Strength of the Lightning Activity in the Territory of Azerbaijan Republic

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***Abstract*— In this paper, sufficient statistic data (for a period of over 40 years) on thundery days and thundery hours are presented for the whole territory of the Azerbaijan Republic. Based on these materials, new maps on mentioned characteristics of the strength of thunderstorm activity have been drawn and a diagram giving duration of thunderstorm as a function of the number of thundery days has been plotted. It is presented both in power and exponential dependence. These maps will make it possible, when designing the lightning protection of various objects, to more accurately choose required characteristics of their protection from LS.**

Keywords- power transmission line; lightning strikes; thundery days; thundery hours

I. INTRODUCTION

Electrical transmission lines (ETL) and equipments of substations being objects that serve to transmission of the electric energy produced in the electric power stations to far and near distances and to distribution among consumers, surround all territory of the republic. For this reason concerning to other objects they are considered objects mostly undergo to influence of atmosphere and climate.

In spite of all fulfilled measures, because of different reasons sometimes intervals arise in the passing of the electric energy to consumers. One of such reasons is the undergoing of those objects to lightning (thunder) discharge.

Lightning blows can affect the line props, chains protecting the line from such blows, as well as directly the line itself. In the case the blow place is near the station and substation wave of extreme tension arisen in the result of the blow coming with the line can injure the isolation of the equipments of station and substation.

If the opening of the line in the result of the blow is short-term, after turning off the arisen electric arc, the line automatically joins to electric circuit with the help of the device of repeated joining and consumers are supplied with continuous electric energy.

In the result of lightning blow, if passing of the line isolation through electric arc is accompanied by the worker current, stable arc arises and arisen short circuit sometimes causes long-term intervals in the passing of the electric energy [1].

Minimizing of such intervals, investigation of injure reasons of electric transmission lines and other equipments, as well as making of corresponding measures is very important.

II. INTENSITY OF THE LIGHTNING ACTIVITY

Reliable working of the objects constructed in the earth surface depends considerably on intensity of the lightning activity in the region the object settles.

Activity of the lightning carries statistical character for each region. Depending on seasons of a year intensity of the thundery days in each year can be different and it depends on the climate condition of this region. Activity indicators of the lightning consists of thundery days on that region, durability of the lightning in hours within days and if it is possible number of thunders having the unique surface during year.

Both in the territory of past USSR and in Azerbaijan the activity of the lightning, as well as thundery days and their durability in the hydro-meteorological stations, in the hydro-meteorological points only remarking of the thundery days, in some places as in atmosphere or between sky and earth, between earth and cloud it is implemented with the help of the abacuses.

The registration of the thundery days in the meteorology stations is implemented at least hearing of a lightning's discharging voice within day, or by seeming of its light in the territory circle of 10–15 km. And the durability time of the thundery days is implemented by the registration of the thunder beginning and finishing hours. Making registration with this method by gathering of perennial statistical material, annually thundery days, their durability and average numerical mark is counted and map of the parameters shown for corresponding territory is made.

As information connected with atmosphere is statistical material of character and is considered of probability, the more its durability lasts, the more its prognosis and exactness of middle mark is high. That is why, such materials both in the world and in our republic is registered in the hydro-meteorological stations and points.

In any investigation region the more exact method of defining the lightning activity consists of defining of the average number of thunders in a kilometer ($1km^2$) in that region within a year, i.e. defining its special ($n_{sp.n}$) number. It

is possible to fulfill defining of these parameters in different ways. Each of them has specific shortages.

Sensitiveness of the abacuses in the registration with abacuses, i.e. its influence zone, ability of separation and registration intercloud and between cloud, earth and selectiveness of the abacus define the error received from it. If influence zone of the abacus is specified on the basis of middle prices of the lightning parameters' discharge in the constructed territory, its selectiveness depends on the wireless antenna's and another receiving station's direction to discharge.

It is necessary to note that because of different reasons and difficulty of carrying researches on a large scale with abacuses, such registrations are conducted in a small area episodically.

Registration of lightning blows to different objects is implemented mainly in the props of the high tension TL and broadcasting towers, as well as in the special towers constructed for research of lightning parameters and the price of the $n_{sp.n}$ is defined through report way for those territories [2, 3].

Different formulae have been given in different literatures for counting of $n_{sp.n}$ on the basis of durability of thunder interval and thundery days through report [4, 5].

Commonly, in different literatures it is considered that the number of the lightning in an hour of a thundery day is approximately 0.067÷0.1.

Information received from 52 of 98 hydro-metrological stations located in the republic where the thundery days and hours are registered is 40 years and more and from 42 stations is 50 years and more. Last materials on 5 new metrological stations cover last 2004–2008 years. Information received from 15 of other hydro metrological stations organizes 10÷20 years and from 23 station 21÷39 years.

On the basis of materials of many years maps of average thundery days and middle duration interval of the thundery days have been compiled. In Fig. 1 one of these maps - average number of the thundery day's map has been given.

Beside these maps, in the 2nd picture correlation area of the thundery days and duration interval on republic territory, as well as the graphics compiled on the exponential and top functional bases have been given. These dependences can be expressed in the:

exponential: $$N_{t.h} = 5.75e^{0.73N_{t.d}} \quad (1)$$

and

top: $$N_{t.h} = 0.9N_{t.d}^{1.18} \quad (2)$$

functional forms, here $N_{t.h}$ – number of thundery hours; $N_{t.d}$ - number of thundery days.

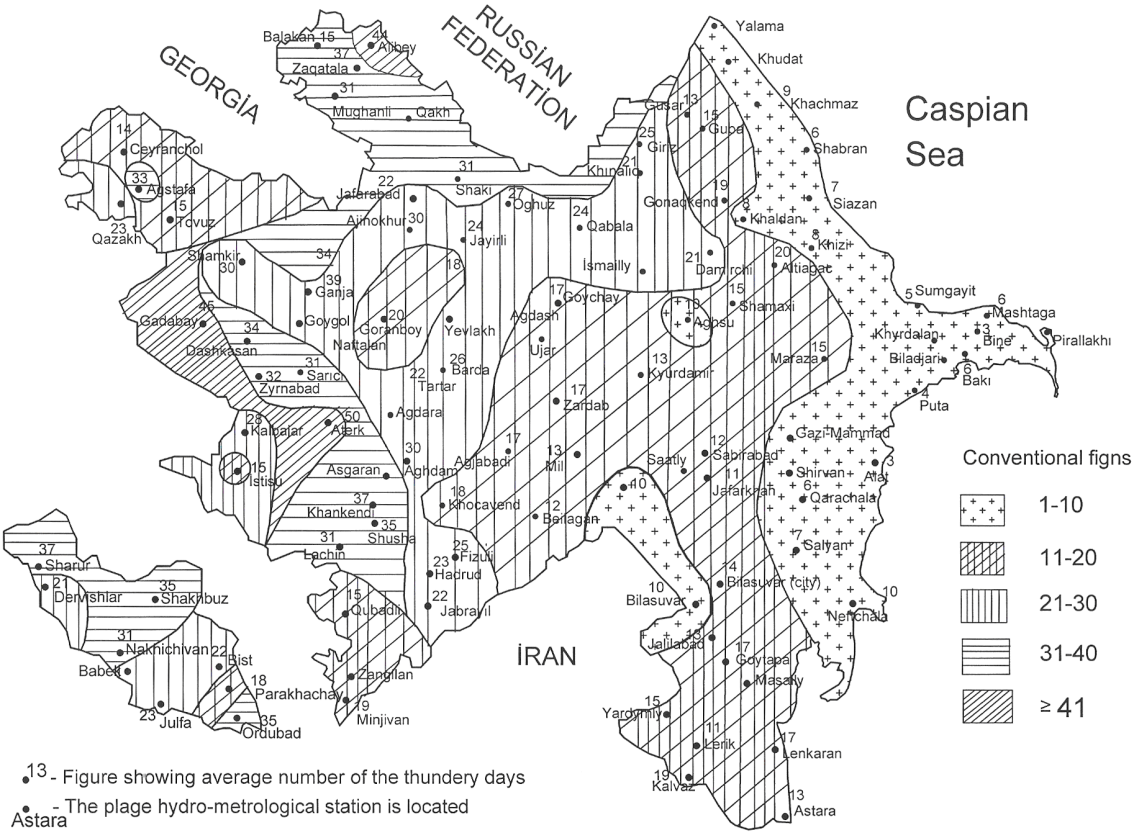

Figure 1. Average number of thundery days in the terrirory of the Azerbaijan republic in a year.

In Fig. 2 on the basis of received information together with the compiled graphics, graphic of dependence which have been given in the [2] formula have been shown. These graphics mostly being statistical materials between 0–25 days almost are closer to each-other (top function graphics).

That is, if one of these parameters is known it is possible to define another one without making any mistake on the basis of formula.

III. Analysis of High Voltage, System Importance ETL's Deploying from the Influence of Lightning Blow

As noted before, one of ETL's deploying reasons is blow of lightning to the line. Transmission of the line isolation through electric arc, perforation and shattering of the insulators, sometimes breaking of the chain or line buttonholes, shattering of the tree props, burning and etc. happens with extreme tension in the result of lightning discharge' blow to the line prop, line conductors or protecting chains of the line. It is necessary to note that in some cases staff of exploitation is not able to define the reason of the automatic opening. That is the necessity for unclear discharging investigation and some corresponding measures arises.

Investigation of the opening connected with lightning blows, as well as ETL's opening date and hour blows as a rule is fulfilled in the dispatcher operation book comparing with the thundery days' date and times registered in the hydro metrological stations close to the route line.

Carrying of the investigation for the "Azerenerji" OSC's system importance lines of 110, 220, 330 and 500 kV power, their automatic opening registered during 2005–2009 have been fulfilled in the comparison with the thundery days and hours registered in those years in the hydro metrological department of the Ministry of Ecology and Natural Resources (except of Nakhchivan Autonomous Republic and occupied territories) which is in the activity in the territory of the republic.

So, for defining the automatic opening's connection with the lightning blows acting time of the thundery cloud along the road and the line cutting time (Fig. 3) was compared with the time of line opening and line along the route registered in the hydro-metrological stations located along the route, or in different distances from the route (10–15 km).

This type of comparison carryment is possible only on the basis of average speed of the thundery clouds. In different literatures an average action speed of the local thundery clouds (arising in the mountainous and sometimes in foothills territories) is approximately 20–25 km/hour and in frontal character clouds is 60–80 km/hour.

In previous years near Shusha city in the result of the observations carried out in the field laboratory and on the basis of the analysis of ETL's deploying it was definied that it is possible to accept the average acting speed of the thundery clouds approximately 30 km/hour in the mountanious and foothills, in the plain arears approximately 50 km/hour.

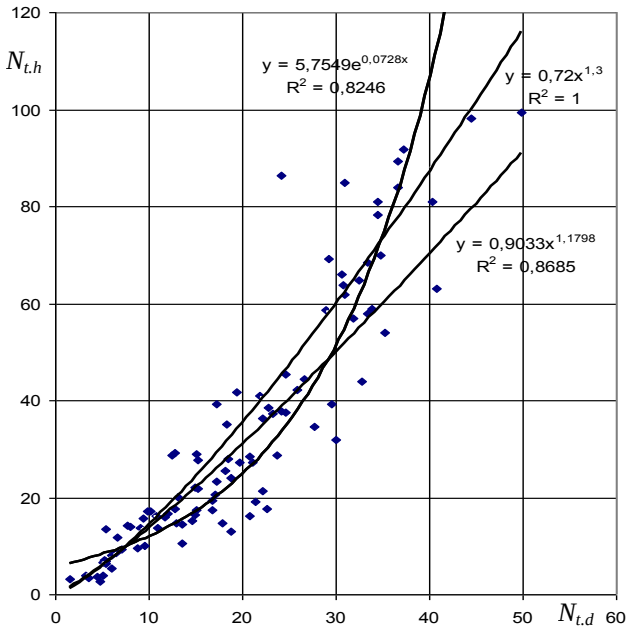

Figure 2. Dependence between thundery days and average duration period of thundery days on average prices on long-term information in the territory of the republic.

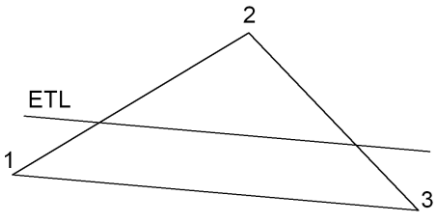

Figure 3. Defining scheme of the actual mark of the average duration period of the thundery day along route of ETL on the basis of the hydro metrological stations (1, 2, 3) location.

In general, comparative analysis of the ETL's resistance against lightning is characterized with the 100 hours of the thundery hour's average price registered in the metrology stations located along the route of line and with the number of deployment that is about 100 km of the considered territory and is specified by following formula:

$$n_{sp.n} = \frac{n_{act}}{T \cdot l \cdot N_{a.t.d}} \cdot 10^4 \qquad (3)$$

here n_{act} – is actual number of deployment connected with lightning in the analysis carrying period; T – period of analysis carrying, year (in our case T=5 years); $N_{a.t.d}$ – average price of durability period of the thundery days during a year registered in the hydro metrological stations along the ETL's route, in hour, ℓ – actual length of the ETL, km.

For conduction of analysis regarding lightning during 5 years, 3 and more lines with 110 kV and deployment, as well as lines on route with 220, 330, 550 kV independently on the deploying numbers, the average price of durability of the thundery hours in a year have been brought to 100 hours and

the length of the ETL to 100 km and the special number of deployment have been attributed.

The comparison of the 110 kV line's special number of deployment indicates that mostly the lines with rather short length and unsupplied with the chain protecting from lightning undergo to thunder blows. Generally the resistance of the line is connected with the lightning parameters in the same line passing area (period of durability of the thundery days), parameters of the thunder current, special resistance of the grunt where the props of the line on route is located, height of the route from the sea level, price of the prop-earth joining. Besides there are exceptions as well.

It is necessary to note that the intensity of the lightning activity and height of ETL's deployment number connected with the lightning meets the March-October month's interval. Metrological information of long years and gathered experience shows that probability of the arising of the local thundery clouds and passing of the frontal clouds in these month is high.

We would have to note here that in the considering 5 years as a matter of fact 20th Absheron line with 500 kV one time, 3rd Shemkir line with 330 kV one time, 1st Absheron line with 330 kV 2 times, 1st and 2nd Mingechevir line with 220 kV respectively 2 and 1 times have been opened in the result of the thunder blow.

As mentioned above because of not getting perfect information about the ETL's chains protecting from lightning it is hard to say decisive opinion about the above mentioned lines of 220, 330, 500 kV power.

IV. CONCLUSIONS

Maps compiled on the basis of the hydro-metrological information of many years about the thundery days and duration interval, can be used as a primary source in the construction of the ETL, electric stations, substations and in the designing of the objects protecting from thunder in the territory of the Azerbaijan republic.

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