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DIAGNOSIS OF ELECTRIC ENERGY USE IN A POULTRY SLAUGHTERHOUSE

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ABSTRACT: The operations that occur in slaughterhouses are heavily dependent on electricity. This study aimed to diagnose, analyze and propose solutions that lead to the rational use of electricity without interfering on the quality of the final product from the production lines of a broiler slaughterhouse. The work was carried in a slaughterhouse located in São Paulo, for the period of 2004 to 2008. It was found that the compressors responsible for maintaining the cold storesshowed the highest consumption of electricity, representing 97% of total consumption. It was observed that the power factor do not reaches the value recommended by ANEEL in none of the evaluated electric motors, and it may be possible to optimize the energy efficiency. It was concluded that there are failures in the electric energy use, demonstrating the need to implement an action plan that aims the conservation and rational use of energy and consequent reduction in production cost of chicken meat.

KEYWORDS: Electrical energy consumption, indicators, rational use, slaughterhouse.

Diagnóstico do uso de energia elétrica em um abatedouro de frangos

RESUMO: Nos matadouros, as operações que ocorrem são altamente dependentes da eletricidade. Este estudo teve como objetivo diagnosticar, analisar e propor soluções que levem ao uso racional de energia elétrica, sem interferir, e manter, a qualidade do produto final nas linhas de produção em abatedouro de frangos de corte. O trabalho foi realizado em um matadouro de frangos de corte, localizada em São Paulo, no período de 2004 a 2008. Verificou-se que os compressores responsáveis pela manutenção do frio do ambiente refrigerado apresentaram o maior consumo de energia elétrica no frigorífico, o que representa 97% do consumo total. Foi observado que em nenhum dos motores elétricos avaliados o fator de potência atinge o valor recomendado pela ANEEL, e que, possivelmente, os indicadores de eficiência energética pode ser otimizado. Concluiu-se que existem falhas no uso da energia elétrica, demonstrando a necessidade de implementar um plano de ação que visa à conservação e uso racional de energia e conseqüente redução do custo de produção de carne de frango.

PALAVRAS-CHAVE: Consumo de energia elétrica, indicadores, uso racional, abatedouro.

1 INTRODUCTION

With globalization and open markets there has been an intensification of international trade. To meet the demands and compete effectively, it is essential that companies invest in technology to increase productivity and reduce production costs. Thus, the efficient use of electricity is presented as a new paradigm to be followed.

The change of habits and attitudes to achieve energy efficiency in industrial installations is presented as one of the biggest obstacles to overcome (RUANDEZ et al., 2009). In developed countries of the OECD, between 1973 and 2005, the global gains in energy efficiency were around 58%. The efficiency gains between 1990 and 2005 were approximately 0.8% per year.

As regulatory agencies have not established, yet, stricter rules regarding the level of "contamination" that consumers can inject into the network and the level of "quality" that utilities must maintain, the scenario is open to legal battles, which encourages the increase in research in this area (Ferreira et al., 2009).

In Brazil there is an effort by the government to regulate the standards of quality in electricity transmission and distribution levels. Currently, it was regulated the PRODIST: Distribution Procedures (ANEEL), which contains the regulatory documents that describe some performance indicators and quality of electricity services.

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In agribusiness, the use of traction engine is the main alternative source of electricity to the use of AC motors; single and three phases are the most used for this purpose (OLIVEIRA FILHO et al 2011). Motors with nominal load index below 75% lower power factors require proportionally greater since they amount of electrical energy to produce mechanical energy.

Motors with rated load index with power factors below 75% require a greater amount of electrical energy to produce mechanical energy.(OLIVEIRA FILHO et al., 2010).

According to CARDOSO et al. (2009), the introduction of more efficient engines in the market resulted in energy savings in the order of 428 GWh and a peak demand reduction of 119 MW, in 2007.

Another agricultural sector that accounts for a large electricity demand is irrigation system, which increases the cost of production and may represent about 25% of it. A set of measures, such as using frequency inverter together with the adequacy of pricing are crucial for process optimization (BERNARD et al, 2008).

Several studies have been conducted that emphasis on the rational use of electricity. Among them, BUENO & ROSSI (2006) and SARUBBI et al. (2008) demonstrated that energy efficiency coupled with the thermal comfort in broiler and swine facilities provided a livestock with higher animal density and consequently, higher production feasibility. DAVID & ROSSI (2009) analyzed the production efficiency of chrysanthemums, checking the performance among the varieties and found that the the use of lamps of high intensity discharge resulted in lower peak demand and in an average reduction in energy consumption of 75 %.

Based on this, the aim of this study was to detect, analyze and propose solutions that lead to the rational use of electricity, without interfering on the quality of the final product of broiler slaughterhouse production lines.

2 MATERIAL AND METHODS

The survey was conducted during 2004-2008 in a commercial slaughterhouse located in the State of São Paulo, in the circumscription of the Office of Agropecuary Defense (CDA, 2009). The slaughterhouse produces chicken or chilled carcass, chicken or frozen carcass, cold cuts and seasoned cold cuts. This slaughterhouse is under the inspection of the Federal Inspection Service (FIS).

The refrigerator has the capacity to storage slaughter 2,500 chickens per hour and the slaughter daily average is of 16,000 chickens that wheight ~ 2.5 to 3 kg.

All analysis were done during weekdays.

The power consumption of all equipment involved in the slaughter process was measured daily for one week. Using these data as reference, we identified some indicators which may become critical or not, depending on its outcome: a) minimum number of equipment or type of equipment that represent a greater part of the measured total consumption of electric power; b) minimum number of areas or equipment that cause the highest costs of electricity; c) factors or control parameters that can influence consumption, losses, and energy costs.

To measure the use of electric, we used the SAGA 4000 and RE 6081 equipments that measure and storage the main magnitudes of electrical circuits that supply electrical equipments. The equipment SMART TRANS was used to conducted the concomitant measurement of power of the seven compressors from the engine and storage room. To determine the average specific consumption (kWh kg-1), the weekly average production of chiken in kilograms and the total weekly production average were calculated. The average specific consumption of energy calculation was done using equation 1:

$$Ces = \frac{CA}{QP} \qquad (1)$$

In which,

Ces – Specific consumption in kWh slaughterhouse production-1 ;

CA - Total weekly average of energy consumption in kWh, and

QP – Total weekly average chicken meat produced in the slaughterhouse in kg

To calculate the load factor of the electric installation of each feeder engine from the engine room's compressor motors, the equation 2 was used:

$$FCi = \frac{CAi}{hi\ DRi} \qquad (2)$$

In which,

FC – Load Factor;

CA - Weekly energy average consumption by the compressor's engine, kWh;

h - 120 hours;

DR – Weekly maximum Registred Demand of potency of the compressor's engine

i – Compressor's engine

According to MARQUES (2001), the minimum structure that the energy consumption diagnostic method must have in order to implement energy efficiency is to identify, quantify, monitor, and modify. As this paper aims to identify, quantify and propose solutions, the steps of implementation and monitoring are not part of the scope of this work, because it was carried out in a slaughterhouse already in operation.

3 RESULTS AND DISCUSSION

Through the analysis conducted, it was found that the compressors of the engine room, which are responsible for maintaining the refrigerated environments, showed the highest consumption of electricity, about 97% of total consumption. None of the electric motors reached the power factor recommended value by ANEEL.

Tables 1 and 2 shows the engines used in each stage of the slaughter process with their operating conditions results. The Table 3 shows the operating conditions of the compressor from the engine room. Days and/or periods when equipments were being used in the analysis week, were discarded. This way, only the periods during which there was current (A) in the engines were analyzed.

Table 1 - *Operating conditions of electric engines in the receiving platform and hanging line.*

Place					
Receiving platform					
Area	**Equipment**	**Quantity of engines**	**Potency (CV)**	**FP**	**C (kWh)**
Waiting room and slaughter platform	Fan	13	0.5	0.44	28.30
		3	1.0		
	Pump Spray	3	4,0		
Hanging line					
Area	**Equipment**	**Quantity of engines**	**Potency (CV)**	**FP**	**C (kWh)**
Insensibilization	Disturber	1	1.0	0.39	1.79
Bleeding	Noria	1	2.0	0.35	1.20
	Bleeder	1	1.0		
Scaldation	Scalder	4	2.0	0.56	9.59
Deplumation	Feather remover	8	5.0	0.64	8.08

FP = Average daily power factor, C = Average daily consumption

Table 2 - *Operating conditions of electric engines in the evisceration line, drying line, and cut line.*

Places					
Evisceration Line					
Area	**Equipment**	**Quantity of engines**	**Potency (CV)**	**FP**	**C (kWh)**
Line	Noria	1	2	0.36	5.22
Table	Mat	1	0.5	0.45	14.29
Feet	Cutter	1	1.5	0..21	2.46
Cooler	Pre-cooler	1	1	0.37	3.12
Cooler	Cooler	1	0.5	0.43	2.88
Internal organs and neck cooler	Gizzard cooler	2	0.5	0.18	1.90
	Liver cooler	2	0.5		
	Neck cooler	2	0.5		
Ice machines (1 and 2)	Pump	2	8.5	0.78	28.29
	Pump	2	0.5		
	Pump	1	2.0		
	Pump	2	7.5		
Área	**Equipment**	**Quantity of engines**	**Potency (CV)**	**FP**	**C (kWh)**
Cut Line	Noria	1	1	0.33	2.83
Table	Mat	1	2		
Área	**Equipment**	**Quantity of engines**	**Potency (CV)**	**FP**	**C (kWh)**
Drying line	Mat	1	2	0.53	4.98
Table	Noria	1	2		

FP = Average daily power factor, C = Average daily consumption

Table 3 - *Operating conditions of electric engines in the engine room.*

Area	**Equipment**	**Quantidade de motores**	**Potency (CV)**	**FP**	**C (kWh)**
Engine Room	Compressor 1	1	50	0.81	321.05
	Compressor 3	1	75	0.89	459.10
	Compressor 4	1	50	0.67	542.03
	Compressor 5	1	75	0.89	539.59
	Compressor 6	1	75	0.64	264.12
	Compressor 7	1	125	0.85	1343.30

FP = Average daily power factor, C = Average daily consumption

The main energy consumption from the slaughter process steps were the machines responsible for ice production and the waiting room with the deck of slaughter, that accounts for 49.23% of average daily consumption (Tables 1 e 2).

The steps scalding and deplumation are responsible for 15.37% of average daily consumption of electricity and both have an installed capacity of 48 CV.

In the evisceration line, the facilities that holds the slaughter, noria and mat steps are automated (a total installed power of 2.5 hp). These steps represent a percentage of 16.97% in average daily consumption. Also, in the evisceration line is present the step of cooling by immersion in cold water, which account for about 7% in total average daily consumption (total installed power 4.5 CV).

It appears that the compressor 7 (125 CV), which showed average daily consumption of 38.72% (Table 3) is the most used. This compressor was later acquired by the company (WEG brand, model 3≈ 250 S, 1775 rpm, 220 V). One can observe that the sum of the daily average intake of electric power from compressors 3, 4 and 5, which have a total installed power of 200 CV, are only 5.69% higher than the consumption of the compressor 7. Aside from the compressor 7, the other five compressors are old and receive irregular maintenance, and because of this, there are expected not to use energy rationally. Some of the compressors were installed in the establishment of the company, about thirty years ago. The maintenance of these compressors is made when the company finds it necessary. This lack of attention on maintaining the equipment contribute to the waste of electricity, with an increase of consumption and consequent increase in costs incurred, as reported by RUANDEZ et al. (2009).

In many companies a minority of the equipment represents the majority of energy consumption. The driving force is among the main use of electricity in industry, accounting for about 50% of final energy use in industry (CARDOSO et al., 2009). Usually compressed air systems, motors and pumps should be the main target of maintenance, repair and adjustments. In industrial environments, according to BORTONI & SANTOS (2001), electric engines and transformers represent 50-70% of industrial loads so that they represent a large potential for energy conservation.

RUANDEZ et al (2009) reported that the efficiency improvement is possible without the need for changes in production demand, when improving plant efficiency one may achieve, as consequence, an increase in production and a decrease in energy costs. The power factor indicates how much apparent power is being transformed into active and reactive power, which must be equal to or greater than 0.92, so it will not overload its network. Note that at any stage in the slaughtering process (Table 1 and 2) and in the engine room (Table 3) this quantity reaches the minimum power recommended by ANEEL. According to CPFL (2007); BUENO & ROSSI (2006); SARUBBI et al. (2008); DAVID & ROSSI (2010) it is one of the factors that lead to increases in costs generated by the electric power.

In the steps of the slaughter process it appears that the power factor reaches more critical values when compared with the values found in the engine room. This is due to the engines used in the slaughter process being of smaller potency, old and in need of maintenance. Similar results were found by BUENO & ROSSI (2006); SARUBBI et al (2008); DAVID & ROSSI (2010) in analysis of electric energy use in agropecuary, where they found values electric engines of power factor below 0.92.

In general, the engine operation (slaughter and waiting room steps) compressors respond to 96.79% (3469.19 kWh) of energy comsunption with an average daily power factor of 0.79. The remaining lines had a daily intake added of 114.93 kWh, or 3.21% of total energy consumed in a day and averaged a power factor of 0.44. These results indicate that the critical point of energy consumption is within the cold chain, where energy efficiency measurements should be deployed. However, note that the power factors of all lines and engine room were found below 0.92, showing the need for rational use throughout the slaughterhouse (NOGUEIRA, 2007; GARCIA et al., 2007).

Similar results can be found in supermarket installations, where equipment installed for cooling are responsible for the highest peak of electricity demand, and that the replacement of old equipment for better energy performance ones would be an alternative to reduce consumption of electricity.

Moreover, during the research period, we observed failures in preventive maintenance of cold chain and FERREIRA NETO et al. (2006) reports that such deficiency may cause an increase in air temperature inside the chamber and an increase in power consumption.

Analysis of energy efficiency indices

About 97% of the slaughterhouse's electricity consumption comes from the engine room that drives the cold rooms; to do the calculation of the load factor, the average weekly consumption of electricity (kWh) concerning the compressors' engine was used as basis. As for the specific consumption (kWh kg of chicken meat-1), the total average weekly consumption of electricity in the slaughterhouse was used as basis.

The highest maximum demands recorded (MDR) concerns to the compressor 7 (96.89 kW) followed by the compressors 5 (64.67 kW) and 3 (46.54 kW), each one of them showing, respectively, load factor of 0.58, 0.35 and 0.41. As for the compressors 1,4 and 6 they showed a lower MDR (31.08 kW, 26.58 kW and 22.96 kW) with load factor of 0.17, 0.85 and 0.48. The specific consume (kWh kg chicken meat-1), in a typical week, taking in consideration the slaughterhouse processes and the engine room, was of 0.15 kWh kg of chicken meat-1.

It is notable that the agropecuary and industrial sectors have deficiency in electric energy use. It can be verified through studies carried out by GARCIA et al. (2007), BUENO & ROSSI (2006); SARUBBI et al. (2008) that found small load factor values in both broilers and pigs farms. A similar result was observed in this study, where all compressors presented lowe factor values indicating inefficient use of energy, since, according OLIVEIRA & RABI (2005), the higher the load factor the lower the cost of energy used and more appropriate and rational is the use of electricity.

In a large production scale, the specific consumption may influence significantly the final cost. This indicator, which is the energy consumption per product, is important and can be used as an indicator of energy use and may indicate the need of implementation of energy conservation measurements.

4 CONCLUSION

There is a necessity to implement an action plan that aim to the conservation and rational use of energy and consequently to the reduction in costs in chicken meat's production. Among the adequations to be apllied in the company analyzed in this study are: the installation of capacitor banks for power factor correction, the resizement of several feeder cables, and the establishment and implementation of a preventive maintenance program and staff training to operate properly the electrical loads. In addition, it may be crucial to develop an appropriate design of electrical installations.

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