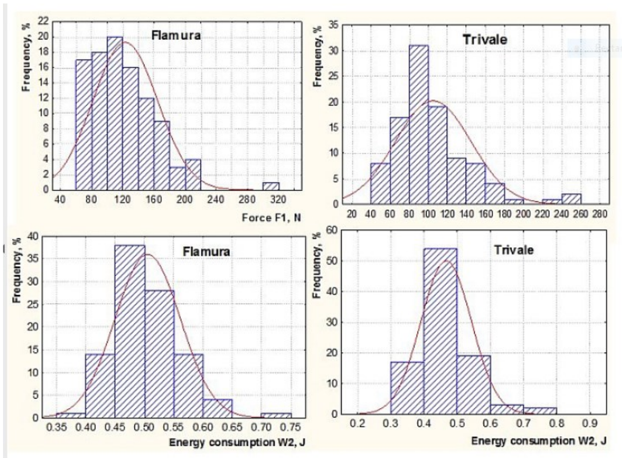

Fig. 11. Study on energy consumed for different wheat varieties in the grinding process (Gheorghe Voicu, Sorin-Stefan Biris, Elena-Madalina Stefan,Gabriel-Alexandru Constantin and Nicoleta Ungureanu. 2013)

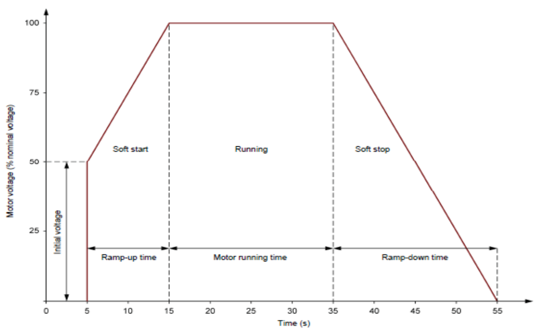

Fig. 12. The standard evolution for a soft starter motor (Festo Didactic. 2014)

Fig. 13. IME – Device Manager Software Evolution 2.5.

In the Fig. 13 is presented the variant of the interface used to monitor the parameters of the motors and their evolution. It has been observed that a variant that does not involve the human factor would be useful. Also, a version that communicates in real time with a whole process management system would also be useful. Such a system could provide a much faster response in case of critical emergency situations. A good example is the study (Zeyad Arif Ahmeda, Rafał Nadulskia, Zbigniew Kobusa, Kazimierz Zawiślaka. 2015) that indicates that, taking into account only the aspect of energy consumption, it is possible to select products with low specific energy during grinding for production and processing, which in effect will cause a reduction of production costs.

4. THE BREAD PRODUCTION SYSTEM

In the next figure is presented the work flow for the third level, for the bourgeois and the final phase of the production chain. As mentioned above, the quality of the finished product is revised at each level. Also, adjusting the steps in this part has effects on energy consumption, working time and productivity.

The baker's scheme is composed of a series of components:

1. 100kg drum
2. Drizzle
3. Refrigerated cabinet
4. Stainless steel table
5. Scales 1-5kg
6. Flour box
7. Mixer
8. Dough boiler
9. Dough divider
10. Long shaped table
11. Tray for trays
12. Modeling table
13. Wardrobe grow
14. Oven
15. Washer

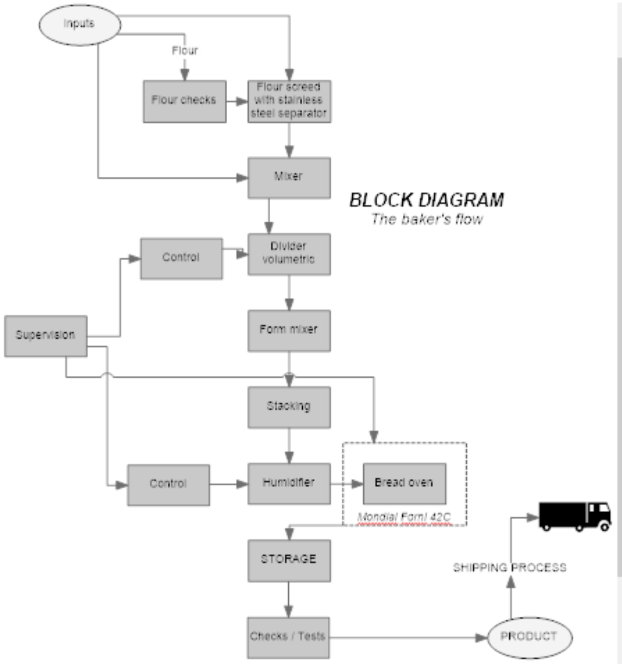

Fig. 14. The baker's flow

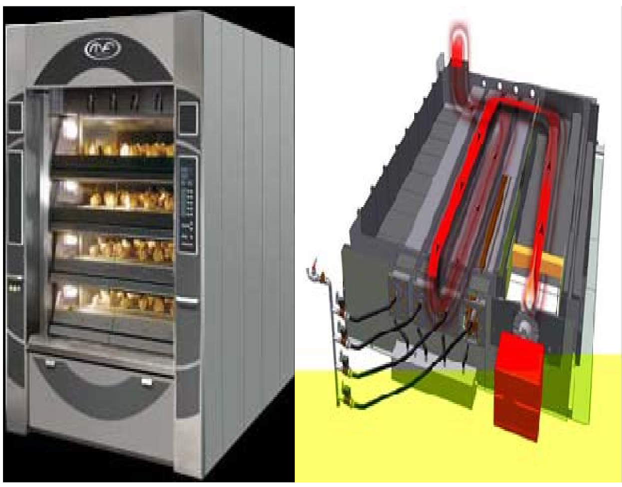

Fig. 15. The 42C Ecomondial oven and baking system

The electronic control panel includes:

1. Automatic firing of the oven for one week (once or twice a week);
2. Fixing the cooking time, independent steam supply for each section;
3. Actual temperature and reference temperature indicator;
4. Temperature indication in each section;
5. Manual switch off of the burner and gas valve indicator.

It should be noted that within this project a number of differences have been observed which influence the quality of the final products. Thus, bread has different aspects depending on the quality of the flour and indirectly depending on the quality of the wheat grains. It can be said that the best qualitative variety was "renan", following the analysis of the final products and that it provides a constant of the bean forms and the fine parameters. It has also been observed that a real-time monitoring and management method for leveling in the production process would be useful.

5. FUTURE WORK

The architecture of the distributed and hierarchical 3-level system to be implemented is shown in Fig.16. The entire bakery flow will be coordinated in a centralized way, starting from the grain parameters before grinding (in the warehouse), allowing the flour to be obtained in the grinding process, after which the furnace operating parameters will be set. At the same time, the system will monitor the entire technological flow, store a history of operation, a metering of energy parameters, and a count of the operating hours to be used for maintenance.

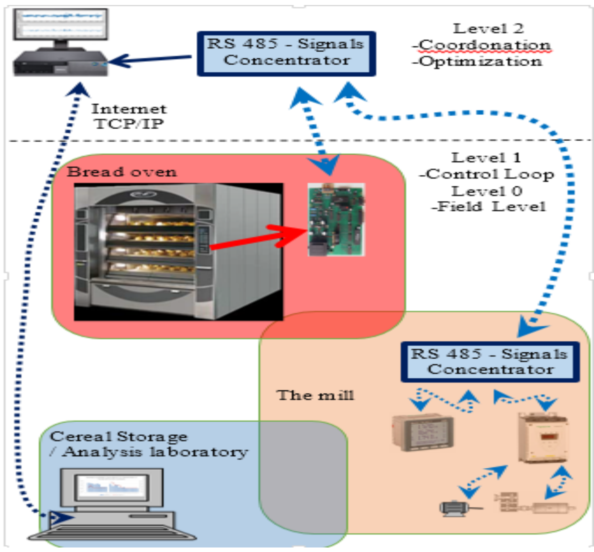

Fig. 16. Scheme proposed for the next development step

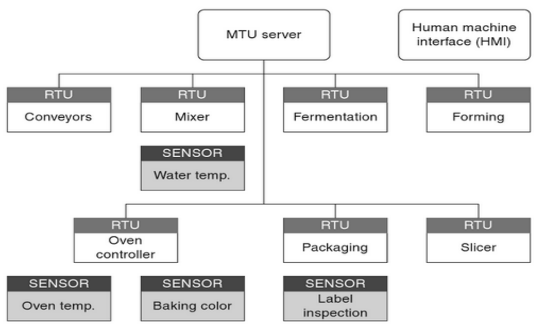

Fig. 17. National SCADA network for baking process (Darwin G Caldwell. 2012)

Rigorous and centralized technology flow planning will lead in parallel with achieving a good quality of the finished product and a reduction in energy consumption with an effect on productivity gains (I.M. Popescu, 2015). As an example of further development for the part of the baker can be considered the model given in Fig.17.

The following list covers the major points to consider when deciding whether to implement a SCADA system or not (Bailey and Wright, 2003):

1. Storage of large amounts of data.
2. Customization of displayed data.
3. Ability to integrate thousands of sensors.
4. Ability to monitor several types of data.
5. Ability to view data remotely.
6. Better consistency of products
7. Automated warning systems

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6. CONCLUSIONS

This article proposes a summary of the activities carried out within the ADCOSBIO project. Within the modernizations carried out in this project we can say that a number of parameters within the three levels described have been improved. Also better monitoring of production phases has been developed. On the basis of the newly used instruments, a more important factor for the parameters of inputs, storage, and processing was also observed. One of the main factors taken into account to be optimized was the electricity consumption for which a number of improvement and monitoring strategies were provided and implemented.

Also, based on the results obtained, a new integrated development model was proposed for a central system of data acquisition and intervention in some stages of the production process. Knowledge of production problems and their rapid retrieval is today an important factor in what is the business or the economic part. The advantages of using new technologies in different production areas are also one of the strengths of industrial process development alongside modern software tools.

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