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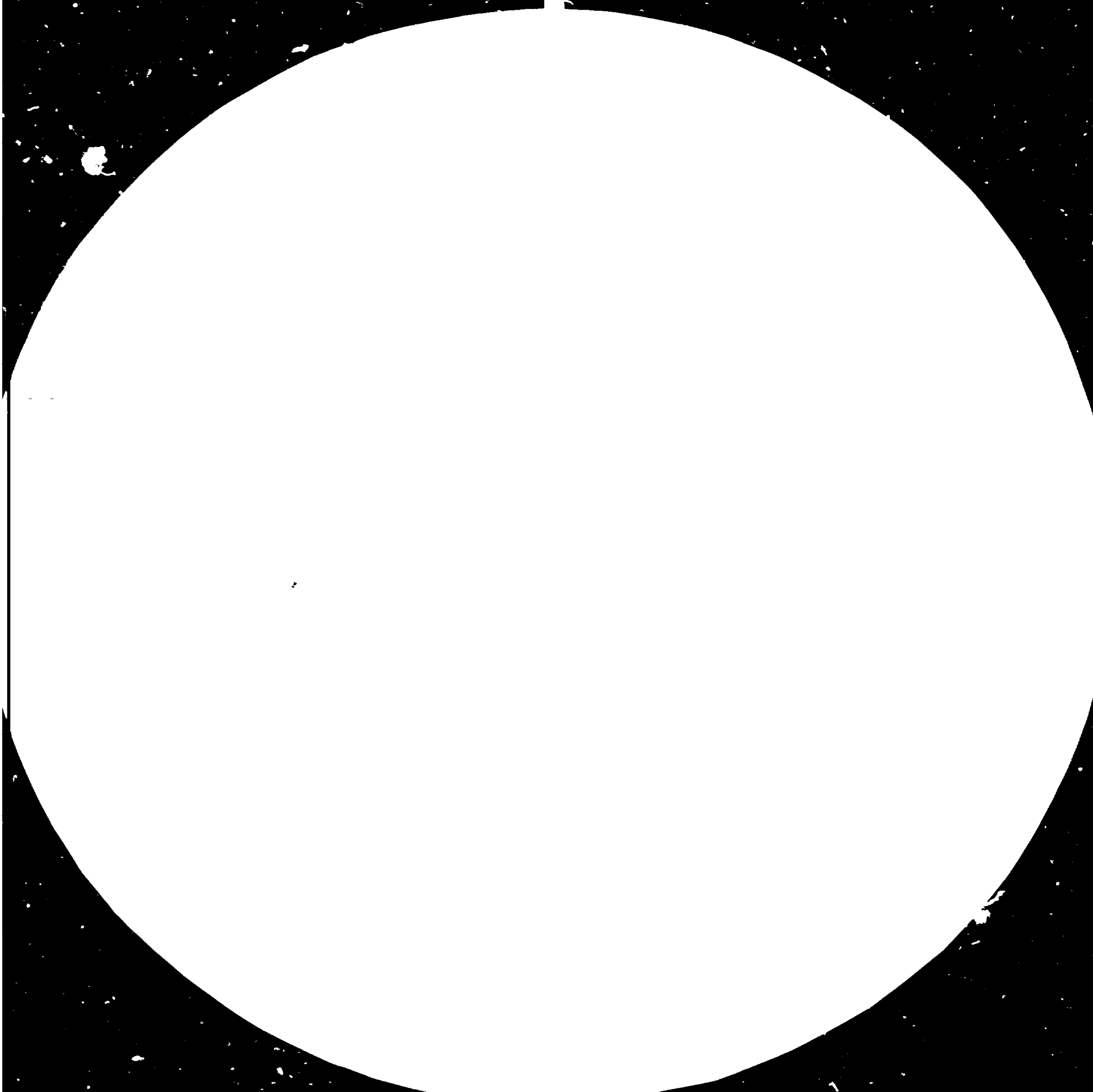

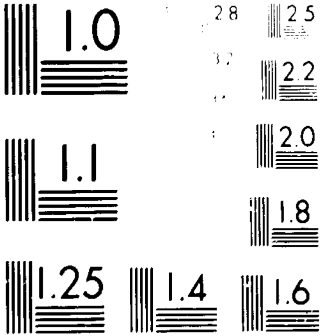
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Distr.
LIMITED
ID/WG.384/11
13 December 1982
ENGLISH

United Nations Industrial Development Organization

Expert Meeting Preparatory to International Forum on Technological Advances and Development

Moscow, USSR, 29 November - 3 December 1982

NEW MATERIALS, NEW TECHNOLOGY*

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V.82-34859

The growing power cost, the universal shortage of oil and other mineral resources dictate a revision of the conventional approaches to the development of technology and materials science. In the developing countries the progress in plastic materials production may be channelled into the creation of high-filled materials containing both mineral and organic fillers. To achieve this, an effective comminution (dispersion) technique is necessary. However, if such a technique were available it would mean much more than solution of the original problem. Finely-divided organic materials (both natural and man-made) may stipulate considerable progress in such branches of industry as flour milling, hydrolysis, wood-working, production of formula feeds, the use of horticultural wastes, etc. The ultimate end of the new technology is to save power, material and labour resources.

Introduction

The energy crisis, which broke out in mid-seventies of this century, corroborated scientists' warnings that the mineral and organic resources were limited. Even the most optimistic forecasts about the still undiscovered oil and gas deposits in the continental shelf and at hardly accessible localities of land cannot soothe mankind from reflecting about the imminent energy famine.

A search for alternative power sources will go on, but even now it is all too clear that the future power cost will be higher. The fraction of the organic fossils currently used for the manufacture of synthetic structural materials is as small as 3% and by the end of this century will, apparently, have increased to 8-10%. In any case, many countries suffer from acute shortage of organic raw materials.

In company with the soaring power prices this may strongly impede the progress of the rate of manufacture of structural materials.

Development of polymer material production technology.

This simplest way out of this situation is to save the power and material resources. Both may be assured by a more advanced process technology.

The major trends in the improvement of plastic materials production and processing technologies may be summarized as follows:

1. Increase of the production capacity of individual synthesis installations to 100-150,000 t/a;

2. Rejection of the "wasteful" process involving multi-

step flow-charts and solvents;

3. Development of highly effective catalytic systems allowing elimination of the washing and drying steps;

4. Optimization of the properties of the materials themselves, which will permit reducing their consumption in products;

5. Optimization of the methods of machining plastic materials into finished articles.

Considerable success has been achieved in each of these directions in recent times, but all improvements have been based on a traditional approach which may be called the "evolution approach".

For instance, the development of a process for preparing linear low-density polyethylene with ordered branching in the macromolecules yielded a material stronger than the conventional high-density polyethylene.

The next step in economy of polymeric materials may be made by having recourse to filled polymers.

Filling as a principally new approach

Fillers - carbon soot, carbonates - began to be added to polymers in the late nineteenth century. The superb properties of glass-reinforced and foamed plastic materials made for their tempestuous development. Cosmic achievements would be impossible unless new composite polymer materials were provided.

However, most of the polymeric compositions available at present are function-oriented. Glass-reinforced plastics are more effective than metals; foamed plastics have superseded a number of natural materials.

But structural foamed plastics with a solid skin and a cellular inner structure may ensure economy of up to 50% of organic materials

Carbonate-filled polyvinylchloride finds wide application (as cable sheath, linoleum, drain pipes, etc.).

We have made a step further in this direction for we have tried to estimate the potential of the filling technique in the economy of power and material resources. Our investigations encompassed all the basic types of man-made polymers, the potential filler materials, filling techniques, processing technology and the uses of filled materials.

Potential fillers

As regards their origin, they may be divided into inorganic and organic, natural and man-made. One important class are the industrial and agricultural wastes.

Attention will be focused on three aspects of the problem:

1. Power saving potential;
2. Improvement of the functional properties of materials;
3. Utilization of wastes - environmental protection.

To render a mineral or industrial waste suitable for use as fillers they must be processed: ground, finely milled, cleaned, dried. The fine milling step is the most power-consuming one, since comminution is effected by application of impact loads in ball or jet mills, shredders, etc. The efficiency of such machines is as small as 1-3%.

Certain compositions may contain unmilled fillers. They include slag, perlite (vulcanic glass), quartz sand - containing structural materials. In these materials, obtained by caking or pressing, the portion of organic polymer is 5-14%.

But if the task in hand is to fill thermoplastic or castable thermosetting materials, the filler particle size cannot be larger than 10 microns. The cost of milling and separation will be offset by the economy of polymeric materials (which is much more power consuming!) and working advantages.

Mineral fillers increase heat conductivity of materials (thus cutting the forming operation time), improve the structural rigidity of materials.

The current state-of-the-art already allows manufacture of packaging containers of different kinds, boxes, articles for everyday use, technical components, low-pressure and drain pipes, shaped sections, etc. from polyethylene (and grades), polypropylene, polyvinylchloride, ABC and other plastics filled about 30-45% by mass.

Beside the conventional techniques of mixing plastics with fillers, new - mechano-chemical and polymerization - techniques have appeared in which monomers are mixed with the appropriate filler and the polymerization takes place on the surface of filler particles

Suitable fillers include many minerals, wastes of mining and metallurgical industries, fly ash of thermal power stations, etc.

Organic fillers

Mineral fillers make compositions heavier, since their density is higher than that of polymers. They increase the wear of the mechining tools, and the cheapest fillers - dispersed ones - render the material brittle if contained in high percentage. Each of these setbacks can be obviated. Some degree of foaming reduces the density; polymerization filling technique reduces the wear and addition of short fibres, or elastomers may reduce the brittleness.

But there is also a wide class of fillers quite free from these drawbacks. Such are organic fillers: wastes of the same plastics, rubber, wood, agriculture and horticulture.

Flour made from wood, nutshells has long been one of the commercially-used fillers. Maximum use of these types of fillers will render the plastics industry almost as effective as metallurgy where re-utilization of iron scrap is an extremely important economic factor.

Two problems must be solved in order to implement this program which may be expected to provide real savings of 25% of the primary oil stock:

(a) we must learn to combine an organic filler with the polymer matrix;

(b) we must develop an effective technique for fine milling of solid organics.

The first problem is solved by different chemical and physical methods (finishing, chemical grafting, surface polymerization, irradiation).

The existing milling methods are all based on application of impact loads to provide brittle fracture or shear. Comminution of wood and rubber involves complicated, power-consuming procedures.

New milling technique

As a result of fundamental investigations of the effect of shear (tangential) deformations in combination with pressure on polymers, a team of researchers of the Institute of Chemical Physics of the USSR Academy of Sciences has developed a new highly effective polymer milling technique at elevated temperatures.

Compared with the conventional milling tecniques for polymers, wood and rubbers, the new method provides a 2 to 10-fold specific power gain.

This result prompted a revision of certain principles in the use of organic materials which had been considered fundamental. The following examples are intended to clarify this conception:

1. Milling Industry. The new technology will permit obtaining flour from bran for addition to bread dough or mill grain of any kind (with husk) without any waste. This increases both the yield of flour and its nutritive value;

2. Production of wood flour from any type of wood wastes can be effected by an economic process;

3. The rate of hydrolysis may be greatly increased if wood flour is used as raw material;

4. Various agricultural and horticultural wastes can be processed into flour or granules for addition to formula feeds. This helps solve successfully the problem of transportation, storage and use of this valuable raw material on the basis of the conventional power techniques;

5. Utilization of waste rubber. The new technology permits saving 20% of rubber by way of addition of finely divided rubber to rubber compositions.

CONCLUSIONS

It has been computed that grinding and milling of various materials (from ores to cocoa-nuts to clinker to medical preparations) takes nearly 10% of the world's power output.

Provision of new, more economic milling processes, combination of milling with chemical treatment of solid materials opens up excellent prospects for upgrading many technological processes. Thus the problem in hand - economy of power, labour and material resources - may be achieved within reasonable time limits.