

# "Tetsu-to-Hagané"

Vol.81 No.4, April, 1995

## The 80th Anniversary Special Issue Towards the 21st Century: Progress of Steel Technology in the Last Decade

### Contents

Preface/N. SANO .....	247
Preface/I. KOZASU .....	248
1. Introduction—New Direction of Steel Technology towards the 21st Century/A. TOMIURA .....	249
2. Ironmaking	
2.1 Progress in Ironmaking Technology for Recent Ten Years/R. NAKAJIMA .....	254
2.2 Advancement of the Theory on Transport Phenomena of Gas, Liquid, Powders and Packed Particles in a Blast Furnace/J. YAGI .....	258
2.3 Development of New Cokemaking Process/M. SAKAWA .....	261
2.4 Technologies for Use of Low-quality Iron Ores/Y. HIDA .....	263
2.5 Recent Advances of Sintering Process Technology/T. INAZUMI .....	266
2.6 Control Technology of Burden Distribution and Realization of Precise Blast Furnace Operation/T. INADA .....	268
2.7 Development of Pulverized Coal Injection Technology/S. INABA .....	271
2.8 Aspect of Innovation for Blast Furnace Technology/K. ISHII .....	273
2.9 Global Environment and Harmonization of Ironmaking/T. FUKUSHIMA .....	276
2.10 Life Prolongation of Blast Furnace and Coke Oven/E. AKIMOTO and M. TANINO .....	279
2.11 Commencement of New Ironmaking Technologies/K. KANAMORI and T. ARIYAMA .....	282
3. Steelmaking	
3.1 Advances in Steelmaking Technologies in Recent Ten Years and Prospective Subjects for Future/Y. UEDA .....	285
3.2 Advances in Steelmaking Technologies for High Quality Steel	
3.2.1 Demands for High Quality Steel/Y. KATO .....	287
3.2.2 Refining Process for High Quality Steel/S. TAKEUCHI .....	288
3.2.3 Continuous Casting Process for High Quality Steel/N. BESSHO .....	291
3.3 Highly Productive Steelmaking Technologies for Reducing Manufacturing Cost Competing with Other Countries	
3.3.1 Improvements of Steelmaking Process Technologies Aiming at Cost Reduction/H. ICHIHASHI .....	296
3.3.2 High Productivity Technologies in BOF/T. OKADA and T. MATSUO .....	294
3.3.3 High Productivity Technologies in Continuous Casting for Slab/T. KANAZAWA and Y. WATANABE .....	296
3.3.4 High Efficiency Production Technologies in Electric Arc Furnace/M. MIWA .....	298
3.4 Advances in Automation and Diagnosis Applied in Steelmaking Process	
3.4.1 Sensing and Automation Technologies in BOF/H. YAMANA .....	301
3.4.2 Automation and Mechanization Techniques in Continuous Caster/M. KIMURA .....	302
3.4.3 Mechanization and Automation for Refractories Installation and Its Diagnosis/R. OSHIMA .....	305
3.5 Newly Emerging Steelmaking Technologies Relating with Environmental Problems	
3.5.1 Demands for Recycling of Scrap and By-products from Steelmaking Process/K. YAMADA .....	306
3.5.2 Scrap Melting Technologies/Y. KIKUCHI .....	307
3.5.3 Processing Technologies for Steelmaking Dust/T. FUKUSHIMA .....	308
3.5.4 Utilization Technologies for Steelmaking Slag/S. IKEDA .....	310
3.6 Current State of Development of Next-generation Steelmaking Processes and Technological Measures/M. TAKEUCHI .....	312

3.7	<b>Recent Progress in the Research of Steelmaking and Further Development to be Expected</b>	
3.7.1	Physical Chemistry/ <i>H. SUITO</i> .....	319
3.7.2	Rate Phenomena/ <i>S. TANIGUCHI</i> .....	321
3.7.3	Nonlinear Phenomena/ <i>K. MUKAI</i> .....	322
3.7.4	Solidification Phenomena/ <i>I. OHNAKA</i> .....	324
3.7.5	Further Development to be Expected in the Research of Steelmaking/ <i>M. TOKUDA</i> .....	326
4.	<b>Metal Working</b>	
4.1	Recent Ten-years-trends of Metal Working and Its Technological Issues/ <i>K. NAKAJIMA</i> .....	328
4.2	<b>Recent Progress of Fundamental Technology of Metal Working</b>	
4.2.1	Analysis of Deformation/ <i>M. KIUCHI</i> .....	330
4.2.2	Tribology/ <i>A. AZUSHIMA</i> .....	332
4.3	<b>Recent Progress of Sheet Rolling Technology</b>	
4.3.1	Rolling Facilities/ <i>N. TAZOE</i> .....	335
4.3.2	Heating and Cooling/ <i>K. YANAGI</i> .....	337
4.3.3	Operational Technology/ <i>M. KAMATA</i> .....	341
4.4	<b>Recent Progress of Shape, Bar &amp; Wire Rod Rolling and Producing Technology of Pipe</b>	
4.4.1	Shape, Bar & Wire Rod Rolling/ <i>T. WASEDA</i> .....	344
4.4.2	Production of Seamless Tube/ <i>T. YAMADA</i> .....	350
4.4.3	Production of Welded Steel Pipes/ <i>S. WATANABE</i> .....	353
4.5	<b>Recent Progress of Other Technologies in Metal Working</b>	
4.5.1	Forging/ <i>O. TSUDA</i> .....	356
4.5.2	Sheet Metal Forming/ <i>H. HAYASHI</i> .....	358
4.5.3	Casting/ <i>I. YAMAUCHI</i> .....	360
5.	<b>Instrument and Control</b>	
5.1	Recent Advances in Instrument and Control Technology in Iron and Steel Industries/ <i>H. KITAGAWA</i> .....	362
5.2	Integrated Information Systems Covering a Wide Area of Steel Industry/ <i>J. YAMASAKI, M. MITSUTOMO, T. HIYAMA and T. KIMURA</i> .....	363
5.3	AI of Established Technology/ <i>M. KONISHI, A. KITAMURA, H. NARAZAKI, H. NAKANO and T. KOYAMA</i> .....	368
5.4	Control Theory in Practical Application/ <i>R. TAKAHASHI</i> .....	374
5.5	Quality Measurement Improved by Intelligence/ <i>K. NISHIFUJI and M. UESUGI</i> .....	380
5.6	Maintenance Management with Information Technology/ <i>E. SUMITANI and Y. KOGA</i> ..	388
6.	<b>Surface Technology</b>	
6.1	Progress in Coated Steel Products for Recent Ten Years/ <i>R. HANEDA</i> .....	394
6.2	<b>Progress in Production Technology of Coated Steel Sheets</b>	
6.2.1	Hot-dip Coating/ <i>H. NAKAMURA</i> .....	397
6.2.2	Electroplating and Coating/ <i>M. ABE</i> .....	399
6.2.3	Dry Coating/ <i>M. SAITO</i> .....	400
6.3	<b>New Coated Steel Products</b>	
6.3.1	Coating Steel Sheets for Automotive Use/ <i>N. MORITO and M. SAGIYAMA</i> .....	401
6.3.2	Coated Steel Sheets for Appliance and Building Materials/ <i>T. SHIOTA and H. FUKUMOTO</i> .....	405
6.3.3	Steel Can Materials/ <i>N. SHIMIZU</i> .....	408
6.3.4	Coated and Laminated Steel/ <i>Y. KAYAZONO</i> .....	411
6.4	<b>Progress in a Technology of Using Coated Steel</b>	
6.4.1	Press-forming Technology of Coated Steel Sheet for Automobile/ <i>C. KATO</i> .....	412
6.4.2	Joining Technology of Steel Sheets for Automobile Use/ <i>T. TAKA</i> .....	414
6.4.3	Heavy Duty Coatings on Steel Structures/ <i>T. KURISU</i> .....	416
6.5	<b>Basic Research on Coated Steel</b>	
6.5.1	Recent Study on the Mechanism of the Electrodeposition of Zinc Alloys/ <i>T. AKIYAMA and H. FUKUSHIMA</i> .....	417
6.5.2	Reaction Mechanisms at the Interface between Liquid Zinc and Iron Substrate/ <i>J. INAGAKI</i> .....	419
6.5.3	Corrosion Mechanism and Estimation Methods for Precoated Steel Sheets/ <i>K. HAYASHI</i> .....	420

6.5.4	New Surface Characterization Techniques/ <i>T. NAKAYAMA</i> .....	422
6.6	Future Prospects/ <i>M. NAKAZAWA</i> .....	423
7.	<b>Analytical Science</b>	
7.1	Progress of Analytical Technologies in Recent Ten Years/ <i>M. SAEKI</i> .....	424
7.2	Contribution of Analytical Techniques for the Development of Materials/ <i>K. HIROKAWA</i> .....	426
7.2.1	Ultra Trace Analytical Techniques for the Development of Clear Steels/ <i>K. HIROKAWA</i> .....	427
7.2.2	Development of Dynamic Methods for Observations of Secondary Recrystalliza- tion Process of Electrical Steels Using Synchrotron Radiation/ <i>K. KAWASAKI</i> and <i>H. IWASAKI</i> .....	428
7.2.3	Standardization of Surface Analysis/ <i>N. GENNAI</i> .....	430
7.2.4	Application of Nano-scale Analysis to Materials Development/ <i>S. HINOTANI</i> .....	431
7.3	Contribution of Analytical Techniques for Process Control in Steel Industry/ <i>A. ONO</i> .....	432
7.3.1	Fully Automatic Analysis System for Process Control of Steel Making/ <i>Y. OHNO</i> .....	433
7.3.2	Development of Direct Analysis Methods for Molten Steel/ <i>A. ONO</i> .....	434
7.3.3	Practical Application of On-line Analysis to Electroplated Steel Sheets/ <i>A. YAMAMOTO</i> .....	435
7.4	Future Prospects/ <i>H. IWATA</i> .....	436
8.	<b>Steel Products</b>	
8.1	Circumstance Change and Related Steel Products/ <i>Y. OHTANI</i> .....	438
8.2	Progress of Science and Technology Required for Development of Steel Products	
8.2.1	Fundamental Theory/ <i>Y. NISHIZAWA</i> .....	442
8.2.2	Materials Basic Technology/ <i>Y. INOUE</i> .....	445
8.2.3	Processing Technology of Steel Products/ <i>K. OHSAWA</i> .....	449
8.3	Progress of Steel Products in Various Fields of Demands	
8.3.1	Steel Products for Automobiles/ <i>T. INOUE</i> .....	454
8.3.2	Steel Products for Architectural Construction/ <i>K. OKAMOTO</i> .....	459
8.3.3	Steel Products for Affluent Life/ <i>K. YAMATO</i> .....	464
8.3.4	Steel Products for Ship and Offshore Structures/ <i>M. KURIHARA</i> .....	467
8.3.5	Steel Products for Energy Utilization/ <i>T. KUDO</i> .....	469
8.3.6	New Trends for Steel Products/ <i>T. TAKEMOTO</i> .....	471
8.4	Prospects	
8.4.1	New Aspects of Microstructure Control in Steels/ <i>T. MAKI</i> .....	473
8.4.2	Ultra High Temperature Materials/ <i>R. TANAKA</i> .....	475
8.4.3	Prospects of Surface Treatment Technology in the 21st Century/ <i>T. MURATA</i> .....	477
8.4.4	Overview on the Research and Development Concerning the Microstructures and the Strength of Steels/ <i>Y. OHMORI</i> .....	478
8.4.5	Outlook on Process Innovation for Iron and Steel Based Functional Materials/ <i>K. NAKAOKA</i> .....	480
8.4.6	Prospects of Stainless Steels/ <i>T. HOSHINO</i> .....	482
9.	<b>Frontier Field</b>	
9.1	Progress of Frontier Field for the Last Decade/ <i>M. ABE</i> .....	485
9.2	Progress and Future Aspect of New Materials and New Processes	
9.2.1	Titanium and Titanium Alloys/ <i>Y. KAWABE</i> and <i>T. NISHIMURA</i> .....	488
9.2.2	MHD Application in Electromagnetic Metallurgy/ <i>K. TAKATANI</i> and <i>S. ASAI</i> .....	492
9.2.3	Thermal Plasma Processing of Materials/ <i>M. USHIO</i> and <i>K. TAKEDA</i> .....	497
9.2.4	Iron Powder Metallurgy/ <i>R. WATANABE</i> .....	500
9.2.5	Composite Materials/ <i>Y. KAGAWA</i> .....	502
9.2.6	Materials for Automobiles/ <i>H. TAKECHI</i> .....	505
9.3	Future Technologies in the Frontier Fields (Round-table Talk) <i>T. YOSHIDA</i> and <i>H. G. SUZUKI</i> .....	508
<hr/>		
ISIJ Information Network .....		N169