

Fertilizer Industry

**Processes, Pollution Control
and Energy Conservation**

CHEMICAL TECHNOLOGY REVIEW No. 123

POLLUTION TECHNOLOGY REVIEW No. 55

ENERGY TECHNOLOGY REVIEW No. 36

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FERTILIZER INDUSTRY

Processes, Pollution Control and Energy Conservation

Marshall Sittig

NOYES DATA CORPORATION

Park Ridge, New Jersey, U.S.A.

1979

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FERTILIZER INDUSTRY

FOREWORD

The use of fertilizers is probably as old as agriculture itself. Cato (the Censor) recommended conservation of soil fertility to Roman landholders by crop rotation, liming acid soils, adding ground bones, fish meal and saltpeter, as well as bird and cow manure. He even knew about growing legumes which fix atmospheric nitrogen—that is, convert it to usable nitrates.

The fertilizer industry of today is primarily a chemical industry, and fertilizers are produced from chemicals known to be needed and are being made readily available to growing plants. Modern chemical fertilizers always include one or more of the three elements most important in plant nutrition: nitrogen, phosphorus and potassium.

Most nitrogen fertilizers, such as ammonium sulfate, nitrate and phosphate, as well as ammonia itself, come from the atmospheric nitrogen industry. The so-called superphosphates prepared from phosphate rock by treatment with sulfuric and phosphoric acids are more soluble than pure calcium phosphate. Potash is nowadays obtained largely from the enormous deposits found in the Saskatchewan province of Canada.

This review deals with the production and handling of fertilizers giving special consideration to pollution control and energy conservation. It contains carefully excerpted and collated data from diverse and difficult-to-locate sources. The technological information to be found here is based on studies carried out by research teams almost exclusively under the auspices of various governmental agencies. It is possible that certain portions of this book may disagree or conflict with other parts of the book. This is especially true of monetary values and opinions of future potential. We chose to include these different points of view, however, in order to make the book more valuable to the reader.

Cost figures provided are those given in the report cited, the date of which is always given. When the dates of the cost figures themselves are given, we have included them.

Advanced composition and production methods developed by Noyes Data are employed to bring these durably bound books to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, binding and shipping methods are no longer suitable. We have by-passed the delays in the conventional book publishing cycle and provide the user with an effective and convenient means of reviewing up-to-date information in depth.

The large Table of Contents is organized in such a way as to serve as a subject index and provides easy access to the information contained in this book. The sources utilized in the preparation of this book are listed in the bibliography at the end of the volume.

Some of the illustrations in this book may be less clear than could be desired; however, they are reproduced from the best material available to us.

FERTILIZER ADDITIVES AND SOIL CONDITIONERS 1978

by M. William Ranney

Chemical Technology Review No. 116

World-wide governmental and social attention is being focused more and more on the decreasing food supply balance and the obvious need for improving crop yields. The problem is particularly severe in the developing and under-developed countries, as they strive to achieve a semblance of modern industrial and political entities.

It is known that plants require various mineral elements before they can synthesize the organic constituents needed for their growth and development. Major plant nutrients include nitrogen, phosphorus, and potassium. Among the secondary nutrient elements are calcium and sulfur. The minor or trace elements, commonly referred to as micronutrients, include the metals zinc, manganese, copper, iron and magnesium.

The development of a good soil structure by suitable synthetic conditioners with their beneficial effects on drainage, aeration, rooting and nutrient uptake is just as important as the addition of the nutrients themselves.

This book describes close to 200 processes related to the improvement of fertilizer compositions through the use of both minor, but essential, additives and complementary compositions which utilize nutrient values commonly available at low cost, hitherto considered as useless by-products and waste.

A partial and condensed table of contents follows here. Chapter headings and important subtitles are given. Numbers in parentheses indicate the number of processes per topic.

1. GRANULAR PRODUCTS (27)

- Granulation Aids
- Anticaking Additives
- Carriers
- Controlled Release Granules
- Ammonium Nitrate Mixes
- Ureaform + Potassium Phosphate
- Semidigested Lignocellulose
- Nonionic Wetting Agents
- Dust Control Agents

2. LIQUID PRODUCTS (13)

- Corrosion Inhibitors
- Kelp Meal Suspensions
- Alginate Emulsions
- Lignin Sulfonate
- Humic Acid
- Vermiculite Addition to Prevent Reversion

Pressure Impregnation of Perlite

3. MICRONUTRIENT

COMPOSITIONS (63)

- Fe Complexes & Chelates
- Other Fe Compositions
- Zn Compositions with KH_2PO_4
- Mn Salt of Sulfonated Lignin
- $\text{ZnO} + \text{H}_3\text{PO}_4 + \text{Ca}(\text{OH})_2$
- Sulfate Salts & Urea
- Water-Insoluble Micronutrients
- Water-Reactive Granule Coatings
- Metal Phosphate Melts

4. NITRIFICATION AND UREASE INHIBITORS (14)

- Aminotriazoles
- Sulfanilamides
- Pyridinesulfonic Acid

5. SOIL CONDITIONERS + PEAT MOSS (45)

- Polyacrylamide Carrier
- Weathering of Bagasse
- Phosphate Rock & Tree Bark
- Kelp, Molasses & Sugar
- Peat-Nutrient Material
- Moss Peat Cake
- Sphagnum Moss Peat
- Lignite + Peat Soil
- Cow Manure + Peat Moss
- Mulch
- Paper Fibers
- + Wetting Agents
- Synthetic Soils
- Exfoliated Vermiculite
- Spent Sulfite Liquors
- Lignin + Alkanolamines
- Soil Treating Capsule

6. SOIL CONDITIONERS + HUMUS & COMPOST (24)

- Humus Processing
- Humic Acid Bearing Ore
- + $\text{NH}_3 + \text{H}_3\text{PO}_4$
- Calcium Humate
- Peat & Fermentation Slops
- Humic Matter + $\text{HNO}_3 + \text{MgO}$
- Alkylated Humic Acid
- + Silica Compositions for Growing Rice
- Composting Methods
- Single Batch Reactor
- Agitation Techniques
- Aeration Techniques
- Thermophilic Phase Process
- Addition of Blood & Offal

GRANULATED FERTILIZERS 1976

by Robert A. Hendrie

Chemical Technology Review No. 58

During the past 15 years consumption of fertilizers has more than doubled, and mixed fertilizer has become the principal form used by the farmer. Mixed fertilizers contain all three major plant nutrients: nitrogen (N), available phosphate (calculated as P_2O_5), and potassium (expressed as K_2O).

With an increase of these analytical percentages, problems of caking became serious, and the mixed product was difficult to distribute evenly. Granulation, however, lessened or prevented caking in storage and facilitated uniform application of the fertilizer. From a technological viewpoint, therefore, the most significant development was the change to granulation processes.

Granular fertilizers flow readily from a bag or storage bin. In addition they are hard and strong enough to stand mechanical handling in farm equipment.

The desirable slow release of plant nutrients is best accomplished by covering the fertilizer granules with water-resistant or almost impervious coatings which in turn may contain micronutrients. Coated fertilizers with suitable barrier layers slowly release the plant nutrients over a period of several months. This prevents leaching losses early in the growing season and subsequent deficiencies as the crop approaches maturity.

This book describes over 260 processes providing several hundred examples of production methods relating to the technology of granulated fertilizers. As such it constitutes an in-depth review of the many important worldwide process developments in the fertilizer industry. A condensed table of contents follows with numbers of processes in ().

1. PHOSPHATES & SUPERPHOSPHATES (23)

Enriched Superphosphates
Porous Granules
Moving Bed Reactor
Fluid Bed Dryer
Calcined Rock Pellets
Silkophosphate Products
Starch Phosphates

2. AMMONIUM PHOSPHATES (27)

Ammoniation Processes
Restricted Ammoniation of Sludges
Rotating Solid Bed Processes
Use of Leonardite Ore

In Situ Formation
of Magnesium Ammonium Phosphate

3. AMMONIUM NITRATE & SULFATE (14)

Anhydrous Granulation
Using Liquid Ammonia
Lignosulfonate Binder
Plus Urea Coating
In Situ Formation
of Small Crystals
Sulfates + Bisulfates + Nitrates

4. UREA PROCESSING (17)

Urea + Sulfur Melts
Urease Inhibitors
Borax and Copper
Prilling with NH_4 -Polyphosphate
Urea + Phosphoric Acid Melts

5. POTASSIUM COMPOUNDS (12)

Extruded Pellets of KCl
Phosphorus + Potassium Fertilizer
Dehydrated Magnesium Salts
Plus Portland Cement

6. CAKING & DUST PREVENTION (48)

Coating Techniques for Fertilizers
Mineral Oil + Ca-Lignosulfonate
Illite Clay Minerals
Urea-Formaldehyde Alkaline Solution
Zinc Chloride Binder For Micronutrients
Montmorillonite + Fatty Amines
Mixtures with Plastic Dust Particles
Compaction plus Granulation
Non-Dusting Limestone Granulation

7. GENERAL GRANULATION TECHNIQUES (18)

Prilling Techniques
Spray from Perforated Centrifuge
Use of Lignocellulose
Potassium Tripolyphosphate Base
Controlled Particle Feed to Granulator

8. FERTILIZERS FROM WASTES (27)

Compacted Sewage Sludge
Cottonseed Meal + Starch + Sewage
Peat Moss and Waste Latex

9. POLYMERIC & OTHER COATINGS (35)

Wax + Polyolefins
Asphalt + Inert Fillers
Leaching Retardants

10. SLOW RELEASE & OTHERS (38)

Vermiculite Processes
Oil Shale Carrier
Seaweed Treatment
Sticks and Spikes

ENERGY-SAVING TECHNIQUES FOR THE FOOD INDUSTRY 1977

edited by M. E. Casper

Energy Technology Review No. 13
Food Technology Review No. 42

The aim of this book is to promote increased energy efficiency in the food industry as a whole and to define sensible improvement targets.

Detailed findings for 47 named individual food industry segments are presented together with the proposed component goals for the year 1980 and the concomitant energy efficiency improvement potentials.

The methods used in the study are fully described. Detailed descriptions of each component of the food industry, as well as the energy conservation measures are also included. For a selected few categories, information concerning the geographic variances in energy and types of energy used, has been added.

Each particular food industry was analyzed and summarily reported in the following manner:

1. INDUSTRY DESCRIPTION

- Component Definitions
- Industry Structure
- Energy Use Patterns
- Energy Conservation
- Achievements & Programs

2. GENERAL METHODOLOGY

- Energy Type Profile
- Energy Use Profile
- Energy Conservation Profile
- Intermediate Improvement Coefficients
- Technological Feasibility
- Economic Practicability
- Other Considerations
- Projection of Charges & Prices

3. ENERGY EFFICIENCY IMPROVEMENTS

- Boilers—Furnaces
- Waste Energy Recovery
- Insulation
- Lighting
- Motors etc.
- Evaporators etc.
- Alternative Operating Procedures

4. CONVERSION FROM SCARCE ENERGY FORMS

- Energy Source Shifts
- Target Setting Implications

5. SPECIAL CIRCUMSTANCES

- Special Industry Considerations
- Target Setting Implications

6. TARGET DEFINITION

- Introduction to Individual Industries

Analytical Framework & Assumptions
Target & Component Goals

7. INDIVIDUAL FOOD INDUSTRIES

- Wet Corn Milling
- Meat Packing Plants
- Malt Beverages
- Canned Fruits & Vegetables
- Fluid Milk
- Bread, Cake etc.
- Soybean Oil Mills
- Cane Sugar
- Frozen Fruits & Vegetables
- Prepared Feeds
- Shortenings & Cooking Oils
- Prepared Foods
- Animal & Marine Fats
- Cheese
- Condensed Milk
- Canned Specialties
- Soft Drinks
- Poultry Dressing Plants
- Distilled Liquor
- Sausage & Prepared Meats
- Pet Food
- Raw Cane Sugar
- Confectionery Products
- Frozen Specialties
- Flour, Other Milled Grains
- Dehydrated Food Products
- Cookies and Crackers
- Roasted Coffee
- Malt
- Cereal Preparations
- Cottonseed Oil Mills
- Pickles, Dressings, Sauces
- Ice Cream, Frozen Desserts
- Creamery Butter
- Chocolated & Cocoa Products
- Flavor Extracts & Syrups
- Poultry & Egg Processing
- Canned & Cured Seafood
- Wines and Brandy
- Packaged Fish
- Vegetable Oil Mills
- Rice Milling
- Manufactured Ice
- Macaroni & Spaghetti
- Blended Flour
- Chewing Gum

APPENDIXES

- Geographic Variances in Energy and Types of Energy Used by Various Food Industries
- Energy Conversion Factors
- Btu Conversion
- Glossary of Industrial Terms

EUROPEAN TECHNOLOGY FOR OBTAINING ENERGY FROM SOLID WASTE 1978

Edited by D.J. De Renzo

Energy Technology Review No. 34

Pollution Technology Review No. 54

The recovery of energy through the combustion of municipal solid waste is by now a well recognized and established technique for conserving energy. Combustion units can produce electricity, hot water for domestic use and steam for district heating and for industrial processes or for the drying of sewage sludge.

Western Europe is definitely the leader in this field. Energy recovery from waste began, in a small way, in France, Denmark, and Italy before the second world war. During the 1950s it was introduced on a large scale in West Germany, France and Holland. The largest single furnace is located in Paris-Ivry and has a capacity of 50 metric tons/hr, while the largest European plant near Rotterdam has 6 units of 20 metric tons/hr.

Much can be learned from these European waste-to-energy systems. For each country a national overview is given, followed by a description of particularly significant developments and case histories: Household sorting and collection methods, combustors, furnaces, incinerators, air pollution control, latest plant designs, operation and economics.

A summary of key findings is also included. Serious study of this book should make it possible to reveal and identify solid waste/energy processes (both existing and under development) that appear to offer potential advantages over processes currently employed in the U.S. Maps and a tabulation of the European systems are included. This book is based on several studies produced under contract for EPA and ERDA (now DOE). A summarized table of contents follows here:

1. SYSTEMS DEVELOPMENT

- Belgium
- Denmark
- England
- France
- Italy
- Luxembourg
- Netherlands
- Spain
- Sweden
- Switzerland
- West Germany
- Source Contacts

2. TOULOUSE—CASE STUDY

Economic & Demographic Data

Waste Collection & Pretreatments
The Incinerator
Pollution Control

3. GENEVA—CASE STUDY

Collection & Disposal
Level of Automation
Recovered Energy
The Market for Electricity
Original Cost & Amortization
Plans for the Future

4. KORSOR—DENMARK

The Incinerator
Heat Recovery Equipment
Steam Efficiency
System Reliability
Costs: Capital, Operating, Overall

5. MUNICH—CASE STUDY

Political Structure of
Solid Waste Collections
Basic Systems (4 Stations)
Level of Automation
System Design Redundancy
System Performance History
Energy Balance Calculations
Maintenance & Modifications
Repairs
Recovered Energy & Materials
Markets for Recovered Energy
and Scrap Metals
Environmental Control Systems
Management & Plans for the Future

6. BRIVE—FRANCE

Development of Current System
Heat Recovery and
Drying of Sewage Sludge
Gas & Solid Emissions Control

7. OVERVIEW

System Configurations
Technical Problems
Economics
Census of West Europe
Combustion Units
Rated Capacities
Starting Dates
Maps and Locations
Energy Recovery
Throughout West Europe
Other Techniques of
Resources Recovery
Used in Europe

ENERGY FROM BIOCONVERSION OF WASTE MATERIALS 1977

by Dorothy J. De Renzo

Energy Technology Review No. 11
Pollution Technology Review No. 33

One of the chief gaseous products of the anaerobic decomposition of organic matter is methane, CH_4 . This is how natural gas was formed in prehistoric times along with other fossil fuels.

By applying this principle today in environmentally acceptable fashion it is possible to bioconvert municipal solid sewage, animal manure, agricultural and other organic wastes into substitute natural gas (95% CH_4). In its simplest essentials the process consists of loading the material into a digester (a closed tank with a gas outlet). Given favorable thermal and chemical conditions, the appropriate biological processes will then take their course.

The bioconversion of waste materials to methane provides at least partial solutions not only to the energy problem, but also to the solid waste disposal problem. The harvesting of heretofore undesirable vegetations, such as algae, water hyacinths, and kelp as "energy crops" offers unconventional opportunities for supplementary utilization of natural resources.

This book describes practical methods for the bioconversion of waste matter. It is based on reports of academic and industrial research teams working under government contracts. A partial and condensed table of contents follows here. Chapter headings and important subtitles are given.

1. SOURCES OF WASTE MATERIALS

- Suitability & Characteristics
- Quantities & Availability
- Agricultural Crop Residues
- Forests
- Urban Wastes
- Rural Wastes
- Strictly Animal Wastes
- Industrial Wastes
- Cost Considerations

2. MECHANISMS & PATHWAYS

- Anaerobic Decomposition Processes
- Terminal Dissimilation of Matter
- Degradation of Cellulose
- Bacteria and Protozoa
- Cellulases & Other Enzymes

- Controlling Factors in
- Methane Fermentations
- Acetate Utilization
- Trace Organics
- Effect of Temperature Changes

3. SOLID WASTE & SEWAGE SLUDGE

- U. of Illinois Studies
- Pfeffer-Dynatech Anaerobic
- Digestion System
- Supporting Studies
- Addition of Coal to Sludge
- Synergistic Methane Production

4. METHANATION OF URBAN TRASH

- Digester Feed Preparation
- Digester Design
- Gas Production
- Gas Scrubbing Technology
- Desirable Gas Characteristics

5. ANIMAL WASTE DIGESTION

- Oregon State U. System
- Animal Waste Management
- Berkeley Conversion Studies
- Digestion for Disposal
- Digestion plus Photosynthesis
- Dept. of Agriculture Study
- Other Studies on Animal Waste Digesters
- Useable for Energy Purposes

6. INDUSTRIAL WASTES UTILIZATION

- Petrochemical Wastewaters
- Distillery Slops Digestion
- Rum Distillery Slops
- Process Flow Sheets
- Design Criteria
- Economic Analysis
- Use of Biogas in the Sugar Industry
- Winery Waste Treatment

7. METHANE FROM ENERGY CROPS

- Integrated Conversion Systems
- Digestion of Algae
- University Studies
- Single Stage vs. Two Stages
- Mariculture Investigations
- Conclusions and Drawbacks
- Storage Difficulties

Note: Each chapter is followed by bibliographic reference lists in order to provide the reader with easy access to further information on these timely topics.

ISBN 0-8155-0656-2

223 pages

UNIT OPERATIONS FOR TREATMENT OF HAZARDOUS INDUSTRIAL WASTES 1978

Edited by D. J. De Renzo

Pollution Technology Review No. 47

This book describes ways of combating pollution from hazardous waste materials through the use of basic unit operations common to chemical engineering processes. These unit operations are either physical, such as neutralization and precipitation, or biological, e.g. treatment with suitable enzymes.

There exists an urgent and immediate need for treatment processes which can detoxify, destroy or apply recovery principles to industrial wastes. This study examines over 40 unit engineering processes for their applicability to treating hazardous wastes.

For each potentially applicable method there are given, in depth, the:

Technical characteristics

Underlying physical, chemical, or biological principles

Operating characteristics

- Physical and chemical properties of suitable feed streams
- Mode of operation
- Physical and chemical properties of the output streams

Operating experience

- Principal current applications
- Potential applications to hazardous wastes

Capital and operating costs

Environmental impacts

Energy requirements

Outlook & development needs

A condensed table of contents follows here:

I. BACKGROUND

II. SCOPE OF THE STUDY

Objectives

Approach

III. TREATMENT PROCESSES

INVESTIGATED

Phase Separation

Component Separation

Chemical Transformation

Biological Treatment

IV. PROCESSES FOR WASTE STREAMS

Philosophy of Approach

Background Questions for

Treatment Selection

Examples of Process Selection

V. WASTE TREATMENT SUMMARIES

TREATMENT TECHNIQUES

1. ADSORPTION, CARBON

2. ADSORPTION, RESIN

3. BIOLOGICAL TREATMENT: OVERVIEW

4. ACTIVATED SLUDGE

5. AERATED LAGOON

6. ANAEROBIC DIGESTION

7. COMPOSTING

8. ENZYME TREATMENT

9. TRICKLING FILTER

10. WASTE STABILIZATION

11. CALCINATION

12. CATALYSIS

13. CENTRIFUGATION

14. CHLORINOLYSIS

15. DIALYSIS (not applicable)

16. DISSOLUTION

17. DISTILLATION

18. ELECTRODIALYSIS

19. ELECTROLYSIS

20. ELECTROPHORESIS (not applicable)

21. EVAPORATION

22. FILTRATION

23. FLOCCULATION, PRECIPITATION & SEDIMENTATION

24. FLOTATION

25. FREEZE-CRYSTALLIZATION

26. FREEZE-DRYING (not applicable)

27. FREEZING, SUSPENSION

28. HIGH-GRADIENT MAGNETIC SEPARATION (HGMS)

29. HYDROLYSIS

30. ION EXCHANGE

31. LIQUID ION EXCHANGE

32. LIQUID-LIQUID EXTRACTION OF ORGANICS

33. MICROWAVE DISCHARGE

34. NEUTRALIZATION

35. OXIDATION, CHEMICAL

36. OZONATION

37. PHOTOLYSIS

38. REDUCTION, CHEMICAL

39. REVERSE OSMOSIS

40. STEAM DISTILLATION

41. STRIPPING, AIR

42. STRIPPING, STEAM

43. ULTRAFILTRATION

44. ZONE REFINING (not applicable)

In order to make all of the information readily available and useful, the section on TREATMENT TECHNIQUES is preceded by a series of reference tables to be used when screening processes for application to an individual waste stream. These tables are so organized as to provide a method for screening out processes that do not have any potential for the waste in question.

PRACTICAL TECHNIQUES FOR SAVING ENERGY IN THE CHEMICAL, PETROLEUM AND METALS INDUSTRIES 1977

by Marshall Sittig

Energy Technology Review No. 12
Chemical Technology Review No. 90

The above-captioned industries were selected for coverage in this book because they are the three largest consumers of energy in the U.S. economy. They constitute an interacting group: they use many common raw materials and are simultaneously feeding products and by-products to one another.

Practical thinking about industrial energy conservation requires interceptive calculations of such material transfers to produce positive energy savings.

The major conservation approaches are arranged as follows:

1. Waste Utilization
2. Process Integration
3. Process Modification
4. Design Modification
5. Maintenance and Insulation
6. Market Modification

The three major industries are subdivided into 39 individual processing industries. The following discussions and proposals are presented for practically every processing industry:

1. Process Technology Involved
2. Major Energy Conservation Options to 1980
3. Goal Year (1980) Energy Use Targets
4. Some Projections beyond 1980 to 1990

INDIVIDUAL PROCESSING INDUSTRIES

Introduction & Analytical Procedures
Metals Industry—General
Steel Industry
Aluminum Industry
Iron Foundries
Copper Industry
Ferroalloys
Non-Ferrous Foundries
Steel Foundries
Other Primary Non-Ferrous Metals
Non-Ferrous Processing Industry
Miscellaneous Metal Products
Secondary Non-Ferrous Smelting
and Refining Industry

Primary Zinc Industry
Primary Lead Industry
Chemical and Allied Products
Alkalis and Chlorine
Industrial Gases
Inorganic Pigments
Other Industrial Inorganic Chemicals
Plastic Materials Industry
Synthetic Rubber Industry
Rayon and Cellulose Acetate Industry
Synthetic Fibers Industry
Drug Industry
Soaps, Detergents, & Toiletries
Paint Industries
Gums and Wood Chemicals
Coal Tar Chemicals, Dyes & Pigments
Aliphatic Organic Chemicals
Nitrogen Fertilizer Industry
Phosphate Fertilizer Industry
Fertilizer Mixing Industry
Agricultural Chemicals
Adhesives and Sealants
Explosives and Allied Industries
Printing Inks
Carbon Black
Fatty Acids & Allied Industries
Petroleum & Coal Products

As can be seen from this large and impressive table of contents, entries have been arranged in an encyclopedic manner whenever possible.

To be found at the end of the book is a complete and detailed list of reports and references cited throughout the work. In this list titles are complete with their publishers and other sources of procurement and are never abbreviated.

Under the Energy and Conservation Act, the U.S. Federal Energy Administration was required to set energy conservation targets for the most energy-intensive manufacturing industries. Goals to be attained by Jan. 1, 1980 were established by the end of 1976. Major contributions to the manuscript are acknowledged from the energy target documents, particularly from those on the chemical, petroleum, and metals industries.

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