Japanese MHD Program

Author(s): S. Kabashima

Session Name: Status Reports - International MHD Programs

SEAM: 27 (1989)

SEAM EDX URL: https://edx.netl.doe.gov/dataset/seam-27

EDX Paper ID: 1306

JAPANESE MHD PROGRAM

S.Kabashima

Tokyo Institute of Technology, 4259 Nagatsuta, Midori-ku, Yokohama 227 Japan

1.INTRODUCTION

In present stage MHD researches and developments in Japan are mainly performed by many groups in universities belonging to Ministry of Education, Science and Culture. The researches are collaborated with private companies including electric power utilities, machinery manufactures etc., especially in the closed cycle system which presents an excellent experimental results with the blow down facility.

They have two experimental facility of power generation. The one is the Fuji-1 blow down facility operated at Tokyo Institute of Technology, where researches of closed cycle MHD power generation are intensively performed by using disk generators. The other is named MDX-1 which has constructed in March 1989 at Hokkaido university, where the concept of shaped field configuration (SFC) generators will be velificated.

As concerned with researches by MITI(Ministry of International Trade and Industry) the national program (ETL-Mark VII) have been finished in March 1989, however, the Mechanical Engineering Laboratory is preparing a new proposal of MHD R & D.

2.RESEARCH GROUPS AND PROGRAM

(1) **Tokyo Institute of Technology**

The group focus researchs on noble gas driven MHD disk generators which are operated under the condition of fully ionized seed.

a) Experiments with Blow-Down Facility Fuji-1

An Ar-Cs and Ar-K driven disk generator with about 6 MW_{th}, pebble bed high temperature heat exchanger and maximum field 4.67T super conducting magnet are installed in the Fuji-1, and its blow time is about 90 s.

Recently the group have yielded an excellent result, that is, the maximum output power of 500 kW, and the enthalpy extraction rate of 15.6 % under operation parameters as:

Thermal Input	3.3 MW
Stagnant Temperature	1850K
Stagnant pressure	0.64 MPa
Seed Fraction	2.0-2.3 $x10^{-4}$
Magnetic field	4.3-2.7 T

The experiments are financially supported by private companies: Toshiba Co., The Kansai Electric Power Co., The Chubu Electric Power Co. and Electric Power Development Co. as well as MESC.

Above results can be qualitatively explained by numerical simulations based on the conventional two-temperature model equations, which suggests the high performance of the disk generator in CCMHD power generation.

They are preparing a He-Cs driven disk generator installed in the Fuji-1 facility which can be expected higher performance as compared with Ar-Cs driven generator. The operation conditions will be:

Thermal Input	10 MW
Stagnant Temperature	1950K
Stagnant pressure	0.30 MPa
Seed Fraction	5 $x10^{-4}$
Magnetic field	4.3-2.7 T.

b) Shock Tunnel Experiments

Using a He-Cs driven disk generator (DISK-III) they have achieved the power generation whose output power and the enthalpy extraction rate are 384 kW and 20 %, respectively. The experiments show that the He-Cs driven disk generator has the higher performance as compared to Ar-Cs driven one.

Experimental results of V-I characteristics, and velocity and potential profiles are well explained by one dimensional analyses which is the same method as used for Fuji-1 results.

A new disk generator has been prepared. The operation conditions will be:

Thermal Input	2 MW
Stagnant Temperature	2000 K
Stagnant pressure	0.22 MPa
Seed Fraction	$1.0x10^{-4}$
Magnetic field	2.6 T.

In the experiment with this generator the enthalpy extraction rate of 35 % will be expected.

c) Generator Design and Numerical Simulation

The recent power generation experiments show that the most important things to operate the generator is how to find the operation parameters which can keep a desirable gas flow for power generation with high enthalpy extraction. For this purpose a method of generator design considering the boundary layer flow is being developed. The one- and two-dimensional simulations based on the two-temperature model are combined with the boundary layer flow equations. Dimensions of the generator which will be used in next stage experiments are discussed.

The simulation studies have clarified that the blow-down experiments with much more enthalpy extraction rate can be achieved, if the generator channel will be designed to maintain desirable gas flow.

(2) **Hokkaido University**

The Advanced Magnetohydrodynamics Research Institute has been founded in 1988 by Ministry of Education, Science and Culture. The institute restart researches of open cycle MHD power generation with high performance.

a) MHD Flow Train MDX-1

A kerosene combustion MHD train MDX-1 has been constructed in March 1989. The main design parameters are:

Thermal Input	5.0 MW
Fuel	kerosene
Oxidizer	oxygen
Seed	KOH aq.
Combuster	cold wall, swirl type
Channel	Faraday
Nozzle	subsonic
Magnetic Field	UFC 2.5 T
	SFC 0.5-2.75T
Output Power	UFC 31.5 kW
	SFC 42.5 kW

The facility will confirm the advantage of the generator with the shaped field configuration (SFC).

b) Channel Performance Study with Shock Driven Generator

In order to decrease the thermal- and electrical-wall stress they employ the SFC-type generator. The performance improvements by this configuration are examined with a generator driven with shock tunnel.

Analytical discussions of gas flow and plasma phenomena have also performed to ensure the advantage of SFC-type generator.

c) Study of Turbulent Nature of MHD Flow

Turbulent MHD flow are studied both phenomenologically and statistically. Fluctuations such as gas temperature and gas velocity are measured and discussion will be made from statistical view point.

(3) **Toyohashi University of Technology**

a) Discharge Phenomena

Behaviors of discharge in magnetic fields are experimentally investigated. The study will be extended to discharge phenomena in nonuniform plasma, and also the effect of time- and space- dependent nonuniform slag layer on the discharge will be examined.

b) Development of Cyclotron Combuster

Based on experimentally obtained information a coal combuster will be realized. Combined the combuster with the generator fundamental researches for coal combustion MHD power generation are planned.

c) Behavior of Giant Arc Discharge

Discharge behavior in combustion plasma are examined. Experiments are confined to investigate the transformation of the microscopic arc discharge to the giant arc one.

(4) **Gunma University**

a) Coal Combuster for MHD

The group are developing a coal combuster for MHD power generation. They adopt two step air injection system which can trap the slag efficiently.

(5) **Kyoto University**

Two groups are concerned with MHD researches and developments. The one is interested in controls of MHD generators and the other deals with liquid metal MHD power generation.

Controls of MHD Power Generation

The researches subjected above are performed in collaboration with some other university.

a) Analyses of Next Pilot-Plant Scale MHD Generators

A generator with thermal input about 100 MW and electric output about 10 MW, which can be proposed pilot plant, has been analyzed. The cycle efficiency of the proposed plant

become 41.4 %.

b) Analyses of Performance of MHD Generator

Being developed two- and three-dimensional codes, analyses of the generator at an accident are carried out. The effects of secondary flow on current distribution in a generator are also discussed.

c) Control of MHD Generation System

Interactions between MHD generators and power grid system including line-communicated inverter system are investigated for subsonic and supersonic diagonal channels.

d) Local Controls of MHD Generator

The equivalent circuit method has been developed to study the electric nonuniformities. The results are compared with the experimental tesults of the U25B DCW channel.

e) Discharge Phenomena in Closed Cycle MHD Generator

A time-dependent two dimensional code has been developed to explain the basic phenomena of the nonequilibrium plasma. The behaviors of streamer are discussed in Faraday and disk generators.

f) Design of Disk Channel of Pilot Plant Scale

An Ar-Cs driven nonequilibrium MHD disk generator with pilot plant scale are designed. Main parameters are:

Thermal Input	30 MW
Load Current	4964 A
Load Resistance	0.16 ohm
Output Power	3.95 MW
Enthalpy Extraction Rate	13.2 %

g) MHD Generator for Fusion Applications

For use of the MHD generator in fusion system MHD channels for exciting poloidal coils of Tokamak are numerically designed, and the Compact Fusion Advanced Rankine cycle are investigated.

Liquid Metal MHD Power Generation

Fundamental researches for the two-phase liquid metal MHD power generation are performed. An induced type ac generator is especially interested.

(6) **Kyushu University**

MHD researches are confined in the fields of developments of laser-aided diagnostics and shock tube researches.

a) Boundary Layer Phenomena

Density profiles of potassium in a boundary layer flow are measured with line-absorption and line-reversal method and also the arc temperature near electrode are observed with laser interferometery.

b) Fluctuation measurements

A fluctuation measurement method of seed atom density with laser-induced fluorescence and an electron density and conductivity measurement method with far-infrared laser are extended and improved.

c) Gasdynamic Characteristics of Supersonic MHD Generator

The propagating shock wave and pseudo-shock wave in an MHD channel are experimentally and theoretically studied. Studies of transient flows for the short or open faults are planned.

(7) **Mechanical Engineering Laboratory**

They are planning to conduct MHD researches and developments and they submit a new proposal of seed cycle system for noble gas MHD power generation.