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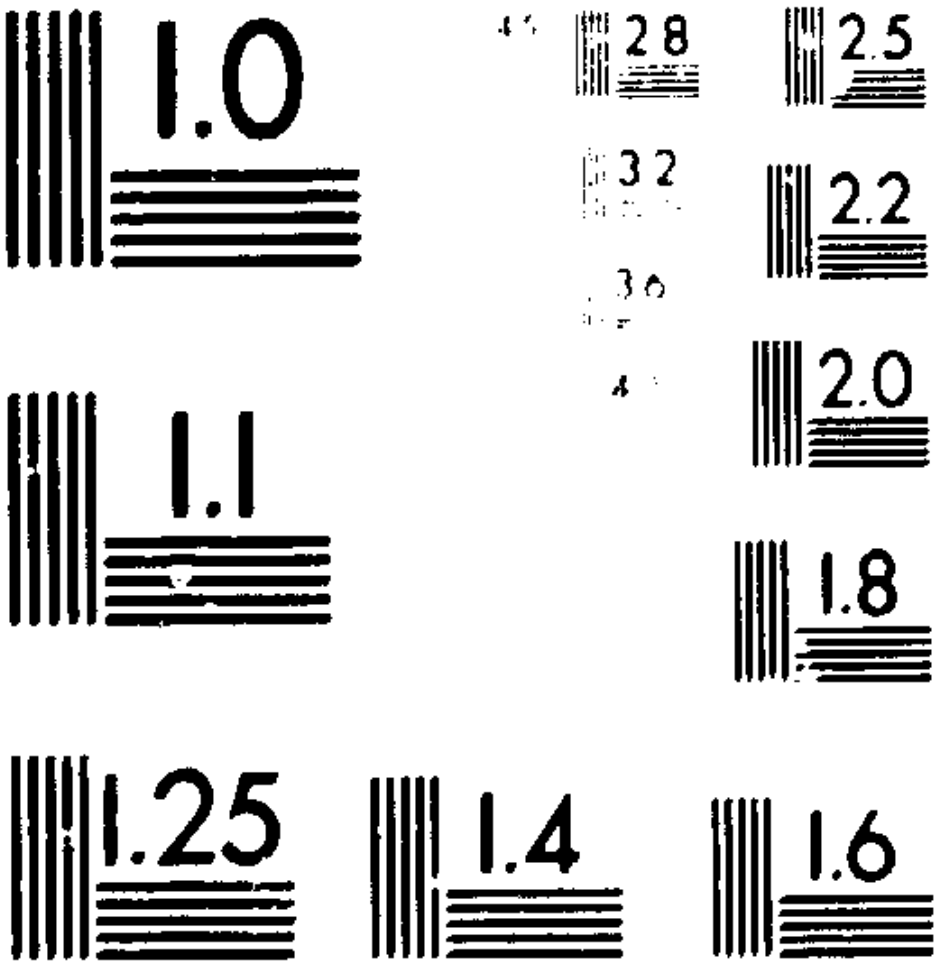

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

DPR Korea.

ASSISTANCE IN THE PRODUCTION AND PROCESSING OF PVC.

A report for the Government of
the Democratic People's Republic of Korea

SI/DRK/83/802

by

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LIST OF ABBREVIATIONS

1. DPRK : Democratic People's Republic of Korea
2. UNDP : United Nations Development Programme
3. UNIDO : United Nations Industrial Development Organization
4. IHMC : Institute of High Molecular Chemistry
5. PVC : Polyvinylchloride
6. LDPE : Low Density Polyethylene
7. MFI : Melt Flow Index
8. SSW : Senior Scientific Worker

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1. SUMMARY

During the mission to the Democratic People's Republic of Korea (IHMC in Hamhung), technical problems were identified in the field of PVC rheological properties using specialized quality control equipment.

A number of lectures in the field of PVC and PVC-compound were conducted, in connection with recent advances in PVC-polymerization, processing and rheology.

Recommendations on further mutual UNIDO-Government activities in the field of PVC and PVC-compound were given. One of the most important recommendations stated was that of expansion of the IHMC activity by establishing a laboratory for rheology of polymers, to provide improvements in both polymerization and processing of PVC.

This new laboratory would be in the position of being able to render technical and advisory services to other laboratories of the IHMC, in particular, for testing and quality control of polymer products, to act as a catalyst thereby promoting close contacts between the industry and the institute and to develop new national plastics standards, etc.

2. INTRODUCTION

The purpose of the mission was to support and strengthen the expansion of PVC industry in the DPRK so that it may make a continuing contribution to the economic development of the country, and, also to provide a range of consumer goods from PVC and PVC-compounds.

The Institute of High Molecular Chemistry was established in 1960 within the Academy of Sciences located in Hamhung. The total Institute staff is 250, of which 110 are scientists with a PhD, post graduates and graduates. The Institute possesses eight laboratories.

PVC and PVC-compounds is of vital importance for the production of polymer materials with valuable properties in industry and in the agriculture of DPRK. The IHMC plays an important role in the present production in the DPRK of 50,000 tons PVC-resins, offering consultancy for the industry in areas ranging from design to tool making, processing and testing.

My work began with the preparation of the activity programme and I later had the opportunity to become acquainted with the details of the laboratory for PVC processing. I also visited the plant for PVC processing into final flexible products and vinalon, where I was made aware of the situation regarding PVC production.

The activity programme on the 'Maintenance and use of PVC Testing Equipment (Rheology) was completed on 1 December 1984.

3. GENERAL AREAS OF RESEARCH

It was noted that a significant rate of growth has taken place in the world in the production of PVC polymer during the last decade, the main reasons for this exceptional growth being:-

- the relatively low price of the polymer
- its versatility, since it can be made into a variety of products from rigid sections to soft elastomers, in a complete range of colours and transparencies
- its good physical, chemical and weathering properties
- the development of better polymers
- the development of improved stabilizer and lubricant combinations
- the development of a wide range of high quality processing equipment

The PVC polymerization laboratory at the IHMC is at present experiencing problems in the improvement of polymer thermostability (low PVC thermostability), PVC processing (processing difficulties) and the absence of necessary modern equipment. With regard to PVC processing, the main problems are:-

- the very low quality of the industrial PVC polymer

- the lack of scientific methods for creation of PVC compounds and their processing into final products
- The lack of necessary modern equipment gives small possibility to determine and characterize the structure of polymer and its influence on the physico-chemical properties of the final product.

4. RECOMMENDATIONS

The aforementioned problems may be solved in the following ways:

1. In the field of polymerization

- by changing some technological parameters, the catalytic system and experimental method of PVC preparation, studying the kinetics of polymerization, as well as decomposition reactions. All such measures can be carried out on the existing equipment.

- taking into consideration the considerable influence of polymer structure on the physico-chemical properties, the use of corresponding modern instruments should be introduced in order to obtain the necessary data for their interpretation.

- to develop research in the complex study of active coal-mercuric chloride catalyst (preparation method, structure and its influence on active properties etc) in order to improve its mechanical property as well as its catalyst life.

- using the existing facilities, the quality of by-products canbe partly improved by:

  a) changing some process parameters, particularly, the order of additional components

  b) pre-reaction heating of distilled water to escape the beginning of polymerization at low temperatures

  c) changing (decreasing) of final conversion degree

- to check some other catalytic systems used for PVC polymerization, such as, redox system, metal salts, metal carboniles, halogen substituted carbons etc., in order to carry out the polymerization process at low temperatures ; the later provides formation of more stereoregular polymers with high thermostability.

- to use, as a component of reaction mixture, special additions to prevent the formation of 'fish eye' structure, as esters of unsaturated fat acids.

- to develop research on the kinetic measurements of polymerization reaction, as well as decomposition of PVC.

- to purchase modern equipment enabling research of the physico-chemical properties and structure of polymers to be carried out. (Please see Annex 1 for list of equipment)

2. In the field of PVC processing

- for improving the microstructure of the PVC polymer and quality, it is necessary:

  a) to carry out the research work on super-purifying vinylchloride from any admixtures, non-reacted acetylene in particular.

  b) to apply more effective peroxide initiator instead of the presently used 'AVIN' initiator.

  c) to change or modify the dispersion agent based on polyvinylalcohol to a more effective one.

- in order to improve the scientific level in the field of PVC compounding and processing, it is necessary to investigate new types of lubricants, to research new stabilizers for flexible and rigid PVC materials and to establish scientific base methods for PVC processing.

- to organize a research test rheology method;

  a) for controlling the PVC structure and its rheological properties, including the addition of small additives of elastomers and oligomers of various structures, for example, the addition of 5% by mass of oligoether to the PVC rigid composition makes it possible to render thermal decomposition less intensive and to lower the processing temperature by 10°C. However, the addition of 5% by mass of elastomer additives makes it possible to reduce pressure of cold moulding by 2 times.

  b) in order to effect an abnormally strong influence of minor additives of low-molecular substances or melt flow of thermoplastics materials, when the addition of micro-additives (up to 5% by mass) results in reducing polymer melt viscosity by ten times.

  c) for introducing plasticizers, which improve the elasticity of polymer both during processing and operation of the final products; the addition of a plasticizing agent to a polymer allows lowering the glass temperature and reducing melt viscosity, thus improving frost resistance and intensifying the processing operation, respectively.

3. In the field of testing

a) Observing with concern the great potential for increased production of plastics in the DPRK and also, the urgent needs in rheology testing services for industry, it is most strongly recommended to expand the IHMC, by organizing a special laboratory in rheology testing methods research (with a total of 8-12 personnel and total area approximately 80-120 m^2). The main function of this facility would be:

- to render technical and advisory services to other laboratories of the IHMC in testing and quality control of polymer products.
- to act as a catalyst to promote close contacts between industry and the institute.
- to conduct industrial research work in the field of PVC compound and other plastics.
- to organize seminars and lectures on rheological test research and methods of polymers.

b) Recognizing that the IHMC holds a prominent position in the field of production and the processing of plastics raw materials and also, that there is an availability of high level, educated, plastics engineers and research workers, having 25 years of experience in the field of plastics testing. The IHMC also has the experience of collaboration with UNDP/UNIDO and in view of the aforementioned factors, it is essential that the laboratory for processing of plastics be provided with basic plastic rheology test equipment in accordance with list attached as Annex II.

c) As the expansion of plastics in the DPRK is closely connected with rheology test research work and also, to the availability of skilled manpower who must be capable of working sophisticated rheology test equipment, it is therefore necessary for several personnel of the IHMC to be trained in this field through progressive institutes in other countries.

d) With the facility of modern rheological test equipment, the IHMC would be in a position to broaden the research work in collaboration with educational institutes and industrial plants. Possible research programmes could include; the investigation of filled polymers, modification of raw materials, selection of the right conditions for plastics processing, assessing production of additional goods from the new polymer materials and recycling of plastics etc.

e) The IHMC having the facility of rheological test research equipment would be able to develop National Plastics Standards, using the experience of international organizations. Moreover, the IHMC would be able to strengthen the direct service and testing assistance to all small, medium and large scale plants, using the facilities available at the Institute.

f) To ensure the realization of the recommendations mentioned above, intensive efforts should be made by competent bodies, to increase the number of engineers at IHMC, thereby making it possible to provide all types of activities including research/investigation work, training, standardization activities, testing and advisory services.

g) Taking into consideration the existing experience of the IHMC in the field of processing and rheology testing, it is recommended that plastics testing devices be designed and fabricated in the future at the premises of IHMC.

5. FINDINGS

1. A number of lectures in the field of polymerization, processing and rheological testing of PVC and PVC compounds were conducted (as indicated in Annex III)

2. There would appear to be scope for further mutual activities between the Government of DPRK and UNIDO/UNDP in the field of PVC and PVC compound.

   Taking into account the existing plans for development of the PVC industry in the country, the following suggestions are put forward:

   - to expand the IHMC
   - to organize a new laboratory for Rheology Research Testing of Polymers

ANNEX I

Equipment required in PVC polymerization and processing projects

No.	Item	Quantity	Cost, US $
1.	Infrared-spectrophotometer	1	16,000
2.	Gel-chromotograph	1	20,000
3.	Light scattering photometer	1	20,000
4.	Differential thermoanalyser	1	15,000
5.	Hardometer	1	3,000
6.	X-ray difractometer	1	12,000
7.	Osmometer	1	300
8.	Two liter autoclave (100 atm pressure)	1	1,000
9.	Conductometer	1	250
10.	High sensitive recorder	1	750
11.	Ultra thermostat	1	500
12.	'Brabender' plasti-corder with extrusiograph	1	40,000
13.	Electro-mechanical universal testing machine 'Shimadzu' autograph with template for counter-cut.	1	25,000
14.	Scania combined laboratory machine (7 uses)	1	25,000
15.	Oxygen index apparatus 'CEAST'	1	10,000
16.	Ultra thermostat ' CEAST '	1	1,000
17.	Reoscap 1,000 CEAST with viscosimeter 'Kastor-serves'	1	25,000
18.	Apparatus for measuring dielectric properties	1	15,000

ANNEX II

List of Rheology Test Equipment

		Quantity	Estimated Cost US $
1.	Melt Flow Indexer Available from following countries: USA, Swik (FRG), Davenport (GB), IIRT (USSR), Drüfgeräte-Werk (DDR)	1	1,200
2.	Reograph - 200 Available from the following firms: Gottfert (FRG), Instron 3210,3211 (GB) Swik 7901 (FRG), VPK-1 (USSR)	1	15,000
3.	Reogonimeter - Weissenberg Pipps 2 (USSR), Rotovisco-Haake (WB) Reotest (DDR), Ferranty-Shirly (GB) Reomat -1st (Switzerland)	1	15,000

* Foot Note: in the DPRK the current frequency is 60Hz

List of Lectures delivered to members of the IHMC during the expert assignment

1. World tendency in PVC polymerization
2. Today and tomorrow of PVC in the world production
3. Up-to-date Rheology Test Research Methods
4. Methods of vinylchloride synthesis
5. Polyester plasticizer : a new class of plasticizers for PVC
6. Introduction to Rheology (simple flow, non-Newtonian flow behaviour. etc)
7. Radical polymerization of some substitute ethylenes
8. The selectivity of stabilizers of PVC, as one of the main problems in PVC compounding and processing
9. Rheology Test Research Equipment (viscometers of different construction, their classification and work)
10. New directions in vinylchloride polymerization
11. Physico-mechanical properties of PVC and PVC compounds and the methods of their evaluation
12. Unstable flow melts of polymers
13. Choice of co-monomer in vinylchloride copolymerization reaction
14. Fillers for PVC compounds
15. Rheological properties of PVC and its processing
16. Application of PVC materials
17. Working up procedure of rheological data for PVC compound