Contemporary high voltage gapless surge arresters

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***Abstract*- This paper presents general description of contemporary high voltage gapless surge arresters. Housing structure, additional equipment and ZnO element are presented here.**

I. INTRODUCTION

Idea of using gapless arresters is quite old. First usage of gapless technology was in 1940. Resistors thyrite were used then. Their nonlinearity factor was about 3,5. Therefore they couldn't be used in surge arresters.

Only invention of varistor with nonlinearity factor about 50 in 1968 allowed to get rid of the spark gap. In 1976 first gapless surge arresters were manufactured.

First generation of varistors were very unstable. Their leakage current was increasing in time and caused increasing of temperature and decreasing of energy absorption ability. Nowadays we have inversed process. Leakage current of contemporary varistors is decreasing in time which is good.

Structure of varistors should be uniform and isolated from environment. This and many discovers have been noticed in nearly 70 years of varistors science

II. TYPES OF HOUSING

First generation of gapless surge arrester had porcelain housing [1]. Total length of contemporary transmission line gapless surge arrester 110kV is about 1,3m. To comparison the length of the same device but with spark gap is equal 2m.

Usually column of varistors is centered in housing but not always. Usually gas inside is SF_6 or nitrogen, sometimes sand.

General division of housing of surge arresters is:

- Polymer housing
- Porcelain housing

A. Polymer housing or porcelain housing

Basic advantage of polymer materials is hydrophobic property. The best hydrophobic properties has silicone rubber. Silicone as outer insulation has been used for over 30 years with good results. It is true that hydrophobic maintains even if there is a high pollution level. It is important because sometimes pollution flashover can occur. Structure of polymer housed arrester is shown in figure 1.

Guaranteed lifetime of porcelain housing is usually equal 50 years. Porcelain surface has hydrophilic properties. Contemporary scientific research show that breakdown voltage of porcelain & polymer housing in high humidity conditions don't differ too much. However in big pollution conditions polymer insulation electric strength is greater than in porcelain insulator.

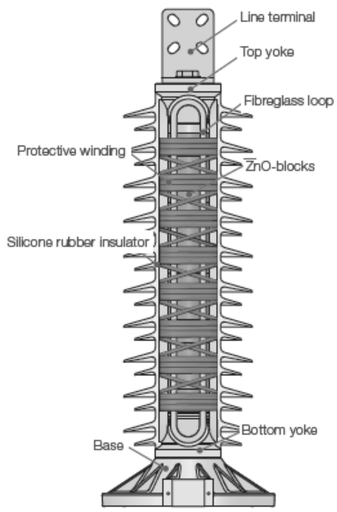

Figure 1. Structure of polymer housed arrester – here ABB design.

III. VARISTORS APPLICATION

A. Structure of ZnO varistor

Zinc oxide ZnO element has been used in gapless high voltage arresters up to now. Its nonlinearity factor is decreasing during big surge currents. Practically reduced voltage doesn't depend on temperature.

These varistors are polycrystalline semiconductors compound by ZnO grains and other metal oxides (e.g. CoO or MnO). 97% of all components is ZnO. However contents of the rest mentioned metal oxides is very important because it has big influence to different features of all varistor. Even a small change in proportions or manufacturing process can affect the properties of this product. Therefore technological details of production are a secret of vendors.

TABLE I
MOST OFTEN USED ADDITIVES TO ZINC OXIDE CERAMICS

Chemical element	Impact
Co, Mn, Sb	Create potential barrier on grains border
Li	Reduce leakage current in working voltage conditions
Sb, Si	Reduce grain growth
Be, Ti, Sn	Increase grain growth
Al, Ga, F, Cr	Increase nonlinearity of U-I characteristic
Sb, Ag, V, Ni, Cr	Stabilization of potential barrier
Bi	Creates heterogenic path

Researches of oxide varistors structure were realized with electron microscopes. Result is visible below at figure 2. The structure consist grains of ZnO and dissolved cobalt Co and manganese Mn.

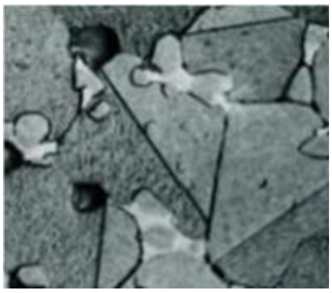

Figure 2. ZnO ceramic structure

ZnO grains touch each other without broking of another phase. Space between these grains is filled with Bi_2O_3 and spinels $Zn_7Sb_2O_{12}$.

B. *Varistor conductance phenomena*

In varistor's voltage–current characteristic (Figure 3) we can distinguish following zones: before breakdown, breakdown and saturation.

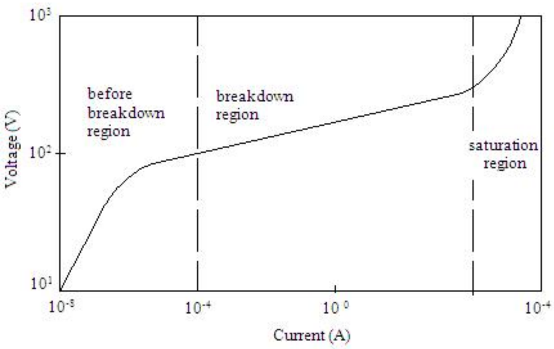

Figure 3. Voltage-current characteristic of varistor

In before breakdown zone resistance of varistor is of the order of GΩ and the current in working conditions is of the order of μA. Following equation (1) is empirical formulation of voltage-current characteristic in breakdown zone.

$$I = kU^{\alpha} \quad (1)$$

I – current, k – constant, U – voltage, α – nonlinearity factor.

Contemporary oxide varistors have nonlinearity factor equal even 80 which depends on manufacture process and on the current.

IV. ADDITIONAL EQUIPMENT

Additional equipment used with high voltage surge arrester is: insulted base, line terminals, grounding terminals, surge counters, function indicators, external grading rings [1].

Stationary 110kV surge arresters are mounted on 1,5m high reinforced concrete bracket. It protect surge arrester from intensive snowfall.

To install function indicators bottom of surge arrester can't be directly grounded. That's why insulated base is used.

Longer arresters often require external grading rings to maintain a uniform and acceptable voltage stress along their length. Operation of such arresters without the grading rings may lead to failure. We use them for voltages exceed 110kV. Usually two grading rings are used for 400kV. They are presented at Figure 4.

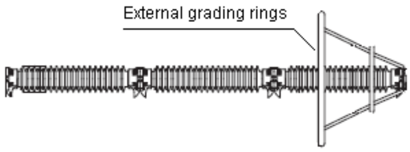

Figure 4. Additional grading rings in surge arrester

The most popular operation indicator is overpressure indicator. When there is operation the colorful cover is throw outside the jet.

Counting of operation number is made by special spark gaps. They also allow to estimate quantity of charge. When spark gap operate the electric arc leaves at electrodes after-arc track. Shape of these tracks depend on value and time of arc current.

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[2] U. Braunsberger, "ZnO arresters in overvoltage protection in pulsed power circuits," *European Electromagnetic Launch Society 12th Topical Meeting. September 2001, Ayr*.
[3] ABB Buyer's Guide ,"High voltage surge arresters"