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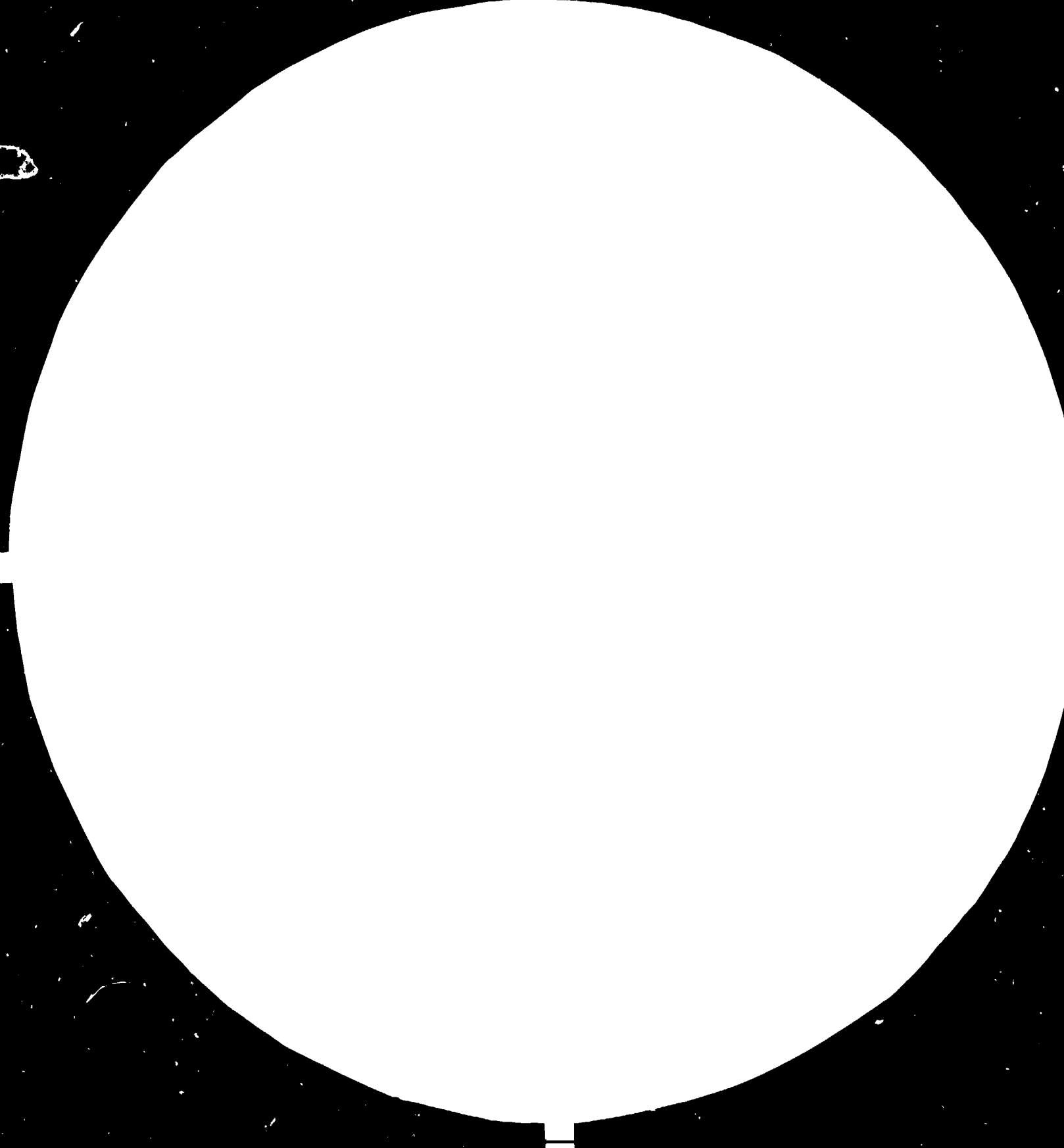


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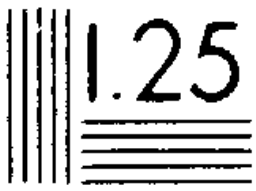
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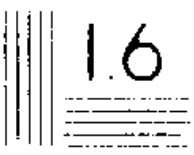
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13th January 1984

Report

on

India.

ASSISTANCE TO CIPET/MADRAS IN THE FIELD OF RHEOLOGY OF POLYMER MELTS

DP/IND/82/044

INDIA

G. Mennig,
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United Nations Industrial Development Organisation
Vienna/Austria

Content

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1. PREFACE

The present report is in regard to my short term visit of 1 month duration to the Plastics Testing Centre (PTC) of Central Institute of Plastics Engineering and Tools (CIPET), Madras, as an adviser (Special Technical Services) in the field of rheology of high polymer melts. CIPET has been known to me since the last 13 years - though at present it is my first mission under UNIDO auspices within the Plastic Material and Product Testing Programme in India - and I had 7 members of staff of CIPET during the last 4 years with me for training of different nature and duration in my own institute Deutsches Kunststoff - Institut, (DKI) in Darmstadt/West Germany. Though I shall concentrate mainly on rheology alone some of my above mentioned long term interests in CIPET as well as the discussions with staff members of CIPET from other sections than PTC, discussion with people from industry and institutes and certainly the frequent talks I had with Dr. C. Brignone, Chief Technical Adviser (CTA), will invariably have a certain impact on the report.

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2. SUMMARY

During my 1 month stay in PTC/CIPET in Dec. 83/Jan. 84 I found the existing rheological equipment in working condition and the concerning staff quite able to handle it. The Haake viscometer was commissioned in this time. Unfortunately the most important equipment, a Capillary Viscometer had still not yet arrived. The progress in the field of standardisation is satisfying as is the inclusion of rheology into the running courses for students. Some internal lectures on basic rheological problems were delivered to selected staff of CIPET. As far as relations to industry are concerned the major activity was a 1 day seminar with participants from some of the important companies in India conducted on 12.01.1984.

Alltogether it is not so much PTC/CIPET itself where there is need for strengthening in the field. As expected it is rather on the more general field of increasing the awareness of industry for the importance of rheology in relation to processing and quality of the product and the role CIPET could play in this respect.

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3. IMPORTANCE OF RHEOLOGY

Anticipating that some readers of the present report may not be familiar with the term "Rheology" a short introduction shall be given.

In plastics processing the primary processes like compression moulding, injection moulding, extrusion calandering etc., they all have in common that the solid raw material must be converted into a melt. This melt is ultimately forced through a die, a calendering slit or into a mould thus creating the shape of the final product (which has to be made solid again either by cooling or curing). To meet this aim the melt must be kept under high pressure. In that stage a number of rheological phenomena occur which are related to the high-viscous, non-Newtonian and visco-elastic flow behaviour of the high polymer melt. Due to the complicated nature of the concerning phenomena and due to the fact that during processing at least two phase transitions take place it is a rather complex area.

There are two aspects to be considered: One is the rheological behaviour itself as a property of the material, the other the influence of flow behaviour on processing. Apart from the purely scientific interest of the academic research scholar there are many cases where the rheological properties alone give already relevant information. For example in case of entrance tests in regard to uniformity of raw material of different batches, identification of various grades of material but also whether a thermal degradation took place in processing (i.e. shortening of molecular chain lengths). If the first aspect is related to testing, the second is in strong correlation to processing. An analytical approach to calculate the flow inside of processing equipment would be meaningless without adequate knowledge of flow behaviour.

In practice the processor may have collected rheological data together with corresponding processing conditions. This enables e.g. to find out in a comparative and often only qualitative way the setting of machine parameters for a newly to be processed material in order to minimize losses respective increase the efficiency.

Thus the knowledge of the rheological properties is of great importance, be it for the raw material or the machine manufacturer or the processor.

4. PRESENT STATE OF ART IN PTC/FINDINGS

4.1. Significance of CIPET

The latest figures (Ref: Plastic & Kautschuk - Zeitung v. 21-4-83) on indian manufacture and consumption of plastics were recently given by the President of the Indian Plastics Federation, O.P.Mundhra. He indicated a yearly potential of 225,000 tons of raw material manufacture with in the country and a consumption of about 300,000 tons per year indicating the size of imports. From these figures a per capita consumption of ca. 0.4 kg/Head and Year may be concluded whereas the yearly consumption in highly industrialized countries is in the range of ca. 75 (USA) and 104 (Finland) kg/Head. The fact that companies like Indian Petrochemicals Ltd. and Maharashtra Petrochemicals Complex plan to produce in 1986/87 an additional 25,000 tons and in 1987/88 240,000 tons does not change the ratio significantly. Indeed the comparison of these figures indicates strongly that the future growth of the plastics field will be assured though India may not have to follow exactly the lines of the development in Western countries.

The same source gives the total number of processing companies as approximately 7500. Apart from simple consumer goods such as household items there is an increasing production of technical parts like pipes, cables and precision items, e.g. in the electrical and electronics industry. Since the number of small scale industries is in the range of 75%, assistance is needed in all fields as these companies are usually not in a position to put up their own R & D facilities.

In view of this fact and in view of the steady increase in quality and better performance there is an increasing demand for centres which offer training/education/development/testing/information services. Anticipating the growth of the plastics field in India, the importance of such centres is even higher. The degree of independence from western know-how and the ability to compete on an international level is also strongly dependent on the quality of the work done by these centres.

CIPET plays in this context a more or less unique role since it offers consultancy in a way which is particularly meant for industry on a wide range from design, to tool making, processing and testing. A similar combination is nowhere else found in India.

4.2. Equipment/Training

The existing rheological equipment may be grouped as follows:
(a) for low viscous fluids,
(b) for high viscous media.
Under (a) there is a Brookfield spindle viscometer a Hoppler Falling Ball Viscometer, a Ubbelhode and a Osswald Viscometer. Though the range of viscosities in case of the Brookfield is given as upto 8.10^7 cPoise these instruments are mainly for low viscous fluids. They are used for measurements in regard to molecular weight (intrinsic viscosity, K-Value etc.) and therefore helpful in all concerning cases. The Haake Viscometer

(Couette type), belonging to the same group of instruments, arrived only recently and was commissioned during my stay with a calibration oil and with non-Newtonian model fluids which I brought from Germany.

Group (b) consists of a Melt Flow Index (MFI) unit as a purely rheological equipment and the Brabender which can also be used for processing studies. A laboratory size injection moulding machine may be partly included though it is primaryly a processing unit. Tests like spiral moulding refer to the mouldability thus to the viscosity of high polymers.

The existing equipment was found to be in working condition (some accessories were commissioned during my stay, e.g. automatic timer for MFI) and the staff to be familiar with it. Infact I was impressed by a booklet compiled by PTC staff containing for every instrument a description, a manual, sample sheets for data collection and directions for evaluating of results. Unfortunately the most important equipment, a high pressure capillary viscometer (Instron) was yet to come. Further the Rheovibron which to a certain extent may be considered a rheological instrument arrived during my stay. Due to delays in the clearing procedure there was no possibility to bring it into working condition.

In general I feel that group (a) carries slightly too much weight compared to group (b). To adjust it may be discussed wheather the Haake should be equiped additionally with a cone plate head (and relevant accessories like plotter and speed control). This would enable to measure also high viscous fluids like polymer melts and enlarge the range of shear rates in addition to the one of the capillary viscometer ($\dot{\gamma} \approx 10^1$ to 10^5 s^{-1}) toward zero shear viscosity μ_0. Apart from that no further equipment is needed (last not least since it could not be housed properly at present due to lack of space).

For Ahmedabad only a MFI and a Brabender is planned. This should be sufficient as more sophisticated rheological problems should be dealt with in Madras.

The design and manufacture of simple test equipment like MFI has not yet started though there seems to be a demand. After my return I shall procure a drawing for Melt Flow Index from DKI for further use, if desired. Similarly there could be scope for test moulds like spiral mould, cup mould (thermosets) which all deal with flow properties (another example would be a tester for bulk density). CIPET would be the logical place for such activities since design, manufacture, trial and calibration would be under the same roof. I also shall send samples of raw material for calibration purposes. Also storage of indian raw material for reference matters would be advisable. Such samples should be offered to third parties.

Rheology is included into the training programme for students of CIPET as the volumes for the courses show. Much useful routine has been established in this field.

Altogether there is little within PTC itself where assistance by a foreign expert would be required in the field of rheology except for general strengthening and updating in regard to latest trends in research, application and equipment. Taking into account the particular small day-to-day difficulties (e.g. occasional power failure) and the general pecularities in regard to lengthy administrative procedures PTC is quite impressive.

4.3. Related areas/General

In PTC all necessary standards i.e. ASTM, ISO, BS, IS and partly DIN (full record of DIN is already ordered) are available. There is a lot of prefectly accumulated data with cross-references amongst the various standards. In case of IS it is peculiar that no single standards on measuring procedures exists. These are included into the various

materials standards. PTC also takes part in the current activities of the Indian Institute of Standardisation. At present PTC is scanning through all relevant IS to find out which measuring methods would be available in PTC. This is in preparation for a move already considered by the Advisory Committee to apply for the status of a National Test House. Though CIPET certificates carry already the weight of a recognised independent Institution it would be certainly worthwhile (also in regard to earnings) to be elevated onto a higher, government recognised status.

PTC has a lively relation to outside customers as I could note in person. In fact there was hardly a day during my stay without one or more parties seeking advise, ordering tests etc. (in which I took some part). The number of orders resulting from such contacts was given as 140 for 1982 amongst which were no requests for pure rheological measurement except MFI. However, some rheological measurement is carried out regularly in connection with problems like comparing two batches of same material, judgement of influence of processing on molecular structure etc. The almost non-existing demand for rhological measurements as compared to industrialized countries is a proof for the lack of information in industry on the importance of rheology in relation to processing. This is certainly a field still to be strengthened. The 1-day seminar (Annexure IV) is a contribution towards this aim. Prior to my assignment there was already a discussion on a nationwide seminar (with international participation) on this subject. If properly arranged and with the necessary long-term preparation it would certainly serve the purpose as well as making CIPET still better known in concerning circles.

There seems to be no streamlined procedure for outside customers in approaching CIPET with a problem. It is somehow left to their own initiative to find out the right person in CIPET for a particular problem. Also there are often problems which are related to more than one section of CIPET, e.g. the development of a process would

touch Processing and PTC. I suggest to discuss weather the old idea of a Consultancy Cell should be brought back to life. Perhaps some central figure acting as a Consultancy/Business Development Manager should represent CIPET against third parties in the field and also promote by going to industries. Of course this would have to be somebody with an all-round experience of high quality. As far as charges are concerned I do not share the view of an earlier foreign expert that charges may be lowered. (50% reduction for small scale industry is already given). It is my general experience that service offered free of cost is often not valued high. This seems particularly true under indian conditions.

There is some delay in erecting a new site for PTC and soon the point will be reached when no further equipment can be squeezed into the existing building. Therefore new equipment arriving hereafter (like the High Pressure Capillary Viscometer) may be commissioned only temporarily. I feel that the delay is exclusively on the government side though UNDP Delhi seems to try to accelerate things at their best. In view of the fact that already valuable equipment is laying idle the strongest possible means should be taken in order to achieve quick progress in erecting the new building.

I found CIPET quite aware of the activities in other institutions as well as in the R & D centres of the chemical industries in the field of rheology. Full data are just now accumulated (includes contributions from the CTA when on tour to Ahmedabad in Dec. 1983 and IPCL/IIT. It would be certainly useful to have complete information on rheological activities in the indian scene, last not least to direct customers to the nearest place for measurements of flow behaviour.

I felt that the previous visits of CIPET staff in my own institute (Annexure III) were quite helpful for their work in CIPET and I shall continue to offer such facilities.

Lastly I cannot refrain from commenting that my visit might have been of still higher efficiency (e.g. in connection with the 1-day seminar on 12-1-1984 or visits to industries etc.) had the administative procedures could be finalized earlier (e.g. I received my ticket two days prior to my departure to India). I do comment on this particularly in view of a possible 2nd mission in due time.

5. RECOMMENDATIONS

- No recommendation for further equipment at the present stage, except for accessories for the Haake Viscometer.
- Recommend to take up all possible means to improve the conciousness of industry for testing and quality in general and rheological measurement in particular by e.g. circulation of information or a nation wide (long term prepared) seminar.
- Recommend the collection of sample raw material with well known properties for calibration purposes and reference tests.
- Recommend not to offer services at charges below the actual costs for testing.
- Recommend to discuss the post of a Consultancy/Business Development Manager for stream lining particularly in case when more than one section of CIPET is concerned.
- Recommend continuation of collecting information on other places in India active in the field of rheology.
- Recommend strong assistance of UNDP etc. in regard to government matters, such as e.g. erection of new building etc.
- Recommend UNIDO to arrange for visits of foreign experts well in advance for maximum preparation prior to the visit.

6. OUTLOOK ON 2ND MISSION

My 2nd mission - if desired - could have, apart from general strengthening like internal lectures to the PTC staff, procurement of sample raw materials for calibration purposes etc., the following aims:

a) Advanced use of the (hopefully) then arrived and commissioned capillary viscometer.

b) Strengthening of the interaction between CIPET and industry by assistance in preparation of and participation in a nation wide seminar on the subject.

c) Initiation of quality minded societies of processors (e.g. pipe manufactures or cable manufactures) with CIPET/PTC as the independent institution for regular product testing and checks on processing.

In view of the necessary long-term preparation, particularly in case of the seminar, a 2nd mission should not be planned within less than 12 month, preferably even later. Also the job description would have to be expanded slightly.

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ANNEXURE - I

Mission Schedule

06.12.83	Briefing Vienna
10.12.83	Departure to Project
12.12.83	Prestopping Delhi
13.12.83	Arrival at Project
14.01.84	Departure from Project
16.01.84	Backstopping Delhi
18.01.84	Arrival from Project
x_1	Debriefing Vienna

x_1 date not yet fixed at preparation of report

Visits to Industries/Institutes

14.12.83	Polyene General Industries Pvt. Ltd., Madras.
21.12.83	High Polymer Engg. Lab., Chemistry Engineering Dept., I.I.T., Madras.
22.12.83	Inauguration All India Seminar "Recent Developments in Polymer Science" University Madras and Soc. Polym. Sci. India.
02.01.84	Inauguration "Silver Jubilee" I.I.T. Madras.
17.01.84	Appl. Mech./Fibre Sciences, I.I.T. Delhi.

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ANNEXURE - II

Lecture Programme

Date	Title/Topic	Venue
22.12.83 :	An Introduction to Rheology	CIPET
29.12.83 :	Aspects of Automation in the Plastics Industry	Rotary/ Madras
26.12.83 : until 30.12.83	Series of daily lectures for selected staff of CIPET (Simple flow, Non-Newtonian flow behaviour, viscometers, flow anomalies - etc.)	CIPET
03.01.84 :	Aconstic emission studies with short fibre filled thermoplastics	I.I.T/ Madras
12.01.84 :	1-day seminar on "Flow Behaviour in Polymer Processing" (see Annexure-IV)	CIPET
17.01.84 :	Filler distribution in injection moulded test specimens	I.I.T. Delhi

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ANNEXURE - III

Visit/Training of CIPET staff in DKI

Name	Number of Month/Year	Nature of Training/ Interest
C.S. Raja Manickam	1,5/80	Processing/Testing
S.K. Sharma	2/80	-do-
A.K. Gupta	1/82	-do-
Sanjay Kumar	1/82	-do-
K.P. Govindan	0.5/83	Processing/Mould Design
Mohammed Nainar	0.5/83	-do-
R.P. Singh	1/83	Physical methods/ Processing

ANNEXURE - IV

Programme 1-day seminar in CIPET on 12-1-81

CIPET

Offers

ONE DAY PROGRAMME

on

Selected aspects of

"FLOW BEHAVIOUR IN POLYMER PROCESSING"

by

Dr. Ing. G. MENNIG
UNIDO Expert
(Head of Plastics Processing & Testing Division
German Plastics Institute, Darmstadt).

Course Director
Dr. C. BRIGNONE
Chief Technical Adviser

PLASTICS TESTING CENTRE
CENTRAL INSTITUTE OF PLASTICS
ENGINEERING AND TOOLS
Guindy, Madras-600 032

Grams : CIPET Tel : 432371

ANNEXURE - V

Abbreviations / Nomenclature

(in chronological order)

CIPET - Central Institute of Plastics Engineering and Tools

PTC - Plastics Testing Centre

DKI - Deutsches Kunststoff - Institut

CTA - Chief Technical Adviser

MFI - Melt Flow Index

ASTM - American Standard

ISO - International Standard

BS - British Standard

IS - Indian Standard

DIN - German Standard

HPEL - High Polymer Engineering Laboratory

IIT - Indian Institute of Technology

$\dot{\gamma}$ - Shear Rate

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