CHEMICAL ENGINEERING IN A CHANGING WORLD

edited by

WICHER T. KOETSIER

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Proceedings of the Plenary Sessions of the
First World Congress on Chemical Engineering,
Amsterdam, June 28 – July 1, 1976

edited by

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ELSEVIER SCIENTIFIC PUBLISHING COMPANY

Amsterdam – Oxford – New York 1976

ELSEVIER SCIENTIFIC PUBLISHING COMPANY
335 Jan van Galenstraat
P.O. Box 211, Amsterdam, The Netherlands

Distributors for the United States and Canada:

ELSEVIER/NORTH-HOLLAND INC.
52, Vanderbilt Avenue
New York, N.Y. 10017

Library of Congress Cataloging in Publication Data

World Congress on Chemical Engineering, 1st, Amsterdam, 1976.
Chemical engineering in a changing world.

1. Chemical engineering--Congresses. I. Koetsier, Wicher T. II. European Federation of Chemical Engineering. III. Interamerican Confederation of Chemical Engineering. IV. Title.
TP5.W55 1976 660.2 76-54357
ISBN 0-444-41543-2

Printed in The Netherlands

FOREWORD

The World Congress on Chemical Engineering "Chemical Engineering in a Changing World" has been sponsored as its 165th event by the European Federation of Chemical Engineering (EFChE) in conjunction with the Interamerican Confederation of Chemical Engineering (ICChE) and with the participation of other scientific societies throughout the world.

This Congress has been organized under the auspices of "De Koninklijke Nederlandse Chemische Vereniging (KNCV)" and "Het Koninklijk Instituut van Ingenieurs (KIVI)".

The initiative to this Congress was taken jointly at the regular meetings of the Liaison Committee of the ICChE and the EFChE. The first actions taken, date back to the years 1969 - 1971. In 1971 the EFChE accepted the formal responsibility for organising the Congress and its Executive Committee decided to hold it in the Netherlands. This Executive Committee delegated the initiatives, the organisation and the financing to the Dutch member societies KNCV and KIVI. Thereafter a Congress Committee was installed with the following members:

Dr.Ir. K.R. Westerterp, the Netherlands, CHAIRMAN *
Prof.Dr.Ir. W.P.M. van Swaaij, the Netherlands, SECRETARY *
Dr.Ir. W.T. Koetsier, the Netherlands, SECRETARY * and **
Dr.Ir. T. Reith, the Netherlands, TREASURER *

Dr. A. Badakhshan, Iran
Prof.Dr. E. Bartholomé, Fed.Rep.Germany
Dr.Ir. W.J. Beek, the Netherlands **
Prof.Dr. D. Behrens, Fed.Rep.Germany
Dr. S.D. Bhasin, India
Prof.Dr. W. Brötz, Fed.Rep.Germany
Prof.Dr.Ir. S. Bruin, the Netherlands
Prof.Dr. H. Brusset, France
Dipl.-Ing. M.G.J. Desensy, the Netherlands
Dr. W.J. Murray Douglas, Canada
Dr.Ir. A.A.H. Drinkenburg, the Netherlands **
Mr. G.A. Dummett, United Kingdom
Dr.Ir. J.M.H. Fortuin, the Netherlands **
Prof.Dr. A. Gianetto, Italy
Prof.Dr. D. Glasser, South Africa
Ir. J.H. de Groot, the Netherlands *
Dr. C.M. Hackenberg, Brazil
Prof.Dr. H. Inoue, Japan
Prof.Dr.Ir. R. Jottrand, Belgium
Ing. M.Kamenetzky, Argentina
Ir. J. Ligthart, the Netherlands
Dr. G. Lindner, Sweden
Dr. V. Márquez, Mexico †
Dr. J. Munnik, the Netherlands
Ing. Manuel Pulido M., Venezuela
Mr. G. Scoullar, Australia
Dr. F.J. Van Antwerpen, U.S.A.

Dr. T. Weaver, U.S.A.
Prof.Dr. J. Wei, U.S.A.
Prof.Dr. F. Widmer, Switzerland
Prof.Dr. N.M. Zharovonkov , U.S.S.R.

* = member of the Executive Committee
** = member of the Scientific Committee.

The Scientific Program of the Congress has been organized under the responsibility of the Scientific Committee with the aid of Working Parties of the EFChE. In the preparation of some sessions the Scientific Committee received the personal support of Prof. F.J. Zuiderweg (session A2), Prof.Dr.Ir. H.A. Leniger (session A3) and Prof.Dr. A.D. Randolph (session B7).

The Scientific Program consisted of two parts:

A. A series of main sessions of general interest covering the following themes:
A.1 New advances in chemical engineering;
A.2 Co-operative research in chemical engineering;
A.3 Food process engineering (under the responsibility of the Food Working Group of the EFChE);
A.4 Energy and raw material resources;
A.5 Environment and human activities?
A.6 Education in science and technology;
A.7 Frontiers of chemical engineering.

B. A series of specialist sessions, mainly organized by the corresponding Working Parties of the EFChE, covering the following themes:
B.1 Routine programs and use of electronic computers in chemical engineering;
B.2 Information and documentation;
B.3 Loss prevention;
B.4 Particle technology (organized by the Working Parties: (a) Comminution, Agglomeration and Classification, and (b) Mechanics of particulate solids);
B.5 Non-Newtonian liquid processing;
B.6 Crystallization;
B.7 Distillation, absorption and extraction.

The Proceedings of this first World Congress on Chemical Engineering comprise:

- WELCOME ADDRESS by Dr.Ir. K.R. Westerterp, Chairman of the Congress Committee;
- OPENING ADDRESS of His Royal Highness the Prince of the Netherlands;
- REPLY TO HIS ROYAL HIGHNESS by Dr.Ir. W.J. Beek, Chairman of the Scientific Committee;
- The papers of the seven A-sessions together with the summaries of the panel discussions of the sessions A2, A4, A5 and A6;
- The program of the seven B-sessions for specialists together with the names and addresses of the authors;
- CLOSING ADDRESS by Prof.Dr. E. Bartholomé.

The Congress Committee expresses its sincere appreciation:

- to His Royal Highness the Prince of the Netherlands for delivering his Opening Address;
- to all the authors of the A- and B-sessions for the presentation of their paper(s); especially to the authors of the A-sessions for the preparation of their manuscripts on the Camera Ready Copy sheets enabling us to prevent a costly and time consuming preparation of the Proceedings;
- to all the chairmen and secretaries of the A- and B-sessions;
- to all the Working Parties of the EFChE with whose aid a large part of the program has been organized;
- to Prof.Dr. E. Bartholomé for reading the Closing Address;
- to Prof.Dr. D. Behrens, DECHEMA, Prof.Dr. E. Bartholomé, BASF, Dr. F.J. Van Antwerpen, AIChE, Prof.Dr. James Wei, University of Delaware and Dr. T. Weaver, Fluor Corporation for their excellent and successful cooperation during the organization of this World Congress;
- to the State Secretary of Education and Sciences, Dr. G. Klein, and the Burgomaster and Alderman of Amsterdam for receiving all participants at the Rijksmuseum;
- to Mrs. C.E. Huisken and her staff of the Municipal Congress Bureau for their accurate help during the organisation and the days of the Congress;
- to all the participants for their contributions.

In the name of the Congress Committee:

Wicher T. Koetsier

Editorial Secretary

The Netherlands, 10th September 1976.

OPENING OF THE CONGRESS

WELCOME ADDRESS

by K.R. Westerterp, Chairman of the Congress Committee

Your Royal Highness,
Your Excellency Cabinet Minister of Sciences Policy
Your Excellency State Secretary of Education and Sciences
Mr. Deputy of the Cabinet Minister of Economic Affairs
Mr. Deputy Burgomaster of the City of Amsterdam
Messrs. Presidents of the Interamerican Confederation of Chemical Engineering and of the Asian Pacific Confederation of Chemical Engineering
Messrs. Representatives of the Dechema
Messrs. Presidents of the Royal Institute of Engineers, of the Royal Chemical Society of the Netherlands and of the Federation of the Dutch Chemical Industries.

Ladies and Gentlemen,

I have great pleasure in welcoming you at this world congress on chemical engineering. In 1970 , in one of the regular meetings between representatives of the Interamerican Confederation of Chemical Engineering and of the European Federation of Chemical Engineering, the initiative was taken to organize jointly this congress. In 1971 the Dutch member societies of the European Federation were asked to organize the congress with the participation of other chemical engineering societies in other parts of the world. As a first step Dr. Beek wrote to about two hundred leading chemical engineers around the world and invited them to express their opinion on the most important tasks, with which chemical engineering would be confronted in the coming decades.

From the very large response the final programme and also then the title of "Chemical Engineering in a Changing World" were

born. Speakers from around the world were invited to express their views on the subjects of major concern to all of us and seven general themes were selected for our chemical engineering profession being:

- new advances in our science
- international cooperation in research
- food production and processing
- energy and raw material resources
- environment and human activities
- education in science and technology
- the frontiers of our science

We are most happy that so many outstanding chemical engineers have accepted our invitations to present papers on a given subject. We hope that the panel discussions will be able to develop guidelines and policies for future action in these areas of importance.

The Working Parties of the European Federation of Chemical Engineering have undertaken to organize a large number of specialist sessions. Most Working Parties are active for already a large number of years. Some are recently founded and hold this week one of their first public manifestations; the Working Party on Information and Documentation and the Working Party on Loss Prevention.
We are most happy with all the preparatory work the Working Parties have done and highly appreciate their contribution to our congress.

You have come in the large number of more than 600 chemical engineers - around 200 from outside Europe - and it is with great pleasure that we welcome you here in Amsterdam to the first World Congress for Chemical Engineers.
We hope that a good communication will arise between all of us and we hope that a real exchange and mutual understanding for the different aspects of our discipline in the various parts of the world will develop, through the individual contributions of every one of you in the discussions inside and outside the congress premises.

We have received strong support of our Federations, but I specially like to mention the support of the Dechema, the German Association for Chemical Apparatus, who wholeheartedly collaborated with us in coordinating their Exhibition in Frankfurt with our World Congress.

In the last year of our preparations we have received great interest and strong support of His Royal Highness the Prince of the Netherlands.
Your Royal Highness, you always have been very considered about the future development of the world, of industry and trade and of the flora and the fauna on our earth. You have dedicated a large part of your efforts to call the attention of humanity both to its challenges and to the destructive trends in our society towards our environment and towards the nature , that surrounds us. The same is of concern to responsible chemical engineers and chemical industries. You know, how much your efforts in this area are appreciated by us. It is therefore that we feel sincerely honoured that you will perform the opening ceremony of this first World Congress on Chemical Engineering. And therefore I as chairman of the Congress Committee with great respect now invite Your Royal Highness to deliver your address to us, chemical engineers, and to open our congress.

OPENING ADDRESS

of His Royal Highness the Prince of the Netherlands

For a pessimist our era is full of problems for which solutions fail to come. For him we are in a difficult period of transition, where we have to give up thinking in terms of growth.

For an optimist our era is full of challenge, possibly more than ever before. When he reflects on our problems he sees unknown opportunities, be it that these opportunities probably are not unlimited anymore.

Reality in my opinion will lie somewhere in between the optimistic and the pessimistic view-point. This means that research and development work, engineering sciences and entrepreneurship shall have to continue to play their stimulating and innovating role as before. Especially developing countries must take this into account, but also the future of the industrialized countries will depend on it.

One of the difficulties of our time is that for some reason the knowledge of an expert is mistrusted as much as the large organizations in which he works. It will be clear to everybody however, that we are confronted with a number of problems of a very complicated nature, which even with excellent know-how and with the help of large, well functioning organizations, are very difficult to solve. I will name some of them: the development of new fuels and their economical use; the research for the replacement of scarce raw materials and minerals like copper, including the recycling and reuse of waste materials; the introduction of new transport systems for a society which so much depends on the mobility of people and

goods; the development of an improved system of health care with regard to the illnesses which endanger the people of our world today, curative, but, even better, preventive.

The distrust towards the expert and his organization leads to a fear of the concentrated, large scale effort to cope with these problems. The alternative is considered to be an adaption of the mentality, together with a small scale approach.

Perhaps our course should turn in that direction, but that will occur slowly. Social change can not be dictated. This takes time. Too much time for some of our worries. One should not forget that the majority of the world population eagerly awaits the advantages and blessings that technological advancement could bring to their society. With hunger, illness, under-nourishment and poverty at their doorstep, it would be a crime not to use every bit of knowledge that can improve their situation.

This has all been said before, but we live in a period in which fundamental truth can not be repeated often enough. One fundamental truth is that we dare not curse knowledge because knowledge gives power. This would be a mediaeval attitude whereby one cursed one's tools because of their sharpness.

The negation of the possibility of obtaining through research the required know-how for the solution of our problems - which is being considered by many as modern and progressive - is in fact the same phenomenon. The essence of our scientific heritage is thereby denied. And this heritage teaches us that people can develop the ability to solve their own problems independently.

Development cooperation should have this as its ultimate aim. Assistance in the founding of schools and universities and contracts for the transfer of know-how are very good at this stage of our development. But ultimately the most important goal is that everybody shares in our heritage of directed

thinking and researching, so that everybody can look for and obtain the specific knowledge that his own society needs for solving its own problems.

This should be the main theme when fellow professionals of the whole world meet and I am pleased to see that your congress-committee has not avoided this theme.

After I have tried to explain to you why we, together and every society by itself, should put our faith in science - be it not a blind faith - I come to the next consideration concerning the management of our scientific efforts. Has our society a structure that is adequate to bring about the desired change? Is the achieved progress the result of individual actions or of a long-term planning programme of a governing body?

I already mentioned that different societies will attach different importance to similar problems and will have different priorities for research - and development-work. This corresponds with the essence of the scientific trade, which is: to bring forth ourselves the knowledge to solve our own affairs.

As a general rule, therefore, a research programme will be the more colourless and without inspiration, the more its conception and approval is centralized. On the other hand, a programme which is no more than the addition of the wishes of individual research workers, sometimes becomes so expensive that a community can only afford this in periods of expansive growth.

We have not yet succeeded in finding the right middle course between these poles. An important question, which we have to answer in the near future, is: in what way can a wise, central governing body leave the execution of the research work to scientists who are willing and prepared to spend the public money put at their disposition responsibly and efficiently?

And by the way, where exactly is this central governing body? History has left us with many restrictions. In every nation a pattern or a design of social coherence can still be recognized. However, in the scope of our actual problems which at least are of a multinational nature, if not of world size, such a design or pattern is still lacking. Our social institutions tend to foster provincialism, because they derive their power from their provincial influence. Our international managing institutions regretfully are weak.

This definitely has to be changed. But until this change has been achieved, we will need other social forces in our community which are able to realize a cooperation beyond our frontiers.

The only globally uniting force which has been able to achieve this, is the old-established, often despised power of international trade and industry. It would appear that international industries are in a better position than governments, which run only uninational activities, to use know-how completely and well directed and to effectually develop international management skills.

This, of course, does not mean that we must not continue to look for control and balance in international trade and cooperation. In some areas the worries about our environment are very much a reality. Fauna and flora have to be protected almost everywhere, especially because they have too often been brought near catastrophe. A more righteous, global distribution of income per capita is a genuine desire as well as the desire to guarantee to every individual the right to gratifying meaningful work.

But if the striving for a better balance in the international distribution should lead to a bureaucracy that kills the spontaneity then the source itself of scientific inspiration and of an entrepreneurship which is prepared to take risks would dry up: if this aim would lead to a dictated levelling-off with its fixed securities for everybody, then the desire

to distinguish oneself would disappear and the need to produce the knowledge that can be used for the community and for one's own benefit as well.

For the entrepreneurship, therefore, the same law is valid as we have found for the practice of science: without a certain minimum of freedom the striving for more than average achievement stops.

I am glad to see that human activities and education are also on your programme. Because in the end it is the individual, with his ripened experience, his managerial abilities and his motivation, who will determine the road which nations, and consequently the whole world, will follow. Social possibilities and restrictions probably are more conclusive than the technological ones. Having a conviction is probably as important as being well educated and trained. Convincing a group of people is one of the most challenging and most difficult tasks for a community of scientifically trained persons. If in the coming days you dedicate yourself to this purpose, you will prepare yourself for a very good job of work in the future, and I can, at this moment, do nothing more for you than wish you every possible success.

And with this wish I declare this congress, "Chemical Engineering in a Changing World", open.

REPLY TO HIS ROYAL HIGHNESS

by W.J. Beek, Chairman of the Scientific Committee

Your Royal Highness,

I would like to thank you on behalf of the Congress for your opening words, which so clearly introduced the theme of our symposium.

Science and technology are part of our cultural inheritance. As such they are subject to the paradoxes which one finds in every mix of cultural activities.

To name a few. Do we rely on individual action or on central social planning? Could genuine intellectual power be developed with the masses of people or is it too much dependent on heredity and the individual social environment? Do we look upon education as a means to foster creativity in individuals and in small groups or as a tool for merely training people? Is scientific language, its reporting and its retrieval systems, a conditioned reflex or a vehicle for genuine thinking? And: do we work to liberate ourselves from work or to free ourselves through work?

All these are real paradoxes. The answer is never the one or the other. They cannot be solved in a scientific way. The value of our culture is not the consensus we can get on these paradoxial questions, for instance by voting, but how we find a way to live in harmony with these paradoxes.

Therefore, I think, ladies and gentlemen, that His Royal Highness stressed so rightly the social implications of the scientific trade. There is no technological possibility

without a social acceptability. Being well trained is a poor talent without having strong convictions. Science without judgement is an oddity, an idiosyncrasy of pedantic people. This is the very reason that your organising committee has centred the programme of the next days around seven main themes of more general interest: food, energy, environment, education, co-operative research, new advances and frontiers in chemical engineering.

Of course, we have to stay modest in this approach. What we have to offer more than our fellow citizens, is some specific knowledge in a specialized field of engineering. Chemical engineering will be the subject of this symposium, not only in the specialist sessions but also in the plenary sessions, although the latter put the problems in a wider context. Today's two sessions will prove that we will not be over-ambitious. Both sessions, new advances and co-operative research in chemical engineering have our profession as a central issue. We are glad that our distinguished colleagues Grassmann, Bird and Weisz have accepted our proposal to review what is new in our area. They will talk respectively on fundamentals, rheology and energy. I propose that we now listen to them and I invite the three gentlemen and the secretary of the first session to join me at this table.