PARAMETERS OF INSULATORS AT ATMOSPHERE SF_6

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ABSTRACT

The aim of this work is the observation of parameters of composite materials used in high-voltage technique for HV switches. These materials were exposed to the dissociation products of sulphur hexafluoride formed by the action of electrical discharges.

This work describes the properties of sulphur hexafluoride, the composition of technical sulphur hexafluoride and the properties of its decomposition products in the first, theoretical part. In the experimental part, work procedure, experimental setup, method of sample preparation a samples condition assuring the reproducibility of measurement are described.

1 INTRODUCTION

Sulphur hexafluoride, used in the instruments and the transformers HV a EHV, allows more effective construction of the equipment specially in the hard conditions, which means conditions on the development and industrial centers and in the extreme operating conditions in the area of the transmission and the distribution of electricity.

For using in the electrotechnics it has its benefits (compared to solid and liquid insulators):

- High specific dielectric strength (in usual conditions just about 2,5 times more than air) and smaller volume at the elevated pressure
- Regenerative capability (the dielectric strength is recovered after the breakdown to its initial value)
- Small rise of pressure while by the extinction of the electric breakdown or arc (it increases by warming up and later goes back to starting value). [1]

2 BASIC CHARACTERISTICS

This synthetic gas of the inert nature is colorless, odorless, fire-resistant and insoluble in the water. It is one of the heaviest gases. In the liquid state exists only at pressure higher than atmospheric, at the normal pressure is in the gaseous state, which by heat of sublimation –

63,8 °C goes straight into solid state. It is appurtenant to the electronegative gases. In other words, it is able to trap the free electrons. [2]

2.1 CHARACTERISTIC OF THE DISSOCIATION PRODUCTS

At electrical spark discharge or arc discharge, sulphur hexafluoride dissociates at the temperature (1500-2500) K, at temperature higher than 3000 K the dissociation is complete. Most of the decomposition products recombine quickly to beginning gas, part of it still stays dissociated and it reacts with the impurity and the ambient material. This includes the waste products in the gaseous state, and also the solid one, specially the fluoride of the metal.

SOF_2 - fluoride of sulfurous acid (sulfur oxide-difluoride) – in the normal conditions is steady, toxic, what is obvious at concentrations from 100 to 500 ppm. SOF_2 is rises by reaction with a oxygen absorbed in contact W/Cu or W/Ni/Cu used ordinarily as the materials for contacts, where rises the arch. The copper electrodes or the electrodes from the stainless steel essentially limit the rise of SOF_2.

SO_2F_2 - fluoride of the sulfuric acid (sulfur dioxide-difluoride) – in normal conditions is steady, toxic (it causes convulsions of the respiratory system), it is formed in smaller amount than SOF_2 and is dangerous at concentrations from 2000 to 4000 ppm. It occurs always together with SOF_2, so is easily identifiable. It rises by reaction of oxygen with the activity of the arc.

SOF_4 a SF_4 - fluoride of fluorosuphuric acid and sulphurouse fluoride (sulphur ofide-tetrrafluoride and sulphur tetrafluoride). They have similar effects as SOF_2. They are less stable and they dissociate in the present of water.

S_2F_2 - sulphur fluoride – is odoriferous toxic gas. While the discharges it reacts with hydrogen, this caused a rise of H_2S a H_2F_2.By reaction with the oxygen rises SO_2.

CF_4 - tetrafluormethane - formed by the reaction with the materials of the contact metals and surrounded insulators. It cannot be absorbed by filters.

HF - hydrogen fluoride – is aggressive and unsteady. It reacts with the surrounding metals and insulators. It can not be captured by filters.

WF_6 a **SiF_4** - tungsten hexafluoride and silicon tetrafluoride – formed by reactions as CF_4. They dissociate in the presence of the water vapor under formation of the solid waste products.

H_2SO_4 - sulfuric acid – is formed by the reaction with the water.

SO_2 - sulfur dioxide - it is formed at corona discharge. [3,4]

3 EXPERIMENTAL PART

The reaction chamber: the vessel has been made from the PVC. Its volume was 3,1 x 10^{-3} m^3 .

Used samples: experiment proceeded at the samples of the composite materials based on the epoxy resin. The company ABB Brno, Inc. uses this material for the production of the rods of the high-tension switch. Delivered rods by company Orgrez, a. s. have the dimensions 10 x 260 x 31 mm. It was necessary to cut cable into smaller pieces - with regard to proportions of the reaction chamber filled by SF_6. In this case was the cable cut into four pieces, three of them were used for the measurements. A three-electrode system was fabricated on them using the conductive graphite lacquer SIB 643.

Exposition time of the electric discharge on the samples: the sample No. 1 was exposed for 1380 minutes, the sample No. 2 for 1020 minutes, and both experiments were terminated because the resistivity R_V dropped almost to zero to values below the measuring range of the IM6. The sample No. 3 was sparkled for 1500 minutes and it was ended because the spark plug electrodes were damaged by erosion.

3.1 EXPERIMENTAL PROCEDURE

I. Before every insertion of the sample to the reaction chamber it was necessary to clean all the interior of the chamber from the dirt and the waste products made by previous sparking. After it was inserted the sample, the chamber was closed. Than, the air was removed by a vacuum pump and then the chamber was filled by the SF_6 on demanded pressure 100 kPa.

II. The sparking of the sulphuric fluoride together with the inserted sample proceeded in the 60 minutes cycles. Electric and dielectric attributes: C_p, tg δ, R_v, R_p was detected after each sparkling cycle. The parameters : ρ_v, ρ_p a ε' were evaluated.

Fig. 1: *The reaction chamber at estimation of the loss factor and relative permittivity*

3.2 EVALUATION

Comparison of electric and dielectric attributes:

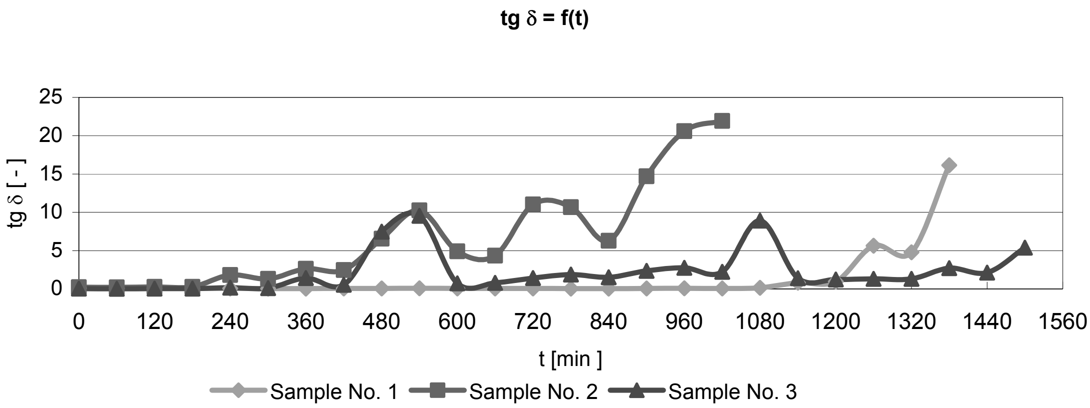

Fig. 2: *The comparison of the loss factor the samples No. 1, 2, 3 during of electrical discharge*

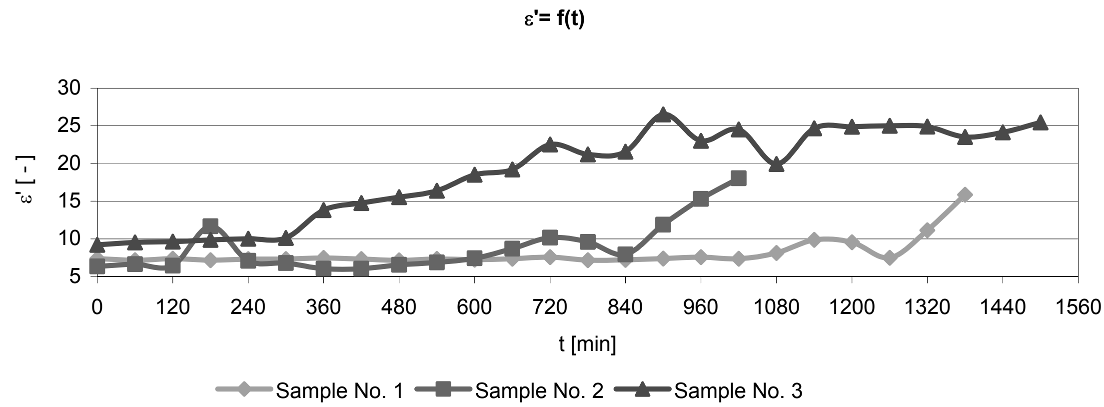

Fig. 3: *The comparison of the permittivity the samples No. 1, 2, 3 during of electrical discharge*

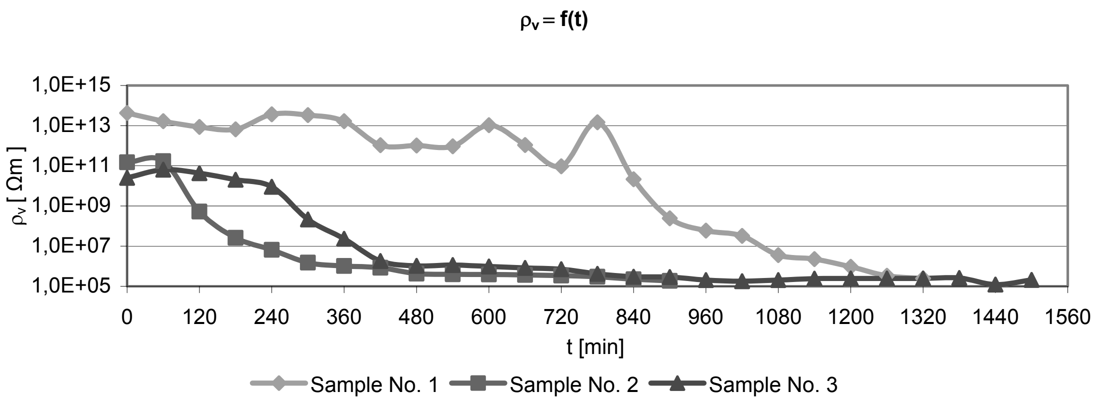

Fig. 4: *The comparison of the volume resistance the samples No. 1, 2, 3 during of electrical discharge*

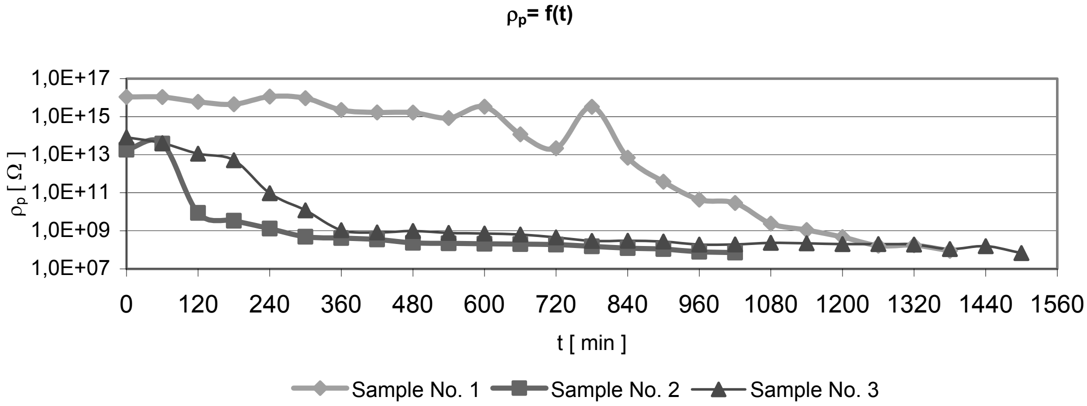

Fig. 5: *The comparison of the surface resistance the samples No. 1, 2, 3 during of electrical discharge*

4 CONCLUSION

Electric attributes of each sample were measured after insertion in the chamber, before and after filling of the chamber by SF_6, short time before the action of electrical discharge. An increase of surface resistance was observed in all cases; it was the bigger the longer time elapsed from the filling of the chamber by SF_6 to the action of electrical discharge. Sample No.1 was different from the others, because of its better isolation characteristics by 2 orders of magnitude higher. Its characteristics needed to sink to those of the others time interval 1260 minutes of discharging. It was different than the others with its dielectric attributes too, it brought low dielectric losses to 1080 minutes and low relative permittivity. The worst isolating attributes brought sample No.3, in case of which then decrease of specific conductance was the fastest. The samples No.2 and No.3 reached constant attributes after 420 minutes.

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