MANUFACTURING OF 20 KV PIN TYPE SEMI-CONDUCTIVE GLAZED INSULATOR AND SUCCESSFULLY USE IN BANDARABBAS AREA

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Introduction
Transmission and distribution of electrical power in the south and northern part of Iran have ever been one of the problems in electricity industry of the country. High moisture and created pollutions of seawater salts and other different industries in the said regions have destructive effects on insulators performance. In the past, glass insulators were one of the desirable choices but their brittle fracture, caused them to be put away. From long ago, porcelain insulators have been used because of their domestic producers. But these insulators have not presented remarkable advantages in the said regions. Thus utilization of import insulators has been one of the inevitable selections.

In recent years (less than 5 years), composite insulators have been progressively used in south areas of Iran. Because of the talents and latent sources of Iran in the fields of fossil fuels and variant inorganic sources, porcelain insulators are of unique capability to be used in severe conditions. In production of porcelain insulators in Iran, dependence percentage to import raw materials is 10-20%, which is about one forth of that in composite insulators.

Drying characteristic and semi-conducting properties in glaze of porcelain insulators will bring about the possibility of utilizing this type of insulator as a unique family among other bands of insulators.

Experimental method
In this research work, designing of insulator was based on IEC815 standard. Polyethylene model of pin type insulator designed and manufactured with a shed of 32 cm creep distance. Used plaster mold had plaster to water ratio of 1.33 and molds were dried in 45°C for one day. On the other hand, Iranian raw materials, with formulation of alumina porcelain (table 1) were added to ball mill in the order of their hardness and milled for 48 hrs and deflocculated by sodium carbonate and sodium silicate. After that, forming process was performed by means of molds and then formed pieces were dried in an oven at temperature of 105°C for 48 hrs while no crack observed in this stage.

Slurry of semi-conducting glaze with a density of 1.3 g/cm³ and indicated composition in table 2, was applied on dried bodies by spray method.

Firing process was performed in one stage, namely; glazed bodies were fired at temperature of 1300°C and soaking time at maximum temperature was 2 hrs. A picture of manufactured insulator is shown in fig.1.

Results and discussion
Production process of semi-conducting glazed insulators, resemble that of porcelain insulators and the only difference refers to precision and permanent supervision in different stages of production. It must be said that, in relation with insulators treatment under pollution condition, stability voltage of porcelain insulators with semi-conducting glaze in various degrees
of pollution, is 3 times that of normal glazed porcelain insulators and 2 times that of anti-fog normal glazed porcelain insulators. [1]

These insulators also act better than polymer insulators in foggy and pollution conditions even from viewpoint of stability voltage. [2]

Regarding to existence of leakage current in semi-conducting glazed insulators which is about 1 mA, formation of dry bonds in these insulators doesn’t lead to creation of potential difference and partial arcs, because this content of current keeps insulator warm and dry. Energy loss due to leakage current in semi-conducting glazed insulators, is about 0.5% of energy loss via resistance in conductors. In semi-conducting glazed insulators, voltage distribution is more monotonous than that of other insulators. [2]

Monotonous distribution of voltage decreases the probability of corona discharge. It is noticeable that using of semi-conducting additions in the glaze, is more effective than utilization of corona ring. In semi-conducting glazed insulators, interaction with radio waves is about 1% of that in other insulators. The specific resistance of semi-conducting glazed insulators is low in comparison with that of normal glazed insulators. For semi-conducting glazed type, this content is in the range of $10^5-10^{10}$ Ωcm/cm and for normal glazed type is $10^{12}-10^{14}$ Ωcm/cm. [2]

Semi-conducting glazed insulators show a successful performance in long period of time and average lifetime of these insulators estimated to be 30-35 years. Results indicate that impedance change with time passage is relatively low. In this case, increased content of impedance, which is about 20%, is not observed in 35 years, even in the worst conditions of pollution. After this period, entirely failure never occurs in insulator, but stability voltage under mentioned conditions decreases gradually. Any way, the performance of semi-conducting glazed insulators is more suitable than that of normal glazed type. [3]

Using of semi-conductive mixture with ratio of 0.5/29.5 to 3/27 for antimony oxide/tin oxide in standard samples, presents the surface resistance of 0.16 to 10.57 MΩ respectively.

The thickness of glaze must be monotonous that’s why the spray method was used. Also reduction in glaze thickness, leads to linearly increase in resistance. Selection of glaze thickness of 0.75 mm (to obtain the best mechanical stability) and on the other hand, creep distance of 32 cm in the insulator, was the reasons to choose the ratio of antimony oxide to tin oxide equal to 1/29.

The physical characteristics of obtained product according to ASTM standard tests are as followed (table 3):

### Table 3- The physical characteristics of obtained product

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open porosity</td>
<td>0%</td>
</tr>
<tr>
<td>Close porosity</td>
<td>0-0.1%</td>
</tr>
<tr>
<td>Mechanical strength after firing</td>
<td>607 kgf/cm²</td>
</tr>
<tr>
<td>Surface resistance of glaze</td>
<td>13.8 MΩ</td>
</tr>
<tr>
<td>Surface resistance of body</td>
<td>$10^{12}$ Ω</td>
</tr>
</tbody>
</table>

The body resistance in comparison with the resistance of semi-conducting glazed insulators is in possession of good accordance. By using this type of insulators in distribution lines of polluted and humid regions, because of it’s surface conduction equal to 1 mA and heat creation characteristic, the surface of insulator is kept wipe and therefore no external pollution will remain on insulator and disruption creation will be suppressed. Thus without any need for washing, insulator will be useful during it’s work life. In addition, surface conduction will result in more monotonous distribution of electrical potential on the surface of insulator.

**Summery**

Pin type semi-conducting glazed insulator designed and manufactured with Iranian raw materials and creep distance of 32 cm. Glaze slurry consisting of 10% semi-conducting additions and with density of 1.3 g/cm³ was applied on the dried bodies by spray method with final thickness of 0.75 mm. Firing process was performed in one stage at temperature of $1300^\circ$C and soaking time at maximum temperature was 2 hrs. Normal glazed insulators under severe foggy and polluted conditions, show partial arcs on insulator surface but in visual inspection of used pin type semi-conducting glazed insulators in the region and under said conditions, no
partial arc was observed.

Conclusions
- Electrical resistance in the body of semi-conducting glazed insulator is not function of it's shape and has no difference with normal glazed insulators but only is dependant on purity of raw materials and proper production process.
- Surface resistance of the semi-conducting glazed insulator is much less than that of normal glazed type. With 10% of semi-conductive mixture in glaze, leakage current content, for optimum performance and results is obtained.
- Because of the losses created by leakage current in semi-conducting glazed insulator, utilization of these insulators is not recommended in all areas, although the created losses is less than 5% of that in conductors.
- For power delivery with better quality and suppressing the RIV in urban and polluted regions, it is recommended to utilize the pin type semi-conducting glazed insulators.
- Substitution of utilizing the pin type semi-conducting glazed insulators need for no change in posts and towers.
- Normal glazed insulators in severe foggy and polluted condition, show partial arcs on insulators surface but in visual inspection of used pin type semi-conducting glazed insulators in the region and under said conditions, no partial arc was observed.

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