Preface to the Special Issue on “Advanced Application of Electromagnetic Force to Materials Processing”

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This special issue of ISIJ International has been published to open the research results of “the Research Group on Advanced Application of Electromagnetic and Magnetization Forces to Materials Processing”. This research group was established in 1999 under the Iron and Steel Institute of Japan and went into action to extend the area of EPM (Electromagnetic Processing of Materials) during 4 years. It constituted the basis of practical researches gathering 19 members from universities, 4 from national institutes, 18 from companies including steelmaking, electric and heavy industries. Foreign members from China (3) and Korea (2) also joined this group. The major activity of the research group was performed by holding regular meetings three times per year to exchange the knowledge among group members. Special lectures were often made especially to get new knowledge on the application of in-

Fig. 1. Objectives of the Research Group on Advanced Applications of Electromagnetic and Magnetization Forces to Materials Processing.
tense magnetic field. And also, a joint symposium was held together with the other research group of steelmaking to know the needs and demands for the new functions of EPM. Besides, many research results were provided for the 3rd International Symposium on EPM in 2000 and the France-Japan Joint Seminar on EPM in 2001. The academic cooperation was formed with the Japan Research Center for Metals (JRCM) that was responsible for the execution of National Project on Application of Electromagnetic Force to Continuous Casting of Steel. These activities are illustrated in Fig. 1.

Major results of this research group will be described briefly in the following.

1. Application of EPM to Metallurgical Process

New application of the cold crucible has been developed to measure the equilibrium of slag–metal reaction at high temperatures and to produce alloys having high melting points with high purity and cleanliness. In addition, high efficiency has been pursued in the design of cold crucibles. Relating to clean metals needed in various industries, methods to remove nonmetallic inclusions from liquid metal have been proposed by using electromagnetic force or magnetization force. In the electromagnetic removal, the estimation of separation efficiency and the design of equipment have been performed considering the effect of the flow of molten metal. Furthermore, agitation methods of slag-metal interface by electromagnetic force or Marangoni flow with electric potential gradient have been proposed.

2. Proposals of New Technologies and New Processes of EPM

The followings have been proposed: an electromagnetic pump for liquid metals with a twisted rotating magnetic field; a hybrid electromagnetic rotating stirrer without free surface deformation; an electromagnetically generated ultrasonic vibrator without contact to molten metal; levitation melting of metal without flow by simultaneous imposition of AC and DC magnetic fields; inclusion separator from liquid metal with a high frequency magnetic field.

3. Investigations on Application of Intense Magnetic Field to Materials Processing

The following results have been obtained: increase in tensile strength of carbon fiber; honeycomb-shape arrangement of ceramic particles in particle-dispersed electroplating; control of morphology of electrodeposited semiconductor film; crystal orientation of film fabricated by PVD or CVD; elucidation of the principle of magnetic orientation of primary crystals in binary alloys. A new technology to generate intense alternating magnetic field has been developed, which may lead us to a breakthrough in new EPM.

4. Cooperation with National Project on EMC

Suggestions were given from academic side to the new continuous casting machine equipped with advanced EPM devices. After the project was finished in 2000, our group members continued researches on the development of an electromagnetic velocity sensor and an electromagnetic stirring to prevent bubble capture into solidified shell in continuous casting mold.

5. Numerical Simulation

Major progresses have been made in the followings: flow design of single crystal generator with a stationary magnetic field; establishment of analytical method of convection by magnetization force; precise analysis of the effect of electromagnetic brake in continuous casting mold; analysis of electromagnetic flows around two spheres suspended in liquid metal; estimation of the shape of gas bubbles rising in water with imposition of a stationary magnetic field.

Above results are partially given in this publication. In addition, invited papers from France and United Kingdom are published together with a paper from Korean member, which will be useful to know the recent situation of EPM in foreign countries. Editors of this special issue on EPM appreciate the contributions of all authors of this special issue and hope that this publication will develop a new stage of EPM in 21st Century.