ENERGY QUALITY ANALYSIS IN A SEWAGE TREATMENT PLANT

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Abstract - **This paper presents a half wave three – phase rectifier bridge, that is used in a eletrolysis sewage treatment process. In this work, it shows the average and effective voltage behaviour in function to the shot angle. Two voltages are illustrated in this behaviour: - 127V/60Hz and 220V/60Hz. Simulation and Experimental results are compared to validate the average and effective voltage expressions. Furthermore, the output voltage harmonic spectrum rectifier are shown under two forms:- one for pspice software and another for data matrix using the matlab program.**

KEYWORDS

Harmonic, Energy Quality, Sewage Treatment

1. INTRODUCTION

The sewage treatment plants, by the chemical process, need great areas for the construction of decantation tanks. Another disadvantage of this process is the chemical components reaction time, with the sewage to be treated.

The other sewage treatment process is that of electrolysis. This process demands less space to setting up the plant, by where the sewage will flow in order to be treated. Standing out that the electrolysis treatment process is a continuous one. As the sewage goes through the beehives, occurs the chemical reaction which has as a product a more transparent water, carried with floccules.

The electrolysis is made by half wave three-phase rectifying bridge, as it presents the negative pole connected to the network neutral. This configuration supplies more security to its operator, and has as guarantee the same zero voltage network reference.

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2. OPERATION PRINCIPLES

The electrolysis is made by three thyristors, being each one for one phase, converting the alternative current in pulsing direct current, and the load is formed by ten beehives group. The direct current in the beehives accelerates a reaction process, making the microorganisms react and forming little floccules. In the second part of the process, these floccules will be retained in the flocculation tank, whereas the water will flow for the sewage canalization.

The Fig.1 illustrates the three-phase rectifier circuit, composed by three thyristors, controlled according to the sewage flowing, in order to maintain constant the current density in the beehives. The polarity inversion by the C1 and C2 contactors decrease the irregular abrasion beehives plates, otherwise these will be a more accentuated abrasion of one pole in relation to the other.

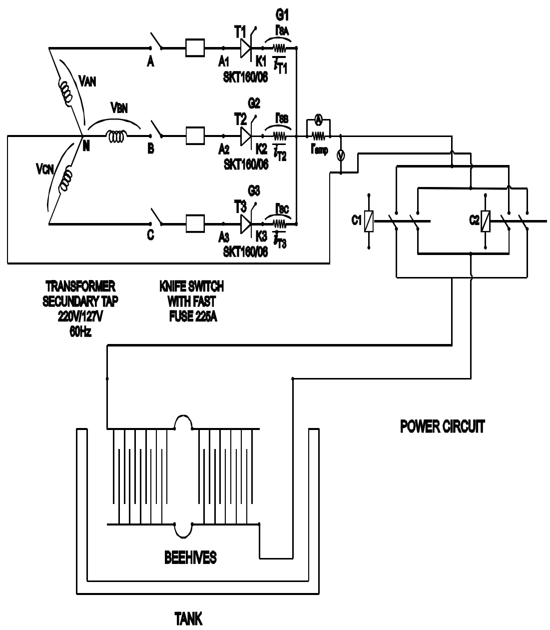


Figure 1.- Half wave three-phase, with polarity inversion.

2. QUANTITATIVE STUDY

In the half wave three phase rectifier, for the pure resistive load, the current waveshape is continuous, for a shot angle α, in the band 0^0 to 30^0. In this case the average voltage is given by the Eq. (1)

$$Vav = \frac{3\sqrt{3}}{2\pi} Vm \cos\alpha \ \ [\text{V}] \quad (1)$$

Where:
Vav - the average voltage in the load.
Vm - the phase peak voltage.
α - The shot angle.

For a shot angle higher than 30°, the current transportation is discontinuous and the average voltage on the resistive load is given by the Eq. (2).

$$Vav = \frac{3Vm}{2\pi}\left[1+\cos\left(\frac{\pi}{6}+2\right)\right] \ \ [\text{V}] \quad (2)$$

The beehives can be considered as purely resistive loads (R), hence the average current (Iav) on the load is given by.

$$\text{Iav} = \text{Vav} / \text{R} \ \ [\text{A}] \qquad (3)$$

The Fig. 2 describes the average voltage behaviour in function of the shot angle. In the Fig. 2 (a), the phase voltage supply is 127 V, and in the Fig. 2 (b) the voltage is 220V.

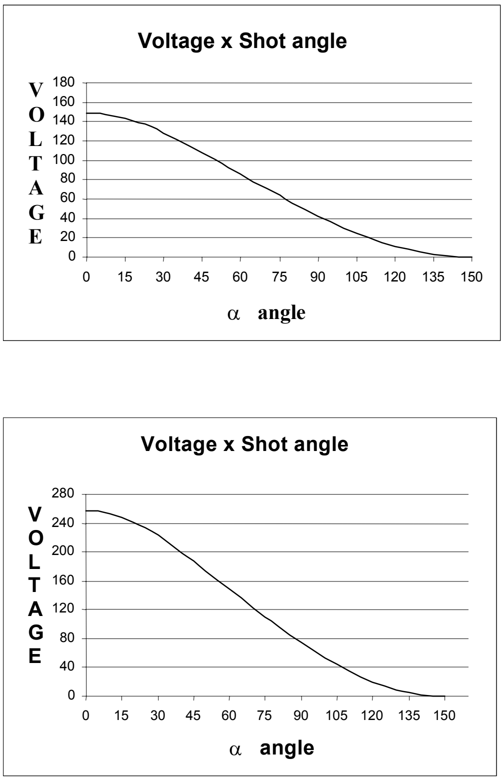


Figure 2 – The average voltage behaviour Van in the function of the shot angle α: (a) 127 [V]; (b) 220 [V].

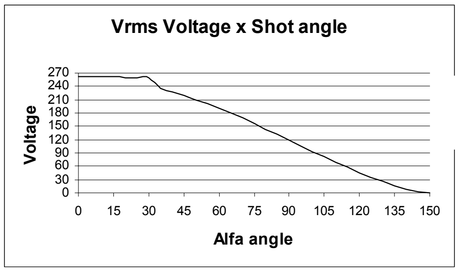
In order to determine the values of the effective voltage (Vrms) on the load, it is used the Equation (4) for a shot angle α between 0^0 to 30^0.

$$\text{V}rms = \sqrt{3}\ Vm\left(\frac{1}{6}+\frac{\sqrt{3}}{8\pi}\cos 2\alpha\right)^{\frac{1}{2}} \quad [\text{V}] \qquad (4)$$

While that the Equation (5) is used for a shot angle higher than 30^0, as for the discontinuous current wave shape on the load.

$$\text{V}rms = \sqrt{3}vm\left[\frac{5}{24}-\frac{\alpha}{4\pi}+\frac{1}{8}\text{sen}\left(\frac{\pi}{3}+2\alpha\right)\right]^{\frac{1}{2}} [\text{V}](5)$$

The Figure 3 (a) shows the effective voltage behaviour in function to the α shot angle for a supply phase voltage of 127 V. In the Figure 3 (b) the voltage supply is 220 V.



(b)

Figure 3 – The effective voltage behaviour Vrms in function to the α shot angle (a) 127 [V], (b) 220 [V].

3. SIMULATION RESULTS

The simulation results are presented below:

- Van = Vbn = Vcn = 127[V]
- R = 1Ω.
- $\alpha = 61^0$

The Figure 4 shows the voltage waveform in the beehives. By the equations (1), (2) and (3) and graphs of the Figure 2 (a), the average voltage, the effective tension and the average current on the load are 75V, 100V and 75 A.

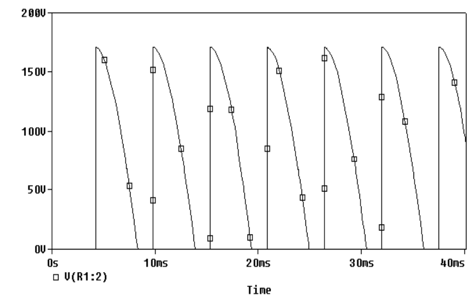
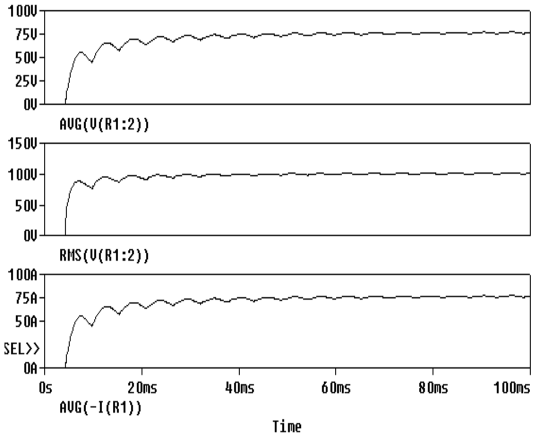


Figure 4 - The voltage waveshape in the beehives.

These values can also be confirmed by the simulation as shown in the Figure 5.



(a)

(b)

(c)

Figure 5 – Simulation results. (a) Average voltage; (b) Effective voltage and, (c) average current in the beehive.

Considering the waveshape in the Fig. 4 the simulation gives a frequency spectrum as shown in the Figure 6. It can be observed that all multiple tracks of 180 Hz frequency appears, as much as the even order as the add one. This is due to the current and voltage waveshapes in the beehives, which are pulsing and only positive in to the abscissa.

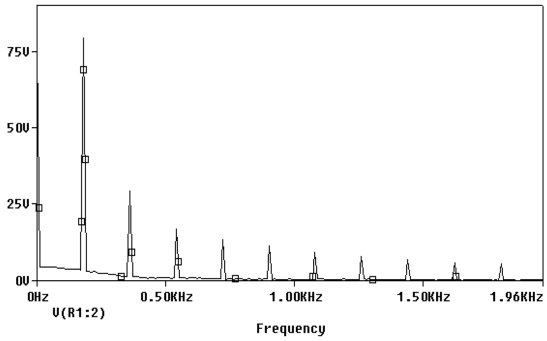


Figure 6. Current waveshape Spectrum in the beehives.

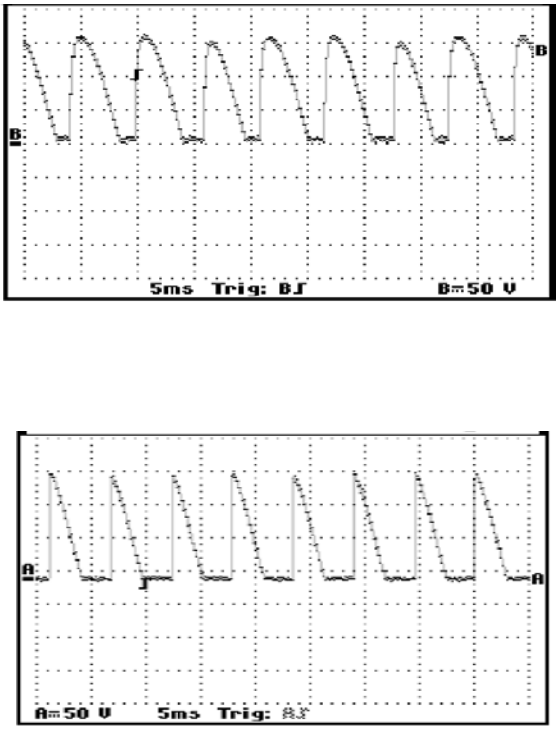
A quantitative analysis about the frequency spectrum shows that the 3^{rd}, 6^{th}, 9^{th}, 12^{th}, 15th harmonic contribuition are respectively 86%, 30%, 23%, 15%, 14%.

4. EXPERIMENTAL RESULTS

The rectifying set up is made of three thyristors SKT 160/06, being the load made by 10 beehives.

Each beehive is made of 15 iron plates of 50x50x2cm. This group gives a load resistence variying of 1,0 Ω to 2,0 Ω; according to the water / sewage flow which goes though it.

The Figures 7 (a) and (b) show respectively the shot angle values of $\alpha = 61^0$ and $\alpha = 85^0$. For these values, the average and effective voltages and the average current on the beehives are given by the table 1.



(a)

(b)

Figure 7 - Voltage waveshapes in the beehives. (a) $\alpha = 61^0$e (b) $\alpha = 85^0$

Table1 - Measured in the retifying output.

Shot angle	Average Voltage [V]	Effective Voltage [V]	Average Current [A]
$\alpha = 61^0$	75 V	100 V	75 A
$\alpha = 85^0$	56 V	83 V	56 A

The Figure 7(a) and 7(b) transformed in a data matrix using the MATLAB program. By using this same program it was found the harmonic spectrum of the voltage experimental waveshape in the beehives by the Fig. 8 and Fig 9 respectively.

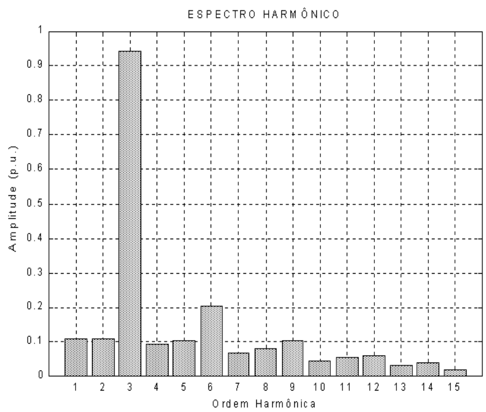


Figure 8 – Output voltage harmonic spectrum rectifier to. $\alpha = 61^0$

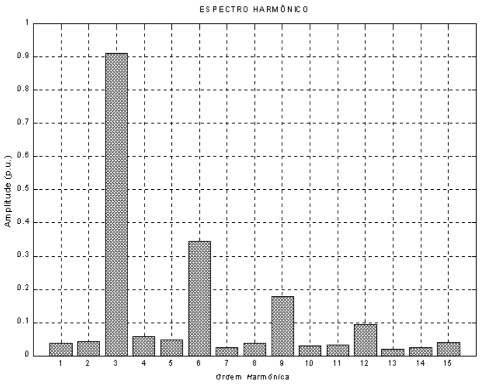


Figure 9 – Output voltage harmonic spectrum rectifier to. ***α = 85***

The most emphasized harmonics are the multiple of three, as the system is a half wave three – phase one.
As example, the figure 8(a), the 3rd harmonic contributes with 90%, 6th harmonic with 34%, the 9th harmonic with 18%, the 12th harmonic with 9% and the 15th one with 4%.

5. CONCLUSIONS

The aim of this work is to present a half- wave three – phase rectifier to be used in a hospital sewage treatment plant.

This rectifier has the advantage of operating with a negative pole, being the same network neutral. This gives to the operator safer work, mainly in humid environment, liable to electric shock.

Another system advantage is the reduction of the treatment plant size compared to other one with decantation tank.

This study allones an electric quantity analysis as average voltage, effective voltage and average current in the beehives. From the basic equations were made abacus in order to determine these values.

The simulated and experimental output voltage traces were compared. From these traces it was made the harmonic spectrum, were the multiple of the third harmonic are predominant, indicating a poor electric energy quality to the system. Further studies can minimize these interfaces without forgetting the operator safety.

ACKNOWLEDGEMENT

Thanks for Hospital Universitário Júlio Muller of Universidade Federal de Mato Grosso – UFMT for the interest in the execution this project and, authorization in the show this work.

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