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和歌山高専におけるプラズマ応用研究
Plasma Applied Study at National Institute of Technology, Wakayama College

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1. Introduction

National Institute of Technology, Wakayama College (NITW) has been studying plasma applied study since 2011. Particularly, we obtained achievement for study of pulse Magnetohydrodynamic (MHD) acceleration with Nagaoka University of Technology (NUT), and started the study of capacitive-coupled MHD Generation with them. In addition, in Wakayama, fruit plantation is popular and the orange production is also the best in Japan in the past few years. Therefore we started study of plasma sterilization for orange and obtained some achievement. The purpose of this paper is to introduce above researches, in particular study of capacitive-coupled MHD Generation and plasma sterilization for orange, and its results.

2. Research of Plasma Sterilization for Mandarin Oranges

The devise of gas-torch type dielectric barrier discharge (DBD) plasma with Neon transformer (KOTERA CR-N16) is set the top of the acrylic container (120×120×290mm), and it irradiates the plasma for 1 to 3min using by the air as working gas and its gas flow rate was 7 l/min and primary voltage was 70V. And then ozone concentration detector is set at the bottom of the acrylic container. Figure 1 is indicated profile of ozone concentration with plasma irradiation time. Interestingly, ozone concentration is decreased for the case of irradiation time of over 2min despite plasma irradiation is continued. We could not say clearly, when the difference of ozone concentration of the plasma source and the around is nothing, ozone is not generated.

If this fact is true, it has the possibility that sterilization effect is able to obtain for the case with interval time about plasma irradiation. Fig.2 shows sterilization effect w/ and w/o interval time. Although plasma irradiation time of 40min could achieve about death rate of 90%, it was achieved about 70% for the case of irradiation of 3min, stop irradiation for 3min as interval time and irradiation of 3min again (case of 3(3)3). In this research, if we do without having to control ozone concentration, sufficient sterilization effect is obtained with interval time.

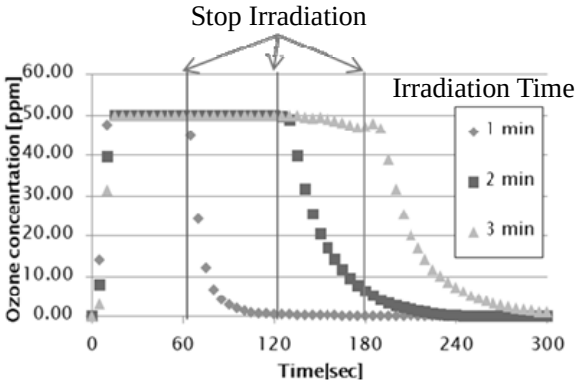


Fig.1 Relationship of Irradiation Time and Ozone Concentration

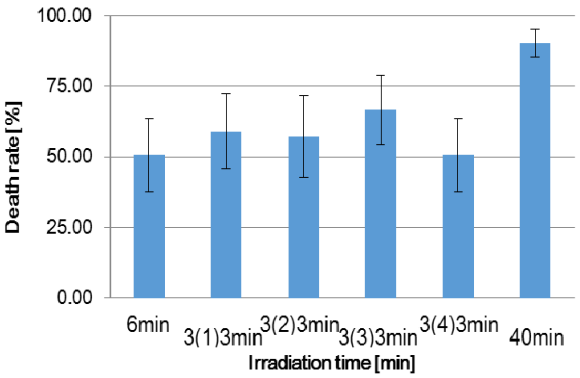


Fig.2 Comparison with Sterilization Effect by Indirect Plasma Irradiation with and without Interval Time (( ) shows interval time)

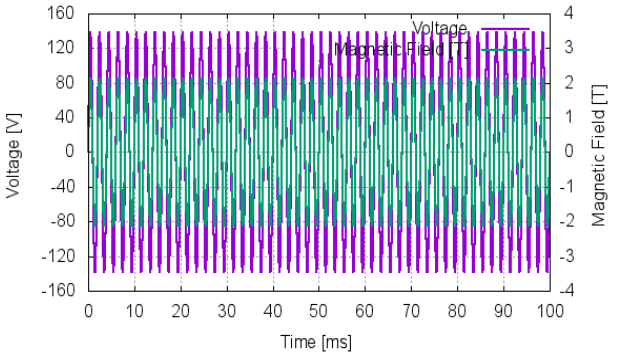
3. Fluid Behavior as Discordance of External Impedance for Capacitive-Coupled MHD Generation

This MHD generator is quite unique, insulator is set as MHD channel wall between the electrode and plasma, and when we can supply AC induction voltage, virtual electrodes are formed in the close to MHD channel wall. Therefore it is possible to avoid wear of electrodes and perform the operation with

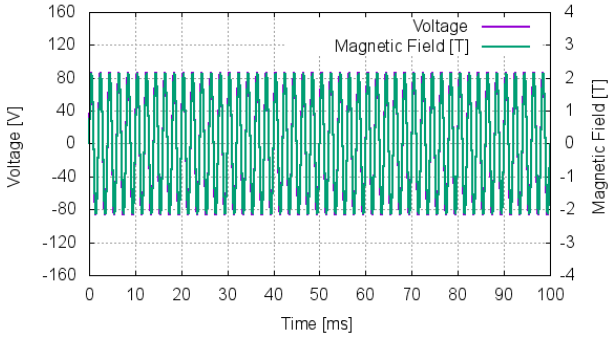
high velocity fluid because no slip operation is available. In this section, we verified fluid behavior for capacitive-coupled MHD generation under non impedance matching.

To compare fluid behavior, internal impedance was 0.264Ω, therefore, both external load was set to 0.264Ω (with impedance matching) and 0.7Ω (without impedance matching). As other input condition, alternating applied magnetic flux density of 2.0T and its frequency of 0.5kHz, inlet plasma temperature of 10000K, inlet plasma velocity of 3000m/s and Argon gas as working gas, are decided.

As Results, both output power was slightly difference, they were 27kW for the case of 0.7Ω and 28kW for the case o 0.264Ω. In addition, Fig.3 is indicated output voltage and applied magnetic flux density. In this figure (a), maximum output voltage of 140V and 80V is obtained for the case of (b). The reason is pressure decreasing to 40kPa in the downstream of MHD channel. In this case, gas velocity of about 2500m/s was also faster than 2000m/s of case (a). Although gain of plasma velocity shows gain of output power generally, variation of plasma temperature in the downstream of MHD channel was about 1000K, accordingly gain of electrical conductivity was small.

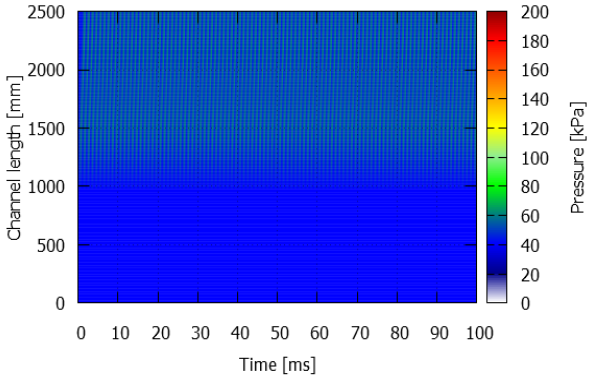


(a) 0.7Ω (without Impedance Matching)

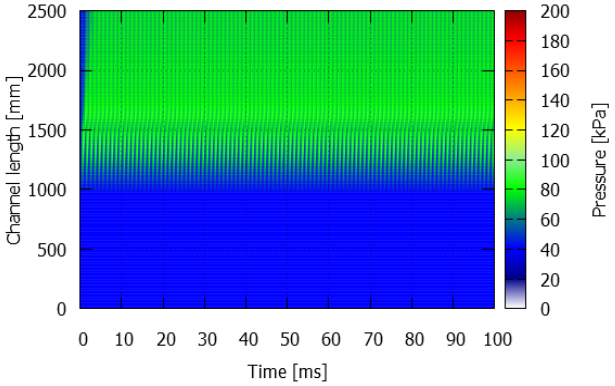


(b) 0.264Ω (with Impedance Matching)

Fig.3 Relationship with Output Voltage and Magnetic Field for Variable External Load



(a) 0.7Ω (without Impedance Matching)



(b) 0.264Ω (with Impedance Matching)

Fig.4 Pressure Profile at MHD Channel Exit with/without MHD Acceleration

4. Summary

We described introduction and briefly results for pulse MHD acceleration and plasma sterilization for orange. As future works, bacteria or mold is sprayed to orange peel directly, and we need to perform sterilization experiment under the environment where the orange are easily taken ill. In addition, it is necessary to investigate influence of frequency variation to output power for capacitive-coupled MHD Generation.

According to the study of pulse MHD acceleration, we will present at poster session.

Reference

[1] Natsu Kawashima, Shinji Takeshita, “Investigation of Sterilization Effect on Oranges Using Atmospheric Pressure Plasma during Transportation”, 10th Asia-Pacific International Symposium on the Basics and Applications of Plasma Technology, 2017

[2] Shinji Takeshita, Natsu Kawashima, Atsuki Okaura, “A Preliminary Study of Plasma Sterilization after Harvesting for Mandarin Orange”, 6th International Conference on Sustainable Energy and Environment (SEE2016), 2016