Journal of Physics: Conference Series **516** (2014) 012031 doi:10.1088/1742-6596/516/1/012031

Experimental results of breakdown in "Dena" plasma focus device

Shervin Goudarzi*, S M Hoseinian, A Raeisdana

North Kargar Ave., Atomic Energy Organization of Iran, Nuclear Science and Technology Research Institute, Plasma Physics & Nuclear Fusion Research School, Tehran, Iran

E-mail: shgoudarzi@yahoo.com

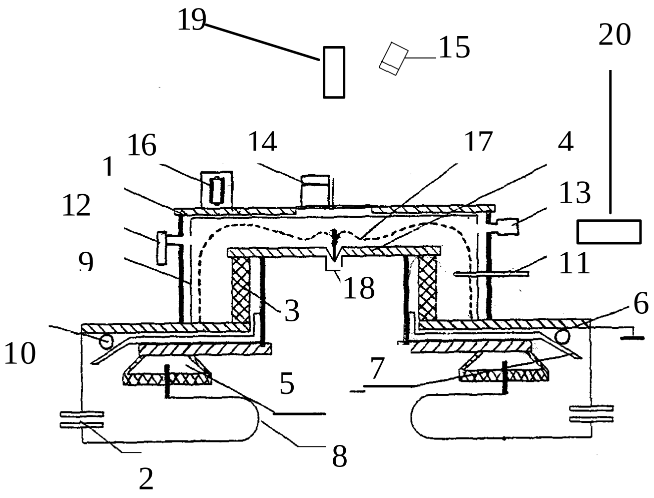
Abstract. In spite of the intense research activities on Plasma Focus devices, the physics of the initial breakdown and surface discharge phase has not been realized completely. In this paper we have analyzed the surface discharge and initial breakdown phase in Filippov-type Plasma Focus Facility "Dena" (90 kJ, 25 kV) on the base of the current and current derivative measured signals by using Argon, Neon and Krypton as working gases at different discharge voltages and gas pressures, and the effects of working conditions (atomic weight, discharge voltage and gas pressure) on the breakdown and surface discharge phase have expressed. Also, on the base of these results, we have investigated about the relation of this phase with final pinch phase.

1. Introduction

From the development of the Plasma Focus devices in 1960s in two different models by Filippov in Soviet Union and Mather in United States [1, 2]. A lot of samples of them in the range of less than one Joule to some Megajouls have been constructed in different research centers all over the world [1–8]. In spite of the intense research activities on these devices, some theoretical problems in them are not resolved completely and there are not proper models for explanation of them [8, 9–11]. In general, the different phases of discharge in Plasma Focus devices can be divided to five different stages [1, 2, 3, 8, 12]: 1 – The initial breakdown and surface discharge , very little is known about the physics of this phase [13], this phase has a great influence on the formation of final pinch **,** 2 – rundown phase that does not exist in Filippov-type devices, 3 – radial compression , 4 – pinch phase , 5 – instability happening and pinch destruction. In this paper we would present and analyze the results of initial breakdown & surface discharge phase in "Dena" Filippov-type Plasma Focus Facility (90 kJ, 25 kV) in different working conditions.

2. Experimental set-up

Our experiments have been performed in Filippov-type Plasma Focus "Dena" (90 kJ, 25 kV). A schematic diagram of "Dena" with all of its diagnostics is shown in Figure1. The description of this device has been reported completely elsewhere [13]. The diagnostic system consists of a 4-channel PC-based data acquisition system including two GPIB compatible oscilloscopes (50MHz) and two fast (500MHz) digital storage Tektronix oscilloscopes. In these experiments, several discharges have been made at different working conditions (discharge voltage, initial pressure, gas composition, insert



1. Upper flange of the vacuum chamber
2. Capacitor energy storage
3. Porcelain insulator
4. Anode
5. Ring-like spark gap switch
6. Collector plate
7. Insulation
8. Matching inductance
9. Liner
10. Rogowski coil
11. Magnetic probe
12. Pinhole camera
13. SXR detector (SPPD-type)
14. Detector-monitor of integral HXR(PhEC)
15. Scintillation detector with multiplier
16. Detector of integral neutron yield (G-M)
17. Plasma-current sheath
18. conic insert anode
19. End –on G-M counter
20. Side-on G-M counter

Fig.1. Schematic diagram of the Dena plasma focus and its diagnostics.

anode) to study the variations of total discharge current and current derivative signals to investigate the correlation between the breakdown phenomena and working conditions. The total discharge current and current derivative signals are measured by a Rogowski coil and a magnetic probe, respectively.

3. Results and discussion

In these experiments Hydrogen, Neon and Argon have been used as working gases. We have done 3 series of experiments, 1- Using Neon and Argon as working gases at constant initial pressures and different discharge voltages, 2- Using Hydrogen, Neon and Argon as working gases at fixed discharge voltages and different initial pressures and 3- Using Hydrogen, Neon and Argon as working gases at fixed initial pressures and discharge voltages. From the investigation of the results of these experiments (discharge current, current derivative), we have suggested about the breakdown phenomena in "Dena".

In the first series of our shots we have observed that as could be predicted at constant pressures (for example, 0.5 torr) for both gases, by increasing the discharge voltage (for example, from 14 k V to 16 kV) and therefore, increasing the pinch intensity and tightness and decreasing the pinch time (tp). The breakdown phenomenon occurs earlier.

By changing the pressure in the experiments with Hydrogen, Neon and Argon at constant voltages, it is seen that for each gas when the pressure approaches to the optimum pressure of x-ray emission (therefore, increasing the pinch intensity and its tightness and decreasing the pinch time) the breakdown happens earlier.

Journal of Physics: Conference Series **516** (2014) 012031 doi:10.1088/1742-6596/516/1/012031

Also, it is seen from the results of the experiments with Hydrogen, Neon and Argon at constant pressures and discharge voltages that the breakdown in Argon happens earlier than two other cases and in Neon earlier than Hydrogen, we can conclude that commonly the breakdown in heavier gases happens earlier than lighter gases. This is acceptable because the heavier atoms can release the electrons of their outer orbits easier than lighter atoms. These results show again the same relation as two other modes between breakdown time and the pinch intensity and tightness and the pinch time

4. Conclusions

The presented results in this paper show that the working conditions (initial pressure, discharge voltage and gas type) have high influences on discharge and breakdown phase. At constant discharge voltage and gas pressure by using heavier gases, surface discharge and breakdown phase happens earlier. In a definite gas with a constant pressure, by increasing the discharge voltage, the breakdown happens earlier and pinch time will decrease. Also, in a definite gas and constant discharge voltage, when the pressure approaches to the optimum pressure, the time of starting the breakdown phase decreases .These results have shown clearly the strong relation between pinch intensity and its tightness and pinch time (t_p) with breakdown time. Commonly, in the discharges with tighter and stronger pinches the breakdown & pinch times are less than the weak pinches

References

[1] Bernard A, Cloth P, Conrads H, Coudeville H, Gourlan G, Joals A, Maisonnier CH and Rager J P 1977 *Nucl. Instrum. Methods* **145** 191-218
[2] Lee S 1989 *Proceedings of the Spring College on Plasma Physics* ICTP Trieste 113-169
[3] Castillo F, Milanese M, Moroso R and Pouzo J 2002 *Brazil. J. Phys.* **32** 3-12
[4] Silva Patricio, Soto L, Kies W and Moreno J 2004 *lasma Sources Sci & Tech.* **13** 329-332
[5] Hussain S, Ahmad S, Khan M Z, Zakaullah M and Waheed A 2004 *J. Fusion Energy* **22** 195-200
[6] Rawat R S, Zhang T, Lim G J, Tan H, Ng S J, Patran A and Hassan S 2004 *J. Fusion Energy* **23** 49-53
[7] Shafiq M, Hussain S, Sharif M and Zakaullah M 2001 *J. Fusion Energy* **20** 113-115
[8] Soto L 2005 *Plasma Phys. Control. Fusion,* 47, A361-A381
[9] Gribkov V A 2000 *Nukleonika* **45** 149-153
[10] Zakaullah M, Akhtar I, Waheed A, Alamgir K, Shah Anwar Z and Murtaza G 1998 *Plasma Sources Sci.Technol.* **7** 206-218
[11] Castillo F 2000 *J. Phys. D: Appl. Phys.* **33** 141-147
[12] Mathuthu Manny, Zengeni Teddy G and Gholap Ashok V 1997 *IEEE Trans. Plasma Sci.* **25** 1382-1388
[13] Goudarzi S, Amrollahi R, Sadat Kiai S M, Morshedian N and Nasiri N 2005 *Czech. J. phys.* **55** 45-53