HIGH-VOLTAGE TACITRON WITH COLD-CATHODE AND MAXIMAL CURRENT AUTO-LIMITATION

I. Drozd; A. Kuzmichev, PhD; A. Pinkavsky
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine

Introduction

Gas-filled discharge switch devices are widely used for high voltage pulse generation in radiolocation techniques, for laser pumping and electromagnetic (including X-rays) radiation generation, in electrophysical apparatus, technological facilities for material treatment, and ozone generators, due to their best relevant features [1, 2]. Extant devices, however, are not capable to resolve all actual problems of power pulse generation, so development of new switches with enhanced features is required. The most actual is creation of the fast gas discharge switches with full control, i.e. as closing/opening devices. The opening devices are capable to interrupt electrical current with simultaneous sharp rising up voltage to high values and the most known devices of such kind are the tacitron type thyratrons with a grid control. However, the usual tacitrons contain the hot cathode with well known demerits, therefore the development of tacitrons with a cold cathode is the vital problem. The cold cathode may provide long lifetime, high radiation resistance, low cost, *etc*. This work deals with development and investigation of the tacitron type cold cathode device which can not only interrupt the current but limit the maximal current, too.

Electrode structure of the gas tetrode

The device employs the hydrogen high density glow magnetron discharge (~ 1 A/cm2) maintained within a cylindrical hollow cold cathode, which is immersed in an axial magnetic field generated with a permanent magnet (see Fig. 1). Two microperforated grids are placed between the open end of the hollow cathode and a flat main anode of the device. The first grid serves as an anode of the glow magnetron discharge. The second grid serves as control one for regulation of anode current.

The hollow-cathode effect together with the action of axial magnetic field provides beautiful conditions for gas ionization by secondary cathode electrons and generation of dense discharge plasma. The plasma surface in the openings of the first grid serves as an electron emitter for the anode part of the device. The products of gas pressure p and gaps d between the grids and between the second grid and the anode are very small (d ~ several millimeters); that is corresponding to pd values at the left of the left branch of Paschen curve. Hence, the self-maintained discharge between the gaps is impossible (as in vacuum) and we have the combination of gas discharge part with vacuum one. However, some gas ion generation by electrons emitted through the first grid and ion compensation of electron space charge in the anode part occur. This provides low electrical impedance

of the gaps.

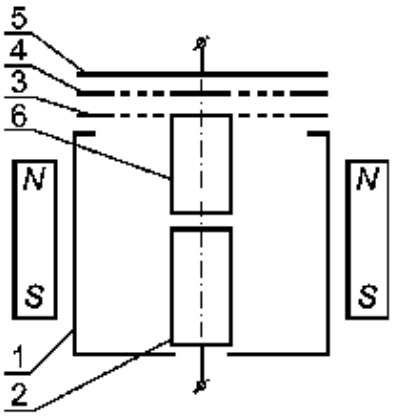

Figure.1. Schematic structure of experimental tacitron electrodes; 1 – hollow cold cathode, 2- auxiliary pre-ionizing discharge electrode; 3 – 1st grid; 4- 2nd grid; 5- anode; 6- supplemental element of 1st grid

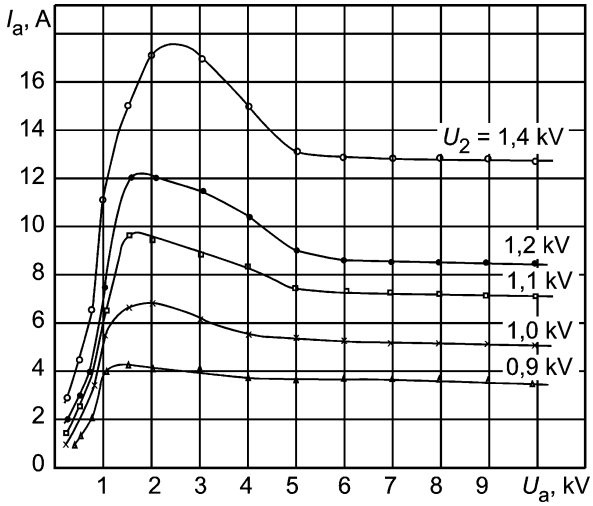

Figure.2. Anode current I_a dependence on anode voltage U_a at different control pulse voltages of the 2nd grid. Load resistance equals zero

Operation performance of the two-grid tacitron

During the given work, very interesting features of control over the cold-cathode gas-discharge tacitron with two grids under the high anode voltage (U_a = 10-20 kV) have been revealed. There are three operation modes: thyratron, pure tacitron, and current limiting modes. In the first thyratron mode, the device works only as a closing switch. In the second tacitron mode, the device works as a closing/opening switch (therewith the anode current pulse duration is defined by the width of positive voltage pulses applied to the second grid), so the device works as a current interrupter. In the third mode, device works as a closing/opening switch but additionally the value of anode current is set up by the second grid voltage, so the anode current value is regulated by the second grid voltage and the device works as a vacuum tube (see Fig. 2). In the last mode, in the case of shortage of the anode load the anode current value I_a was limited by our device.

The following maximum peak anode current values I_a have been obtained: in the thyratron mode – 500 A; in the tacitron mode – 75 A; in the current limiter mode – 5…18 A (at peak pulse anode voltage U_a = 10 kV, current pulse duration – 1…3 μs, average anode current – 150 mA, voltage drop during current pulse – 300...650 V). The study of the tacitron with cold cathode is in progress. We consider the future work on development of the tacitron should be devoted to choice of the cold cathode material to minimize the switch-on time and the voltage drop during current pulses.

References

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Анотація

Особливості роботи високовольтного газорозрядного комутуючого прилада тасітронного типу з двома решітками управління і холодним катодом в магнітному полі. Пристрій може перемикати електричний струм при високій напрузі в тиратронному режимі (як замикаючий перемикач), в режимі тасітрону (як перемикач який замикає/відмикає), або в якості тасітрону з автоматичним обмеженням максимального значення анодного струму (в якості короткого замикання в ланцюзі навантаження). Такі режими роботи пристрою реалізуються через невеликі зазори між мікроперфорованих керуючих сіток і анода з використанням конкретних режимів роботи імпульсних решіток управління.

Ключові слова: прилад-вимикач, тасітрон, холодний катод, обмежувач струму.

Аннотация

Особенности работы высоковольтного газоразрядного коммутирующего прибора таситроного типа с двумя управляющими сетками и холодным катодом в магнитном поле. Устройство может переключать электрический ток при высоких напряжениях в тиратронном режиме (как замыкающий ключевой прибор), в режиме таситрона (как замыкающий/выключающий прибор), или в качестве таситрона с автоматическим ограничением максимального значения анодного тока (в случае короткого замыкания в цепи нагрузки). Такие режимы работы устройства реализуются благодаря небольшим зазорам между микроперфорированными управляющими сетками и анода с использованием специальных режимов работы управляющих сеток.

Ключевые слова: выключающий прибор, таситрон, холодный катод, ограничитель тока.

Abstract

The features of operation of a high-voltage gas-discharge switch device of tacitron type with two control grids and cold cathode in magnetic field are considered. The device is able to switch electric current at high voltages in the thyratron mode (as a closing switch), in the tacitron mode (as a closing/opening switch), or as a tacitron with automatic limitation of maximal value of the anode current (in the case of shorted load circuit). Such modes of device operation are realized due to small gaps between the microperforated control grids and the anode and employing specific pulse operation modes of the control grids.

Keywords: opening switch device, tacitron, cold cathode, current limiter