ГОДИШНИК на Минно-геоложкия университет “Св. Иван Рилски”, Том 49, Св.III, Механизация, електрификация и автоматизация на мините, 2006
ANNUAL of the University of Mining and Geology “St. Ivan Rilski”, Vol. 49, Part III, Mechanization,electrification and automation in mines, 2006

QUALITY OF POWER IN LIGNITE MINING EXPLOITATIONS

Cozma Vasile[1] Barbu Daniela Angela[2]

[1]Constantin Brâncuşi University from Tg.-Jiu, Romania
[2]National Society of Lignite Oltenia, Tg-Jiu, Romania

ABSTRACT: The power quality is a complex and controversed problem that has to be seen in the context of relation between supplier and consumer under the influence of perturbations.
The power consumers can induce perturbations in the power supply net, as: the worsening of power factor, the occurring and amplifying of voltage harmoniques, the deficitary circulation of power in the net, and their existence requests the analysis, monitoring and measures to be taken for the ensuring of power quality.
In the last period, in the power nets of lignite mining exploitations, as following the equipment's refurbishment had appeared driving mechanisms with variable revolution speed using rotor converters or commanded rectifiers for the driving of bucket wheel, for upper structure spinning, for the marching mechanism, for the driving of belt conveyors, by introducing in the power system of superior harmonics, and by this vitiating the quality of electric power.
For a quality consumption of power, in conditions of economical efficiency, it is recommended the amortization of the harmonics that are occurring in the power system.

КАЧЕСТВО НА ЕНЕРГИЯТА ПРИ ДОБИВА НА ЛИГНИТНИ ВЪГЛИЩА

Василе Козма[1], Даниела-Анджела Барбу[2]
[1] Константин Брънкуш Университет - Търгу Жил, Търгу Жил, Румъния
[2] Национална компания за лигнитни въглища, Търгу Жил, Румъния

РЕЗЮМЕ: Качеството на енергията е сложен и дискусионен въпрос, който трябва да бъде разглеждан в контекста на отношенията между доставчик и потребител, влиещи се от смущения. Потребителите на енергия могат да предизвикат смущения в електропреносната мрежа чрез: влошаване на енергийния фактор, настъпва високо напрежение, не добра циркулацията на енергията в електропреносните мрежи, а тяхното наличие изисква анализ, мониторинг и критерии, които трябва да бъдат взети под внимание за да се гарантира качеството на енергия. През последните години в енергийните мрежи на добива на лигнитни въглища, при освежаването на оборудването, се появяват движещи механизми с различни въртящи се скорости, използвайки роторни конвертори или управляващи токоизправители на движещите бутала, за завъртане на горната конструкция на ходовите механизми, за задвижване на конвейерите, чрез внедряване на мощни системи от изключителна хармония и от това влошаване качеството на електрическата мощност.
За качествено потребление на мощността, в условията на икономическа ефективност се препоръчва амортизация на хармонията, което се случва в електро- системите.

Introduction

In modern power systems the non-linear consumers have a an increased weight; by using on a large scale of adjustable auctioning of alternative current having rectifiers with diode as first conversion floor of continuous current based upon rectifiers with tiristors, have as consequence the increasing of harmonical content of the current absorbed by the consumers. The disadvantages of these harmonics of current are well known: increased dissipation of power in cables, transformers, power machines and condensers. In three phased systems with null, the harmonics that are the multiple of three are added in the null conductor and the current in the conductor reaches at unacceptable values. The harmonics of current are causing the disturbance of supplied voltage for all consumers, and are affected also the linear consumers, that are not generating harmonics of current. The harmonics are accelerating the ageing processes of the isolation and are reducing the life of installations.

It is considered deforming regime that alternative regime where the variation in time of at least one of characteristic state dimensions – current or voltage – is describe by a non-sinusoidal periodical function. The occurring of deforming regimes is generally caused by the non-linear elements of transfer and due to the electromagnetic power transformed in other form of energy.

Can be enumerated four major arguments that are justifying the interest towards for the power quality field:

1. Modern equipments are more sensitive to the reducing of power quality, due to the fact that they have in components controlling systems based upon microprocessors.

2. The semiconductor power devices became omnipresent in conversion processes of power.

3. The consumers became more aware and more informed about the impact of electromagnetic perturbances over the electrical equipments and over technological processes and as a following they are requesting to power suppliers to supply the power at quality parameters that were contracted.

4. The complexity increasing of energetical systems has a large influence betwenn the systems and users and also between the connected consumers to the same suplly system.

In general, the industrial cconsumers can loaad the net, simetrically on all phases or un-symmetrically.

Sources of harmonics

At the present the equipments that are containing statically converters are the main source of harmonical pollution of power net. The semiconductor devices of power that are in the converter structure are conducting only a fraction of period the fundamental component. The special proprieties of statically conversion of energy can be obtained by this way; as following the statically converters are absorbing a current strongly distorsioned.

The non-linear loadings are absorbing a non-sinusoidal current, even when the supply conditions are perfectly sinusoidal. The functioning effect of a non-linear load in the power net can be represented by a generator for current that injects a harmonic of order *h.* In the common point of coupling (PCC), the tension is distorsioned (contains harmonics of tension), as following of the presence of I_n harmonic of current.

$$V_{PCC(n)} = (Z_{TR}+Z_S) \cdot I_n ,$$

and the distorsioned tension is applied to the other consumers connected to PCC.

A first effect of the tension harmonics presence is the increasing of effective values and of the top value of tension. Other negative consequences of the tension harmonics presence are: increasing of iron and copper losing, in the respective installations, due to the increased thermical solicitations; starting of thermical protections; burning of fusible; accelerated ageing of isolation. The equipment that is using the net tension as reference can have problems of synchronization. The monophased consumers that have a high content of 3rd harmonic of current are causing a significant increasing of current of null, because these harmonics are in the phase and they are added on the null conductor.

3. Effects of the harmonics presence

Main effects that the deforming regime is producing in the electromagnetic systems are the following:

-Distortions of tension and current: at all levels between the sources and consumers characterized by the coefficient of distortion δ_U, respective δ_I, defined as ration between the deforming residuum and the effective value of a tension respective of current:

$$\delta_U = \frac{\sqrt{\sum_{n=2}^{\infty} U_n^2}}{\sqrt{\sum_{n=1}^{\infty} U_n^2}} \text{ x } 100\ \%$$

$$\delta_I = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{\infty\sqrt{\sum_{n=1} I_n^2}} \text{ x } 100\%$$

where U_n, I_n are harmonics of order n of tension, respective of current

- *Over voltages of harmonical resonance* due to the resonant circuits formed by condensers for the compensation of reactive power and of inductive reactance of the system

- *Overloading of condensers* due to the exceeding of maximum admitted value, 1,3 I_{nc} ; 1,1 U_{nc} ; 1,43 Q_{nc}

- *Supplementary power and energy losing* in the nets due to the increased apparent power

$S = \sqrt{\left(P^2 + Q^2 + D^2\right)}$, where D is the deforming power

- *Occurring of parasite couples and supplementary power losses in electrical machines.*

- *Errors of functioning of the measurement, protection and command devices,* due to the power factor in deforming regime

$$K = \frac{P}{S} = \cos\varphi \cos\varepsilon ,$$

where $\cos\varphi$ is the power factor in the absence of deforming regime, and

$$\cos\varepsilon = \frac{\sqrt{\left(P^2 + Q^2\right)}}{\sqrt{\left(P^2 + Q^2 + D^2\right)}}$$

The circulation of harmonic currents in nets can be a danger for the electrical installations functioning, specially in the resonant circuits of derivation, condenser-system. In this case due to the phenomenon of the current harmonics amplification, in the resonant circuit, it occurs the overloading or destroying of condenser batteries, of generators or other elements of the system. dangerous for the condenser batteries are the resonance that are occurring, usually at harmonics 5, 7, 11 and 13.

The amplification phenomenon of superior harmonics of current is accompanied by the amplification of tension harmonics – over tensions – that can reach to the values that are corresponding to the resonance phenomenon, that leads to the deterioration of cables isolation or of the condensers dielectric.

At the electric cables together with the losing in dielectric and supplementary ohmical losing, is occurring the corrosion phenomenon of the cables in the presence of harmonics.

In the case of asynchronous motors, when supplying them with a non-sinusoidal tension, their output decreases very much.

Ways of reducing the superior harmonics of current and tension

For reducing the effects of deforming regime there are used active filters of power that can be with repression or absorption.

The active filters are static converters of power that can have diverse functions. The actual schemes of filtering allow the syntherization of any form of current with harmonic components of relative high frequencies, and there are sufficient for most of practical cases and at higher and higher levels of power.

The term „active filter of power" has a wide character and is applied to a category of circuits that contains also the semiconductor devices of power and passive elements for the energy storing – inductances or condensers. The functions of filters can be different, depending upon the application.

Pressing filter

It is made by serial connection of the condenser battery with a coil of reactance X_b. The value of this coil is chosen to ensure that the resulting circuit to have a capacitive character for the fundamental frequency and at superior frequencies to have an inductive character. Hence:

$$X_b^n - X_c \geq X_c^n$$

$$X_b \geq \frac{2}{n_m^2} X_c$$

where X_b, X_c, are corresponding to the coil reactance, respective condenser battery, and n_m is the minimum order of unwanted superior harmonics.

Disadvantage**:** pressing filters are loading the net with pressing harmonic currents; for this reason these are used only for the protection of existing installations of condensers.

By this way are obtained the main characteristics of the filter.

- reactance of coil at resonance:

$X_b^{(n)} = \dfrac{X_c^{(n)}}{n^2}$, where $X_b^{(n)} = \omega_1 L_b^{(n)}$ and $X_c^{(n)} = 1/\omega C^{(n)}$ there are the reactance that are corresponding to the fundamental

- absorbed current $I^{(n)} = \sqrt{I_1^{(n)2} + I_n^2}$, where the current for the fundamental is $I_1^n = U_1 a / X_c^{(n)}$, where *a* is the coefficient of supra-tensioning, $a = \dfrac{n^2}{n^2 - 1}$ and it has values between 1,006 (n=13) and 1,04 (n=5)
- tension at the condenser terminals,

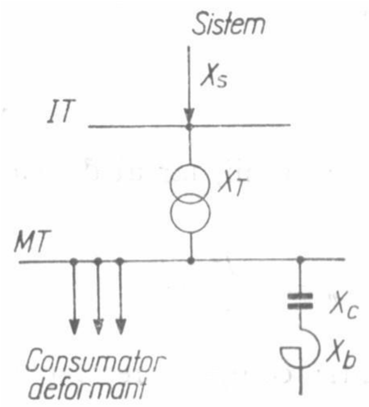
$U_c^{(n)} = \sqrt{U_{c_1}^{(n)2} + U_{cn}^2}$, where $U_{c_1}^n = aU_1$, $U_{cn} = \dfrac{I_n}{nX_c^{(n)}}$

- power of condensers, $Q_c^{(n)} = Q_{c_1}^n + Q_{cn}$, where the first term corresponds to the fundamental of tension and the second term is the overloading due to I_n harmonic, respective

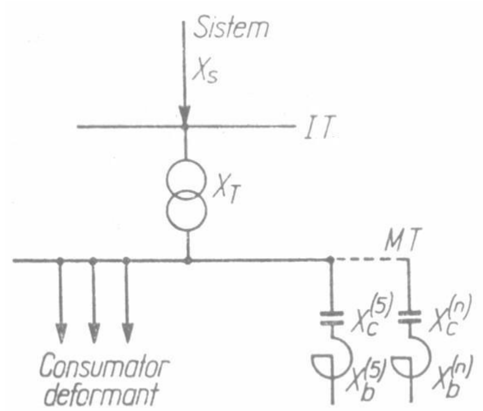
$Q_{c_1}^{(n)} = U_{c_1}^{(n)} I_1^{(n)} = \dfrac{U_1^2}{X_c^{(n)}} a^2$ and

$Q_{cn} = U_{cn} I_n = \dfrac{I_n^2}{nX_c^{(n)}}$

- available power at the filter terminals for the
-



a



b

Fig. 1. Mounting of active filters – scheme of principle
a-pressing filter; b-absorbent filter

Absorbent filter

There are made of condensers in serial connection with coils of reactance X_b that are entirely absorbing the harmonic current on which it was adjusted and in lower proportion the harmonic currents of close frequencies.

The filters are calculated to present a serial resonance for the superior harmonics that are present at the consumer's bars.

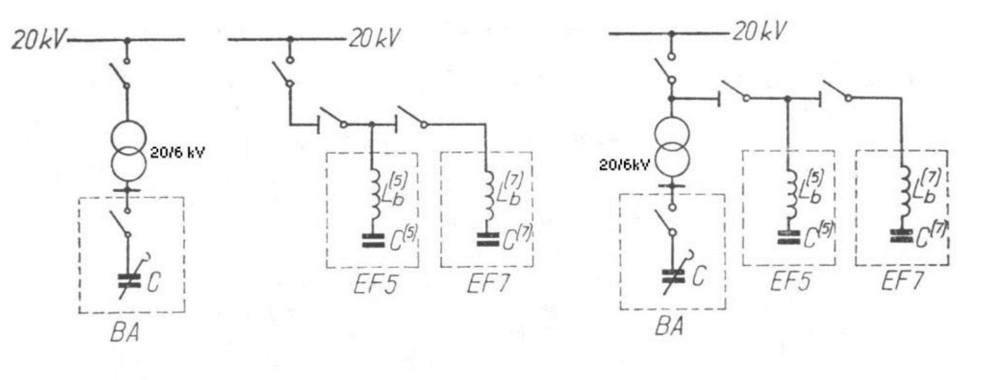
- compensation of power factor

$$Q_1^{(n)} = U_1 I_1^{(n)} = \frac{U_1^2}{X_c^{(n)}} a$$

- filter's characteristic of frequency represents the variation of admittance depending upon the frequency according to formula:

$$Y_\omega^n = \frac{1}{\dfrac{1}{\omega C^n} - \omega L_b^n}$$

.



a ***b*** ***c***

***Fig.2* Variants for compensation and filtering of superior harmonics**
a-automated compensation without filtering, b-compensation and filtering of harmonics 5,7 c-compensation and filtering of harmonics 5,7

In picture 2 are presented variants for compensation and filtering of superior harmonics

Conclusions

For a quality consumption of power, in conditions of economical efficiency, it is recommended the amortization of the harmonics that are occurring in the power system of S.N.L.Oltenia.

Hence we proposed the reducing of deforming effect by using the active filters of power. The active filters are static converters of power that can have diverse functions. The actual schemes of filtering allow the syintherization of any form of current with harmonic components of relative high frequencies, and there are sufficient for most of practical cases and at higher and higher levels of power.

The term „active filter of power" has a wide character and is applied to a category of circuits that contains also the semiconductor devices of power and passive elements for the energy storing – inductances or condensers. The filter's functions can be different, absorbent or pressing.

References

Arie A, Poeată A., *Transportul şi distribuţia energiei electrice*, Didactică şi Pedagogică Publishing House Bucharest, 1981.

Arie A., Golovanov N.,*Poluarea cu armonici a sistemelor electroenergetice functionând în regim permanent simetric*, Academiei Române Publishing House, Bucharest, 1994.

David Chapman, Cooper Development Association, *Calitatea energiei electrice,* Aplication Guide, 2001.

Golovanov N.,*Utilizarea energiei electrice şi mari consumatori*, Publishing Houde of Politechnical Institute from Bucharest, 1983

Postolache P.,others., *Monitorizarea calităţii energiei electrice*, Macarie Publishing House, Targoviste, 2004.

Recommended for publication by the Editorial staff