

Computer Aided Program of Mechanical Calculation of Flexible Conductors

Y.V. Bladyko, I.I. Sergey
eie@bntu.by

Belarusian National Technical University, Minsk, Belarus

Abstract. The numerical method of mechanical calculation of overhead lines and substations flexible conductors on computer is stated. The pack of computer programs MR21 is described, the valuation of reliability of computer calculations is executed. Characteristics of developed computer programs and opportunities of last versions of set on mechanical calculation of flexible conductor are present.

The tendency of reduction of transmission lines and substation dimensions increases the requirements to accuracy of their mechanical calculation. The purpose of this calculation is the determination of tensions arising in wires and basic designs and maintenance in any point of span of requiring minimum allowable distances to various objects at all possible kinds of loads accepted when designing (ice, wind, etc.).

This calculation is executed with use of calculation model of wires represented as flexible elastic thread, that facilitates the decision of task of account of elastic and temperature lengthening of conductor in various regimes of climatic loads. The statics of flexible elastic thread is described by nonlinear differential equations of second order. Their numerical solution is proceeded by difference method with the help of computer. The system of finite difference equations is solved on a base of iterations enclosed each in other: about coordinates, tensions or lengths of conductors. If there are drops to electric apparatus one more iteration on coordinates of points their fastening to flexible bus-bars is added. These coordinates are function of tension in drop, and it in turn depends on the position of conductor.

At development of algorithm the numerous proposals and remarks of design organizations of Russia and Belarus used the early versions of set of programs are discounted. The set of computer programs MR21 working in one integrated environment is composed on a base of developed algorithms. It permits to enter the initial data, execute the calculation, view and print out the results of calculation. The main programs of set are MR1 and MR2.

MR1 represents the program of mechanical calculation of flexible conductors in various climatic regimes, based on models of conductors and insulator strings as flexible elastic thread.

MR2 is improved program of calculation, in which for acceleration of calculations in equations as tension of conductor is accepted its horizontal component H . MR2 is used for spans with small sag (ratio of sag to span length is less than $1/20$). The divergence in results of calculation of sag and horizontal displacements on MR1 and MR2 does not exceed 1.5 %.

The valuation of reliability of algorithms and programs was conducted by comparison of calculation results with data received on conventional methods of mechanical calculation based on representation of conductors by parabolas in wide range of change of initial parameters. In particular, for approach of developed algorithm to calculation model of conventional methods the drop was taken into account by vertical load, that has resulted in to divergence in calculations of sags of 2 - 4 %, horizontal displacements - up to 1 %, tensions - 0.1 - 2.8 %. The closest coincidence of results took place at large tension of conductors. At reduction of tension the divergence between them grows. It is basically explained by increase of error of approximate technique, stipulated by accepted assumption that projection of length of insulator string on coordinate axis along spans is equal to the length of string.

The comparison of results in shows that the error from not taking into account the real arrangement of drops and string depends on the quantity of drops and makes in determination of sags of 3 - 15 %, horizontal displacements - 9 - 32 %, tensions - 2 - 7%. This error is explained by different account of forces, acting from drops on substation bus-bars. For example, at use of values

of forces from drops calculated on program an error of conventional methods in determination of sags decreases to 0.5 - 3%, for horizontal displacements - to 1 - 4 % and for lengths flexible conductors - to 0.1 - 0.35 %. It confirms the reliability of results received on program.

The programs permit to determine sags in two planes and tension of flexible conductor of substations and overhead lines at their various arrangement under action of ice and wind loads. The programs take into account the difference of support heights, tensioning insulator string, spacers, as well as drops (up to three) to electric apparatus taking into account their real arrangement in substation. The programs are suitable for calculation of installation regimes with one string in span and various variants of installation of drops, as well as permit to decide the reverse task, i.e. to determine the tension of conductor for known sag.

The calculation of conductors can be executed in 12 climatic regimes. The number of initial regimes can be equal to 1 or 2. With two initial regimes the program chooses the heaviest regime of climatic loads, at which the forces from conductors on basic designs are maximum. The mentioned regime is accepted for initial one. In this regime on given tension or sag is settled an invoice of length of flexible conductor before stretching which is a base for calculation of other regimes.

By initial data it is possible to calculate installation regimes both at presence of freely hanging drops not fixed to electric apparatus and at their absence during installation.

The results of calculation represent the tables of initial data and calculation parameters: tensions, displacements and sags of conductors, loads on supports and electric apparatus, loads on conductors and insulator string. Maximal sag and horizontal displacements, as well as sags in given points in projections on horizontal and vertical axis are determined. The loads from conductors on supports, from drops on flexible bus-bars and on electric apparatus are calculated in projections on axes of coordinates.

The work with programs is simplified by built-in help, diagnostic of initial data of users, availability of catalogues of conductors and insulator string, as well as opportunity of their updating. The programs permit to draw the horizontal and vertical projection of span for each climatic regime.

The last version of program set MR21 has one integrated environment included program MR1 and MR2, files of initial data, catalogues of conductors and insulator string, files of graphic processing of information and print it out. Besides set enters the control examples of calculation, copies of files of catalogues and initial data. Lengths of drops and conductors, diagnostic of initial data on their fittings to range of allowable values are present.

The work with catalogue of conductors, i.e. entering of new types of conductors and correction of existing ones, is executed in separate menu on password to avoid of non-authorized record in it. To user the opportunity of work with new (temporary) mark of conductor without putting it in catalogue on constant storage is granted.

The version comes to users on Russian and English languages. The complemented built-in help and explanations of calculation results permit to work with set without any instruction. The uniform integrated environment indicates errors of user, as well as authors information for communications with developers on operations of set.