Electric Energy Reuse of Plastic Injection Machine Motors for Lighting Circuit in a Manaus-Amazonas Industrial Pole Company

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Abstract

This work aims to reuse the electric energy used in three-phase induction motors of an industrial plastic injector for the lighting circuit of the same warehouse where the injectors are located, thus eliminating the need to use the energy of the electric company. Any resource that reuses electricity with better efficiency becomes essential today, making it a solution for industries that are thinking of saving the energy used in the productive processes in the manufacture of goods.This project uses a synchronous generator coupled to a three-phase induction motor of a plastic injector, which will reuse the electrical energy used of the induction motor to mechanically drive the synchronous generator, that will be able to generate enough electrical power in its coils for a 47-light shed lighting circuit, thus eliminating the need to use utility power, saving a portion of the energy usage costs on the monthly bill. This installation of the synchronous generator was performed on equipment of the company Moto Honda da Amazônia, which has a 24-hour operating regime for six days a week.

Keywords: three phase induction motor; plastic injection molding machine; synchronous generator; lighting;

1. Introduction

Electric energy becomes essential today in human life, both in economic, political, social, environmental and technological aspects. In short, energy is the ability to do work. Due to the growing demand of the

population, it is considered an important factor in production to boost the economic development of the country [1].

The consumption of electricity has been increasing more and more day by day, creating a big problem for the power generation companies, which to meet this need and generation costs, end up increasing the cost of Kilowatts / Hour, which reaches both In the population and industrial sectors, it is therefore necessary to use it rationally by both low-power and high-power consumer groups [2].

Some factors that interfere with the generation of electricity are climatic and environmental. In times of water scarcity, for example, hydroelectric plants have had limitations on power production, with low levels of water in dams, decreasing or even losing water pressure to move their turbines. In Brazil, its main source of electric energy is generated by the force of the river water current, so to preserve scarce natural resources, it is necessary to consciously use electric energy [3].

There is a lack of electricity supply to factories in the Manaus industrial hub, which can cause several negative impacts. One of them is the shutdown of the production line, especially for companies and small industries, as it is the only alternative source of energy for the production process, because they do not have a high power generator that meets this need. A standstill production line does not meet the goal of delivering to customers, which to alleviate the problem is necessary to approve overtime for employees who generate more spending on labor, equipment and logistics [4].

Amid this scenario all the reuse of electricity is necessary. Many industrialists use means and ideas that can save and make their production possible at the lowest possible cost of electricity. The project described here has as its purpose the reuse of electric energy from motors of plastic injection machines for lighting circuit.The project mentions how Electric Energy can be reused in an Industry that has high power motors in production equipment or any other type, which has a system with continuous rotation, through just a simple idea, which can reuse this energy, low-power circuits such as a warehouse lighting circuit.

2. Theoretical Referential

Increasing energy consumption has become increasingly necessary over time, as one of the main sources of energy generation comes from oil, a natural resource that over time becomes scarcer because it is not renewable. The main factors influencing the increase in electricity consumption and the unbridled increase in world population, production and manufacture of large-scale food and electronic goods and products, among others [5].

Faced with this scenario, any resource for generation, reuse of energy or use with better efficiency becomes essential today. With the advance of power generation technology through synchronous generators, there is an opportunity to reuse this already consumed energy.

The electrical energy generated by a synchronous generator and converted through mechanical rotation on the shaft. The generator rotor is driven by a prime mover machine, which produces a rotating magnetic field within the machine. This rotating magnetic field induces biphasic voltages in the generator stator windings [6].

Synchronous generators have two fundamental parts. A so-called fixed stator where windings and coils are located, known as armature windings. And another moving part we define as a rotor, where the field

winding is housed. It is called synchronous due to the equality between the electrical frequency and the angular frequency, ie the generator rotates at the speed of the magnetic field [6].

Whereas in the case of distribution grids, generators are usually operators in order to keep the active power constant regardless of the grid frequency. However in this work the rotation is continuous with constant mechanical torque.

For use in power plants where some type of fuel or drive is responsible for producing directly or indirectly the rotation of an axis to which an electric generator is coupled, turbo generators are usually used.

Due to their characteristics, especially those concerning generator optimization, driving machines are usually quite fast (1800 or 3600 RPM). These features have the benefit of being able to put as much power as possible in a smaller volume due to the high speed when coupled to any engine such as: Electric or combustion induction motors, plastic injection hydraulic pumps, among other equipment that has a rotation system of compatible speed.

Plastic injectors are equipment whose purpose is the production of plastic parts by injecting polymers (plastics) to high temperatures in prefabricated mould. And in this equipment the consumption of electric motor and 80% of the whole machine [4].

Many injection molding machines have all their operation based on a hydraulic system, i.e. the electric motor drives one or even more hydraulic pumps. The hydraulic oil pump in a plastic injector is a device that receives electrical potential energy through the rotation of a three-phase induction electric motor and transforms part of it into motion and pressure energy. And the pressure and flow of oil that carries out the opening and closing movements of mold, material injection and spindle movement. In this valve opening and closing system is the actuator, taking the oil flow or pressure to where it is needed according to the need of the injection cycle, the transmission is through increased pressure, increased speed, or combinations. between different energies. In other words, the hydraulic oil pump pumps hydraulic fluid, also known as hydraulic fluid, and at times when no pressure or flow is required, hydraulic fluid recirculation occurs [7].

As these plastic injector motors are working throughout the production process in a regime of up to 24 hours without breaks, and at this point it can be reused this energy of the motor in constant motion, coupled to a biphasic synchronous generated, which can generate power to supply luminaires scattered throughout the shed, As these plastic injector motors are working throughout the production process in a regime of up to 24 hours without breaks, and at this point it can be reused this engine energy in constant motion, excluding the need for electricity consumption made available by the dealership. Thus bringing savings to the company in the reuse of electricity in any equipment that has a rotation system that can be coupled to a synchronous generator.

To perform the installation it is necessary to lift the power and speed of the injector engine in relation to the synchronous generator, the speeds have to be close and the power of the electric motor three times higher than that of the generator so there is no overload of the Injector Motor. Every electric motor or generator has data supplied on a plate by the manufacturer fixed in the housing and also in manuals or datasheets, with more specific details of the equipment.

The ratio of the nominal output power of the generator must be greater than or equal to the power of the luminaires to not overload the generator, or in case of any increase in the structure of the shed there will be

no need for total change of the project.

The luminaires used in the shed are LED technology, which have low electricity consumption and with greater efficiency in lighting. Although the use of LED technology still has some challenges to be overcome, especially with regard to its high cost of initial investment, it has great advantages, such as the quality of its light and its energy efficiency [8].

For circuit control and safety and required a control panel with overload and short-circuit protection devices for generator safety in any overload.

In case of the need to disconnect the plastic injector, there is a need by the control Panel a design by-pass system for automatic feedback by the electric power utility. For lighting according to production needs.

When corrective or preventive maintenance of the synchronous generator is necessary for any inspections or exchanges of belts, bearings, coil insulation measurements, checking of couplings and retightening of terminals or even in case of exchange of Own generator, the automatic design by-pass system will also be used on the control Panel.

3. Methodology

The nature of this research is characterized as an experimental research, which determines an object of study, selects the variables that would be able to influence it, define the forms of control and observation of the effects that the variable produces in Material [9].It is characterized by the determination of a study object, the variables that could influence are defined, the forms of control and observation of the effects that is variable caused in the object are selected. So because this modality is sidewalk in experimental methods, it is more directed to the physical and natural sciences. Even if the margin of errors represents a relevant factor, its contribution is quite significant, given its application in practice. In the end, it is part of the practice, aiming at interfering in the reality itself.

The tests were performed in a mechatronics laboratory, in the company Moto Honda of Amazonia. This company was chosen by the vast sheds structure that have large quantities of luminaires and equipment with three-phase induction motors. Assays were performed as shown in Figure 1, with a Kohlbach biphasic synchronous generator, with a power of 2.2 KVA and rotation speed 3600 RPM, which was coupled its axis to that of a three phase induction motor with a power of 2.4 KVA only for testing , and rotation speed of 3800 RPM, compatible with the speed of the synchronous generator, which after energized and by is fixed to the generator,möglich realizar um movimento de medições no seu eixo, ocasionando na saída do gerador uma tensão de V = 220 VAC, aferida por um multímetro de fabricação Minipa de modelo ET-3200 em escala de tensão.According to the specifications and data provided by the manufacturer of the plate attached to the motor housing, it is possible to know the maximum operating current that the generator can withstand in its output, so that there is no possible overload or burning of the equipment of Generation.

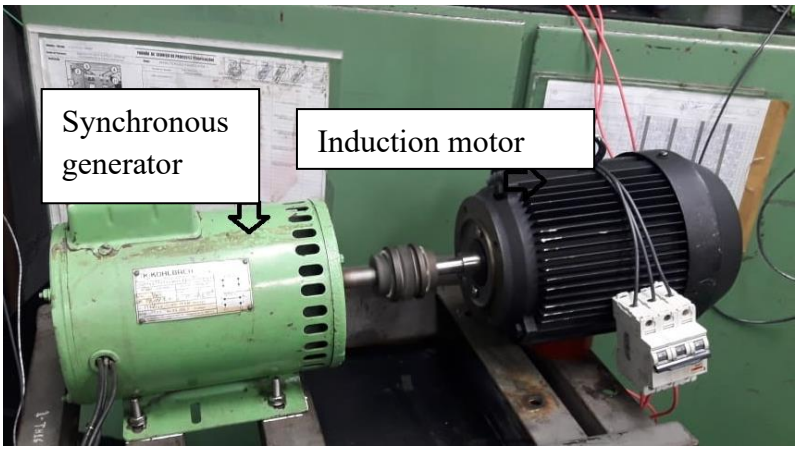

Figure 1. Test with synchronous generator and induction motor.

For eventual tests of the experiment were used the laboratory lighting lamps themselves represented by Figure 2, which have a quantity 7 luminaires, reaching a total of 14 LED bulbs, with 32 W of power and rated current of 0.145 A, That the installed joints reach a total of 2.3 A. These nominal current data of the lamps are also described in the Luminaire housing explained by the manufacturer.

Figure 2. Luminaires with test lab lamps.

It was necessary to remove the input power of the circuit breaker from the general frame of force of the laboratory lighting circuitry, where the interconnection of the generator output circuit was made in the circuit breaker itself, thus eliminating the power supply Electricity offered by the concessionaire.After this process the induction motor coupled to the generator is energized at a three-phase voltage of 220 VAC, which excites the coils of its rectifiers that will carry out measurements movements on its axis thus causing the mechanical drive of the synchronous generator.

While the generator performs rotational motion at a constant frequency, its output voltage will remain stable, and the 7 laboratory luminaires can be fed by its output voltage.

For better analysis, the same multimeter was used in the electric current scale to evaluate and observe whether the electric current will not exceed the nominal current of the generator for safety purposes.

The test was performed in a 24-hour regimen, analyzing whether it will not present oscillations of current and voltage outside the standards of the equipment nominals. After the 24 test hours, the voltage and electric current were measured again, which remained within the specified values, within the working range stipulated by the manufacturer, as well as the engine temperature, measured by the infrared thermometer

of the Fujitsu model TI30, which may not present a value greater than 60 °c in its display, which is the maximum operating temperature of the operating limits provided by the manufacturer.

The electrical diagram of the circuit is described in Figure 3. In it, with the selector switch S1 in the ON position it is possible to connect the panel of the control circuit. When the injector is in production process, its hydraulic motor mechanically actuated the generated synchronous, generating a voltage of 220 Vac in the coils of outputs of the generator.This voltage triggers a TR1 timer connected in parallel to the generator output, which makes a 3-minute count. After counting, the timer TR1 switches its closed and open contact, the contactor MS2 responsible for the power of the luminaires through the utility's electric power and off at the same time the TR1 timer switches the open contact by closing and Triggering the contactor MS1 responsible for the power of the luminaire through the electrical energy generated by the synchronous generator.

The electric command in Figure 3 serves as an automatic by-pass has a safety interlock system using normally closed auxiliary contacts of the contactors themselves so there is no possibility of double triggering.

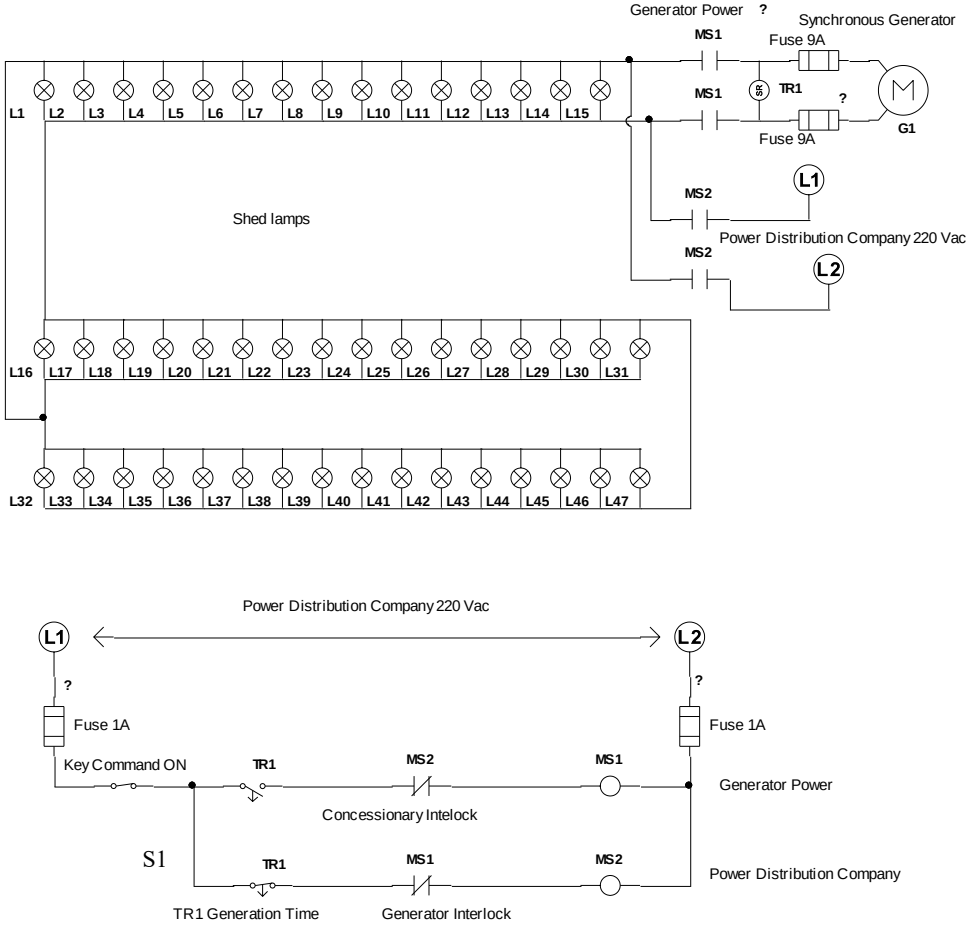

Figure 3. Electrical circuit diagram.

The entire circuit controller is protected by fuses, according to the nominal current of each circuit preventing any overload. To become more viable, the by-pass control Panel is powered by the utility's electric power, leaving the circuit independent of the operation of the plastic injector.

4. Analysis and discussion of results

With this experiment that was performed in the Mechatronic laboratory, it became easier to have a reference to perform the installation of the synchronous generator in the equipment, by itself knowing which material was used and what method to follow, thus executing the activity In the area, where the plastic injector is located and the luminaires installed in the shed.And through the simulation of the experiment it became more reliable to expect the result of coupling to a three-phase induction motor of a plastic injector by possessing a power of 75KW, well above the engine power that were made tests.

After coupled the synchronous generator next to the three-phase hydraulic injector engine of 1300 tons, with its control panel and by-Pass, the design has suppressed the need for electric power supply of the lighting circuit of a shed with 47 luminaires 32 W each, Even increasing the consumption of 160 W of three-phase motor power in the mechanical drive of the synchronous generator, the generated energy compensates, in relation to its modified working power after installation, leaving still a slack of 15 luminaires of the same Power supply, providing a total of 1,984 W of electric power for illumination.The shed has 13 plastic injectors and each consisting of 3 three phase induction motors, the project can encompass a greater amount of power generation, around 39 times the more. Figure 4 shows the luminaires that are present in the shed.

Figure 4. Shed Lighting Fixture.

In the experiment, it was observed that in a sample performed to analyze the tension, to each luminaire that was connected, there was a voltage drop of 0.1 V. Figure 5 exemplifies this voltage drop. For an initial value of voltage 227 V, when no luminaire is switched on, this voltage remains the same stable. When a 32 W luminaire is energized, there is a voltage drop of 0.1 V of the initial value. Therefore, the voltage becomes 226.9 V. When a second luminaire of 32 W is energized, again there is a voltage of 0.1 V, in which the voltage passes be 226.8 V and so on. In Figure 5, the luminaire actuation is exemplified by the range 32 W to 160 W, each time a luminaire and connected, there is a sum of powers, this same process occurs for the triggering of the other luminaires.

Tension(V)

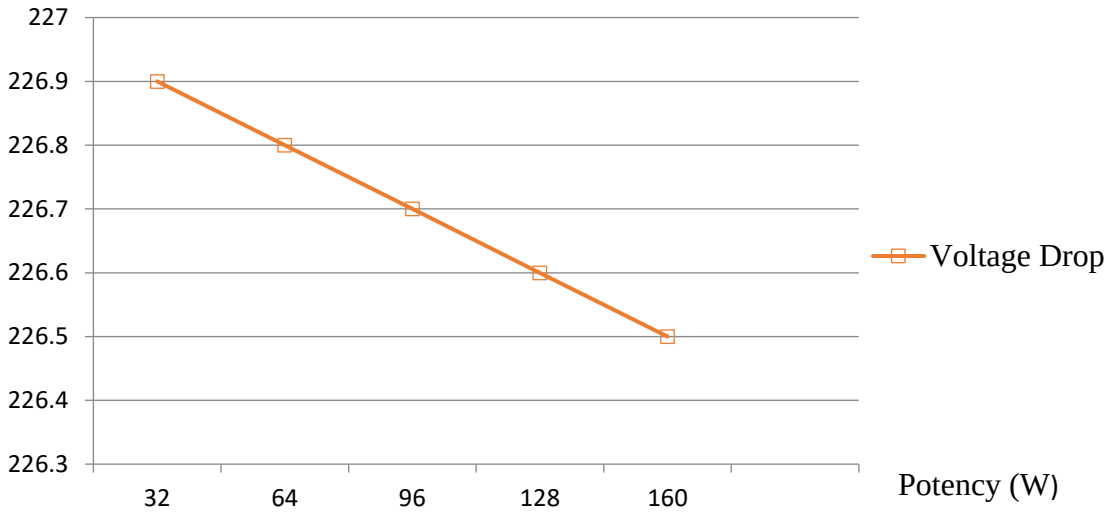

Figure 5. Voltage and power ratio.

This energy, being generated on a large scale, in another plastic injector existing in the factory, can be used in the other sheds, throughout the lighting circuit, implying an economy in the consumption of electricity coming from the concessionaire.

This project being installed in the factories of the industrial pole of Manaus will cause the concessionaires to provide a smaller amount of electricity that ultimately emits less CO2 in the atmosphere from thermoelectric plants due to lower consumption and demand of Electricity, being a great benefit to society and nature.The company can also hire more employees, increase wages, improve employee comfort in the factory premises, and also reduce inputs in its production process, bringing a benefit to society in the generation of jobs, quality of and ease of purchase of manufactured goods.

5. Conclusion

Based on what was presented in this article, we can consider that technological advancement contributes to a better generation of electricity, as well as a better reuse of that which was generated, even more in the scenario nowadays, with increases Unbridled electricity tariffs in the generation in KWh, which has a high cost, as well as in the industrial polo sector of Manaus, making it impossible for some companies to be able to perform their industrial and commercial activities.

In this way, the opportunity to take advantage of this technological advancement in order to save and supply the consumption of electricity, reusing that already used. Due to non-renewable resources each day become scarce and with high value of purchasing power. Electric energy demonstrates to be one of the most argued and disseminated subjects during this decade, because it affects all socio-economic aspects of a society, both industry and trade.

Therefore, after the feasibility of the installed project, the system of reuse of electric energy through a synchronous generator, in the three-phase motor of the hydraulic pump of plastic injector, can meet the need for an electrical installation consisting of 47 Luminaires of 32 W, each luminaire has 2 LED lamps of 16 W of power, in order to eliminate the mandatory need to use the electricity supply of the concessionaire during the production process, where the equipment is in the process of Operation.

The use of the generator coupled to the electric motor of the injector served as learning, that the electric energy used in the industrial process can be more efficient and productive, in the context of reducing the loss to the maximum of a productive process, thus combining All the employment of technology in LED lighting equipment and the technological advancement of synchronous generators existing on the market, thus adding to a greater economy in manufacturing.

6. Referência

[1] KAEHLER, Jose Wagner Maciel. **Comments on ANEEL's proposal to modify the manual for the preparation of the annual regulation to combat the waste of electricity from the concessionaires.** ANEEL, 2000.Available at: <http://www2.aneel.gov. br / applications / Audiencia_ Publica / audiencia_proton / 2000 / ap003 / Comment% E1rios% 20ANEEL.pdf>. Access on 14 Sep.2019.

[2] ACORONI, Junio Célio Pereira. **Energy Efficiency: Best Practices in Energy Saving in an Industrial Sector**. Academic Week Magazine, 2013. Available at: <// semanaacademica.org.br/system/files/artigos/artigo_junio.pdf>. Access on 13 Sep.2019.

[3] **Results Procel2014 Year 2013.** Available at: <http: // www. procelinphus. with. br / resultsprocel2014 / pdf-complete.pdf>. Access on 14 Sep.2019.

[4] **3 problems caused by power outages in your factory**. Available at: <https://www.ballufbrasil.com.br/3-problemas-gerados-pela-falta-de-energia-em-your-factory/>. Access on: 15 Apr.2019.

[5] Oak, Joaquim Francisco de. **Energy consumption, from antiquity to the present day - ARTICLE .Iluminates Energy Sector Development Institute**. Botafogo, Nov.2017. Available at: <https://www.ilumina.org.br/o-consumo-de-energia-da-antiguidade-aos-dias-de-hoje-artigo/>. Access on: 15 Apr. 2019.

[6] The Baptist, Julius Caesar. **Methodology for testing Synchronizer Generator Protection System Model using real-time digital simulator**. Belo Horizonte: [S.N], mar. 2015. Available at: <http://www.ppgee.ufmg.br/ synchronous generators / pdf>. Accessed on: 15 Apr. 2019.

[7] **Hydraulic Pumps**. Available at: <http://www.docent.ifrn.edu.br/bombas-hidraulicas/pdf> Access on: 17 Apr.2019.

[8] GIANELLI B F, SILVEIRA M C F, THAUMATURGO L R Y, ASTORGA O AM, SON M B M, **"The Employment of LED Technology in Public Lighting - Its Impacts on Energy Quality and the Environment,"** The 8th latinamericancongressonelectricitygenerationandtransmission - CLAGTEE, 2009.

[9] GIL, Antonio Carlos. **How to design research projects**. 4 ed. Sao Paulo: Atlas, 2008.