# Development of Current Interruption Simulation Model of Fault Current Interrupting Arcing Horns for 60 kV Class Overhead Transmission Lines

## Background

When a short-circuit fault occurs in an overhead transmission line as a result of lightning strike, operation of a circuit breaker at the substation generates concern about the influence of instantaneous blackout on customers. To cope with the problem, we have developed fault current interrupting arcing horns (Fig.1) for 60 kV class overhead transmission lines, which can interrupt short-circuit fault current, as a low-cost and effective countermeasure against lightning damage *1. To extend the applicable scope of the fault current interrupting arcing horns to overhead transmission lines, analyses and examinations of success and failure of short-circuit fault current interruption are considered necessary using a current interruption simulation model.

## Objectives

Develop a current interruption simulation model of fault current interrupting arcing horns for 60 kV class overhead transmission lines.

## Principal Results

### 1. Development of a current interruption simulation model dependent on arc conductance

We focused on the Cassie and Mayr models *2 to simulate arc dynamics and interruption characteristics, and developed a current interruption simulation model which is dependent on arc conductance. The current interruption simulation model enabled to consecutively simulate entire process from fault occurrence to fault clearing by applying cross-faded switching from the Cassie model to the Mayr model (Fig.2). We showed that the dependence of arc parameters *3, which are included in the Cassie and Mayr models, on arc conductance could be expressed by unique relation from short-circuit fault current interruption tests *4. The relation was applicable to overall range of current up to 10 kA, which the fault current interrupting arcing horns could interrupt, and was shown as constant approximation for the Cassie model and exponential approximation for the Mayr model (Fig.3).

### 2. Application of the current interruption simulation model to EMTP

We carried out EMTP *5 simulations using the developed current interruption simulation model in the short-circuit fault current interruption test circuit, and verified that the computational current and voltage waveforms were accurately consistent with the experimental waveforms.

Therefore, the current interruption simulation model of the fault current interrupting arcing horns for 60 kV class overhead transmission lines was developed, and the validity was verified. The current interruption simulation model made it possible to analyze power system condition when the fault current interrupting arcing horns operated in the case of a short-circuit fault.

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***References***

T. Ohtaka, et.al., 2005, "Development of a current interruption simulation model of fault current interrupting arcing horns - Formulation of a fundamental arc model," CRIEPI Report H05013 (in Japanese)
T. Ohtaka, et.al., 2006, "Development of a current interruption simulation model of fault current interrupting arcing horns (Part 2) - Development and application of an arc conductance dependent model," CRIEPI Report H06007 (in Japanese)

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*1 : Fault current interrupting arcing horns for interrupting one line grounding fault current (22 to 154 kV) were developed in FY1997 by joint research with Kansai Electric Power Co., Inc. and Nippon Katan Co., Ltd., and fault current interrupting arcing horns for interrupting short-circuit fault current (66 / 77 kV) were developed in FY2003 by joint research with Kansai Electric Power Co., Inc., Tokyo Electric Power Co., Inc. and Nippon Katan Co., Ltd. These have been introduced to Japanese power systems.

*2 : The Cassie and Mayr models are macroscopic arc models widely used up to the present. Generally, the Mayr model is used around current zero point, and the Cassie model for large current regions.

*3 : Arc parameters affect the arc dynamics and the interruption characteristics. These are arc time constants, arc power loss and steady-state arc voltage.

*4 : The short-circuit fault current interruption tests are carried out under the conditions of applied voltage 59.8 $kV_{rms}$ and short-circuit current 1, 5 and 10 $kA_{rms}$.

*5 : Abbreviation for 'Electromagnetic Transients Program'.

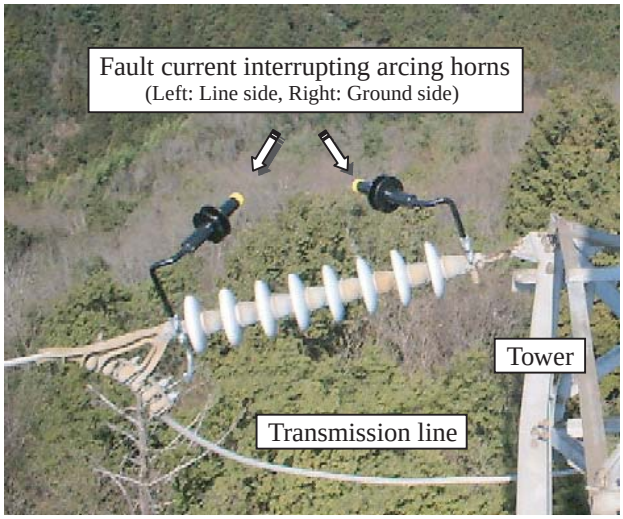


**Fig.1** Fault current interrupting arcing horns

Cylindrical interruption parts made of organic insulating material are added on conventional arcing horns, and their core parts are protected with insulation covers to prevent bird damage.

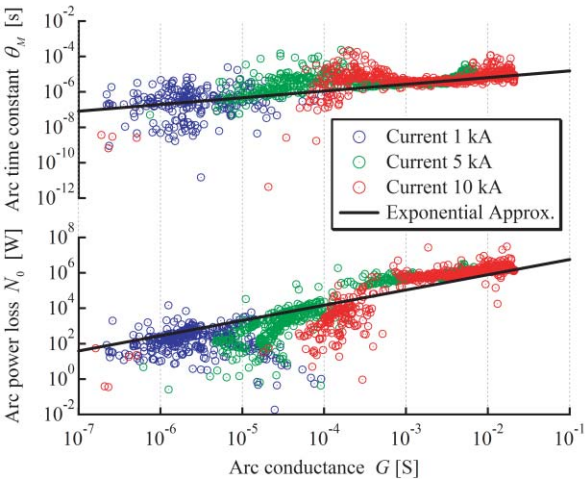


**Fig.3** Dependence of arc parameters on arc conductance for the Mayr model

The dependence of arc parameters (arc time constants, arc power loss) on arc conductance can be expressed by unique relation for overall range of current.

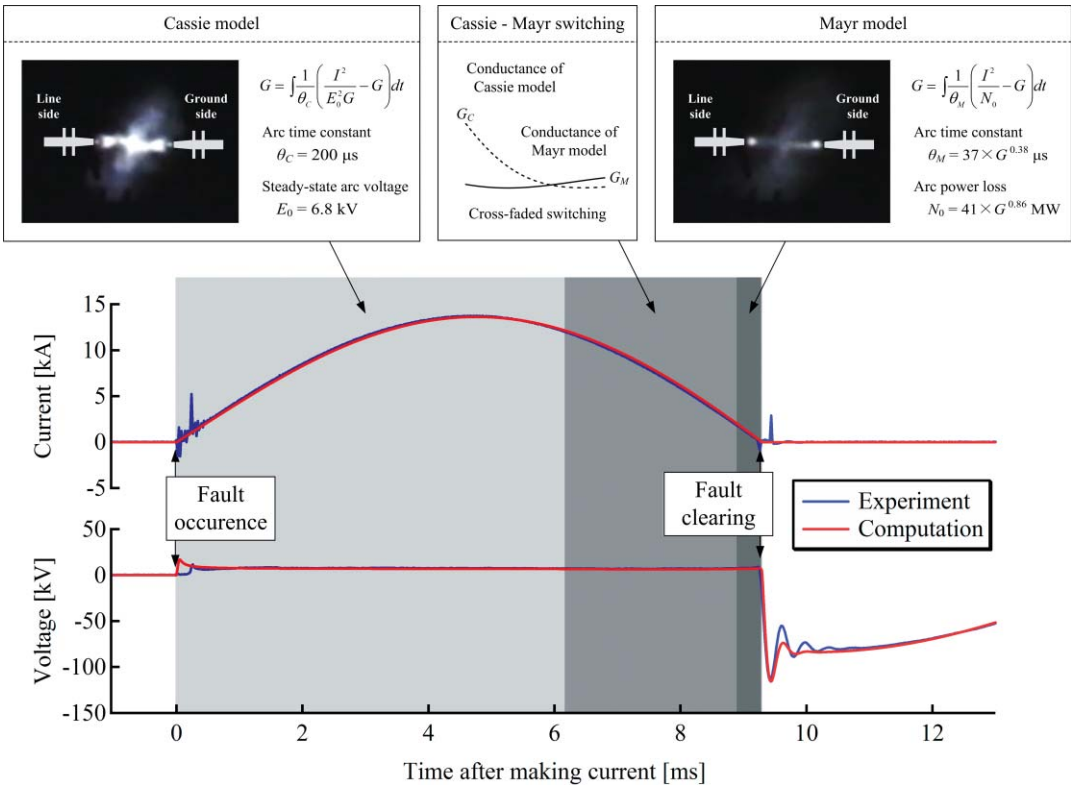


**Fig.2** Current interruption simulation model which is dependent on arc conductance and comparison of current and voltage waveforms at 10 kA between interruption test and EMTP simulation

Pictures in the above figures show the arc jets which blow out from the tips of the interruption parts of fault current interrupting arcing horns. Consecutive simulations over entire process from fault occurrence to fault clearing become possible by applying cross-faded switching from the Cassie model to the Mayr model.