RISE OF PARTIAL DISCHARGES IN THE WALL BUSHING AND THEIR ELIMINATION

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SUMMARY

Users of the wall bushing type IBS 12,5/22p63 complain of an electromagnetic interference by partial discharges. This wall bushing have nominal voltage 35 kV and nominal current 1000 A. We made some models of electrostatic field inside the bushing and around it by means of the method of finite elements. We have used two software for studying this electrostatic field – robust professional software MARC and more simple QuickField. We found the locations where the partial discharges were created. The possibilities of elimination of the partial discharges were proposed as follows: change of the inductive capacity of the cement, increase of the cement conductivity, semiconducting varnish among the middle ribs, increase of the assembly hole to 170 mm, chamfer of the edge and increase of the conductivity coat. This paper consist of comparation of calculated values of electrostatic field for proposed eliminations of partial discharges with values of electrostatic field for current configuration and for possibility of failure of the zinc coat in both foreheads.

Keywords: *Wall bushing, Diagnostic, Partial discharges, Method of finite elements, Designed modification*

1. INDRODUCTION

Electrical products have to comply with the constantly strict requests for electromagnetic compatibility at present. Since the producers of the wall bushing type ISB 12,5/22p63 complain on a rise of the interference, there were performed an expert analysis of the electrostatic field in the wall bushing and its environment. The aim of the research was to find out the locality of the rise of partial discharges, which cause the interference and to eliminate them by the suitable constructive or mounting design.

Company Elektroporcelán Louny Ltd. produces the wall bushing IBS 12,5/22p63 [1]. This component is determined for covered distribution point to max. 35 kV and 1000 A. It is composed of the hollow porcelain roll with the surface ribbing. On this ribbing is fixed the aluminous collar bonded by cement glue, which fixes the collar in the steel wall. Cable of the profile (63 × 10 mm) gets through the wall bushing fixed by the aluminous caps at the end of the wall bushing. These covers are connected with zinc coat (thickness 0,05 ÷ 0,1 mm) thanks to the semiconducting cement glue, which is dashed in a hollow of the bushing. A full configuration is displayed in the longitudinal section on figure 1.

There were used two types of software for the analysis of electrostatic field, which are based on the method of finite elements. The first one was QuickField [2] and second one was MARC [3]. If we would simply compare these two programs it can be said: QuickField is small or medium system suitable for PC. Integrated user menu with all tools are at disposal but the quantity of tools is very limited. This software is suitable for solving of small problems. The control is relatively simple and user friendly. It is possible to solve problems only in 2D. QuickField uses only triangular network for discretiozation of the problem and it cannot be changed. Software MARC can be insert among the large systems. It is the professional software with quantity of libraries for simulation of various technical problems. The network for discretization can be set from the different elements and can be operatively changed. There also can be solved 3D problem in different time levels. These levels can be connected to the animations. The program control is very complicated and it is necessary to have enough time to learn using it.

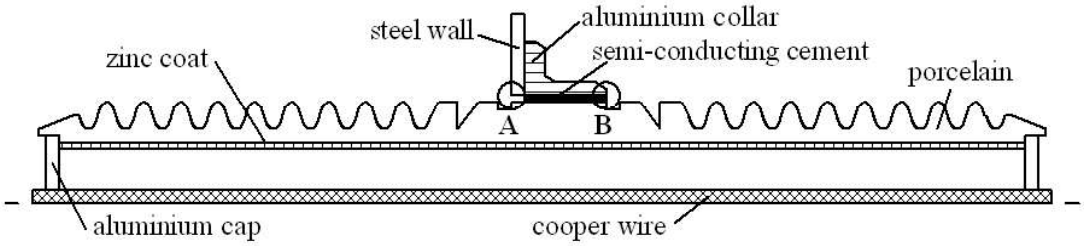

Fig. 1 Schematic cut of wall bushing IBS 12,5/22p63

2. MODIFICATION OF WALL BUSCHING

The first model simulated the current state and showed us two locations where the partial discharges can rise. The first location was on the edge of the steel wall, which the bushing passed through (area A) and the second location was on the opposite place of the collar (area B). Electric field strength was over 4 kV.mm^{-1} in the both cases. The next model simulated the break of the contact between the zinc coat and aluminous cap accordingly with the conductor. In this case created another localities of the rise of partial discharges - at the location of failure and on the edge of the wire. This model verified necessity of the zinc coat and its perfect conductive connection with the copper conductor thanks to the aluminous cap and semiconducting cement. The design of other modifications comes from these presumptions:

- The form of porcelain cylinder is given and it is not suitable to change it;
- The parameters of porcelain are also given and it is not suitable to change them because of new tests of material and it would be actually a development of a new material;
- The other properties of the bushing must not get worse (for example mounting facility);
- The application of modifications must be primitive and technologically and economically unpretentious.

Let us pay attention to cement glue at first, whose parameters are not enough determined. This cement holds the aluminous collar on the porcelain shell. If the inductive capacity of the cement glue will be equal to the inductive capacity of porcelain, then the electric field strength will decrease in both critical locations. If we increase the cement conductivity (100 times more than the porcelain), then will arise two locations with increased electric field strength in the area (A) - in the both edges of the steel wall. In addition all values will increase. If we add semiconducting coat between the first ribs (from the collar), then the electrical field will be homogenized and values of the strength will decrease.

The most important modification seems to be the increase of the assembly hole in the steel wall, which can be in range from 150 mm (diameter of the bushing) to 200 mm (size of the collar, which can be increased in case of needs). If we increase the hole at 170 mm, the value of the electric field strength will decrease at the value about 1 kV.mm^{-1}. This value is acceptable. This value can be decreased thanks to chamfer of the edge or thanks to the increase of the conductivity of the semiconducting coat. Calculated values of the electric field strength in both critical areas are displayed for particular modifications in Tab 1.

The airspace between the hole in the steel wall and the surface of the porcelain shell, where are arising the partial discharges, can be eliminated thanks to the filling of the semiconducting cement. This cement must not make problems to the easy mounting and dismounting wall bushing, therefore we can use for example the rubber, acrylic or silicone cement with the conductive admixture for the disposable usage. This method would be suitable as the alternative one for the just finished distribution point with wrong access for the extension of the hole in the steel wall.

Designed modification	E / kV.mm^{-1}	
	Area A	Area B
Current configuration (Fig. 2)	4,5	4,2
Failure of the zinc coat in both foreheads	4,5	4,2
Change of the inductive capacity of the cement	4,2	3,6
Increase of the cement conductivity	4,75; 5,1	4,7
Semiconducting varnish among the middle ribs (Fig. 3)	2,3	1,15
Increase of the assembly hole to 170 mm (Fig. 4)	1,15	1,1
Chamfer of the edge and increase of the conductivity coat (Fig. 5)	< 1	< 1

Tab. 1 Values of the electric field strength in both critical areas

Provided, that the suitable cement was supplied by some producer, this method would be technologically easier than the extension of the hole in the steel wall, because the bushing has to dismounted at first. In this case it is the question of the disposable and permanent modification. Next possible modifications might decrease the discharge activities. We paid attention to them and researched them, but they have some disadvantages. For example there are mentioned next two possibilities. It is possible to achieve it if we connect the zinc coat with the potential of the wire thanks to the semiconducting varnish. But the allowed tolerant space of the zinc coat would be much too narrow and hardly achievable, the dissociation of the potential would affect not only the conductivity of the layer but also the conductivity of the porcelain (very strong temperature-dependent).

Once the potential difference between the conductor and zinc coat would overrun a relatively low limit, there would be the discharge activities in hollow of the bushing. Additional the varnish layer would represent a possible faulty place and it would decrease a reliability of the whole configuration. The advantage of this modification is very small, because the potential of the zinc coat can be reduced just in kV. It will not be showed in critical locations around the collar.

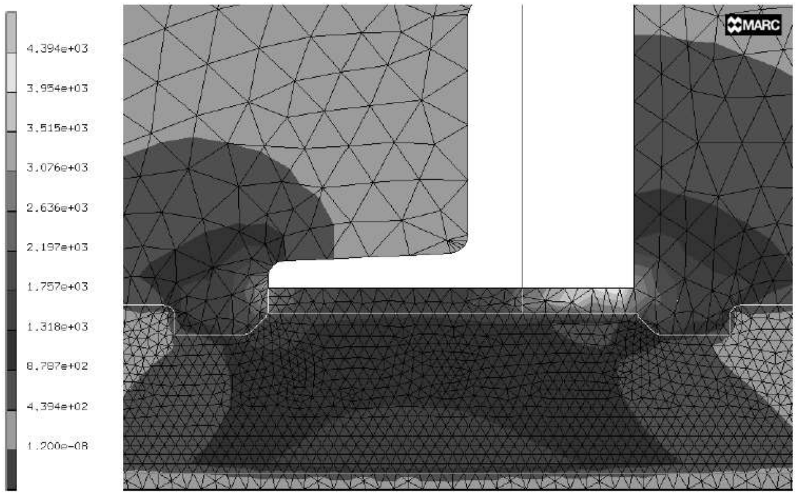

Fig. 2 Electrostatic field for current configuration

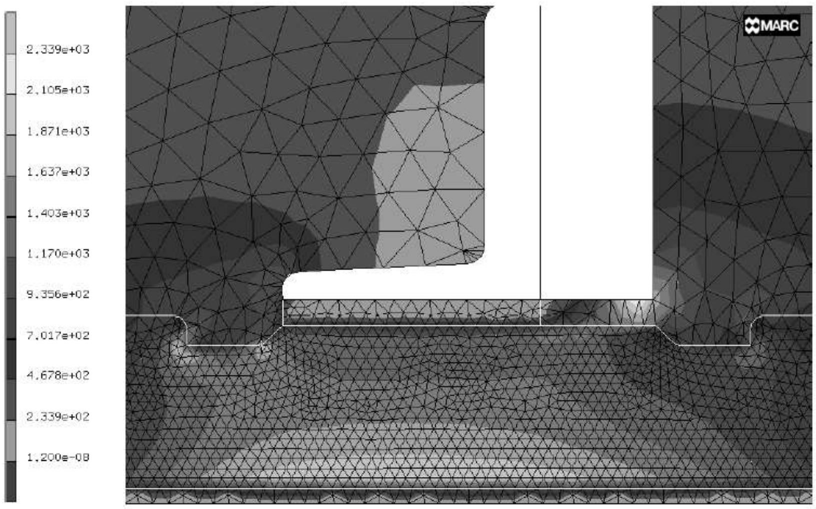

Fig. 3 Electrostatic field for configuration with semiconducting varnish among the middle ribs

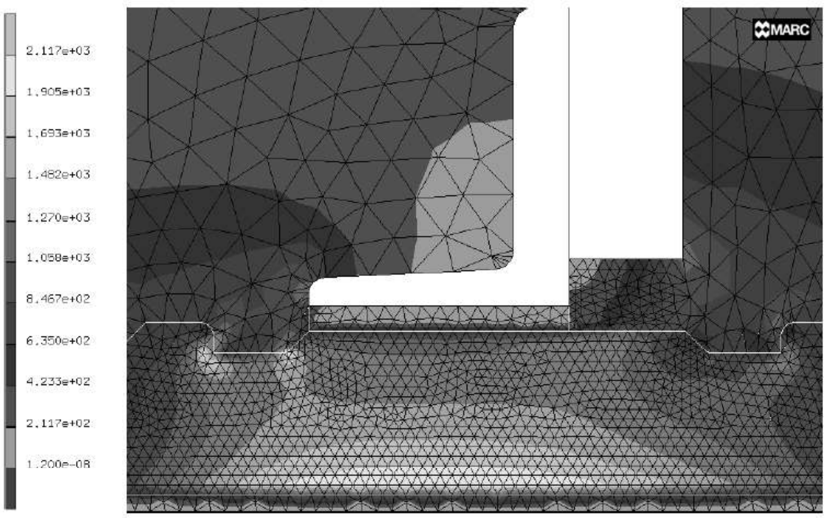

Fig. 4 Electrostatic field for configuration with increase of the assembly hole to 170 mm

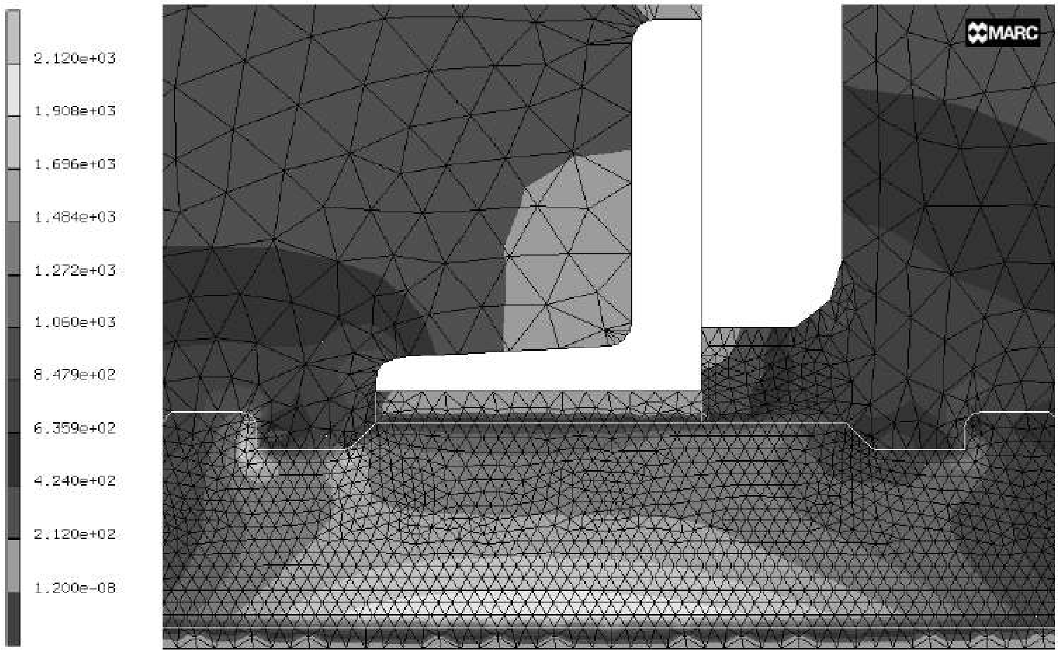

Fig. 5 Electrostatic field for final configuration

Decrease of the inductive capacity of the porcelain and cement at the value about 1 is followed by the equable distribution of the electrostatic field and also the decrease of the value of the electric field strength in critical area too. It is concerned only with theoretical thought, because the material with these properties is not naturally to our disposal.

It is also possible to experiment with the chamfer of the edge of the hole in the iron wall, which is not uniquely determined. The chamfer seemed to be better than the radius. This result is probably the method error because of the used spline-curve did not assure right input of the edge conditions. It is also probable, that at minimum determined diameter of 170 mm is enough to make the chamfer - an angle of 45°.

In conclusion can be said that there was verified the application of covering zinc electrode. It is the important problem, if the conductive connection with the wire is damaged. The most important modification seems to be the extension of diameter of assembly hole in the steel wall, which the bushing gets through. There was also designed a minimal diameter, which can be suitable for a model. For a situation improvement on the edge of the hole is possible to chamfer or round its edge, which might arise corona. The second possibility is the filling the airspaces between the wall and the bushing with the semiconducting rubber. Important modification is also a dab of the coat of the semiconducting paint on the surface of the porcelain shell among the middle ribs and in additional the increase of conductivity of the cement glue under the collar. There is possible to do experiments with conductivity and the range of this coat in case of need.

3. CONCLUSION

All existing parts of the wall bushing stay changeless. It is not necessary to change the form, the structure of components and manufacturing technology from view of suggested modifications. There were improved only the operation of coating with the layer of the varnish and usage of the semiconducting cement glue into the manufacturing technology.

REFERENCES

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[3] http://www.quickfield.com

BIOGRAPHY

Ing. Václav Boček, Ph.D. was born in 1971. In 1994 he graduated at the Department of Electrical Machines of the Faculty of Electrical Engineering at West Bohemia University in Pilsen. In 1997 he defended his PhD. with title "Mathematical replace of function characteristics of diagnostics parameters". Since 1997 he is working as a tutor with the Department of Technology and Measurement. His scientific research is focusing on electrical insulation materials, diagnostics and reliability electrical systems.