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THE BINGHAM MEDAL, 1957

The committee for the Bingham Medal has chosen Dr. Clarence M. Zener to be this year's medalist in recognition of his important work on the visco-elastic behavior of metals. The presentation of the medal will include a discussion of the research activities of the medalist by Dr. Arthur S. Nowick, of the IBM Watson Laboratory, Columbia University.

Dr. Clarence Zener, Director of the Westinghouse Research Laboratories, was born in Indianapolis, Indiana. In 1926 he obtained a B.A. degree in physics from Stanford University, and in 1929 a Ph.D. from Harvard. Following his graduation from Harvard, he spent a year in post-doctoral study at the University of Leipzig, returning to the United States to become a National Research Fellow in Physics.

In 1932, Dr. Zener began specialization in solid state physics at Bristol University in England, where he remained for two years. Following this, he became an instructor in physics at Washington University in St. Louis. In 1937 he moved to a similar post at City College, New York, and three years later became an Associate Professor at Washington State College.

During World War II, Dr. Zener carried on research and development work on projectile design and armor penetration at Watertown Arsenal. Following this wartime work, he became a Professor in the Institute of Metals and the Department of Physics at the University of Chicago.

From this post, in 1951, Dr. Zener came to Westinghouse as an Associate Director of the Research Laboratories. He has directed the work of both the Magnetics and Solid State Physics Department and the Metallurgy Department. In August 1955 he was named Acting Director, and in December 1956, Director of the Laboratories.

Dr. Zener has specialized in research on various aspects of metals, particularly internal friction, diffusion, and ferro-magnetism. He is author of the Zener theory of ferromagnetism and of the Zener effect, a theoretical explanation of electrical breakdown in semiconductors.

THE ANNUAL FALL MEETING—1957

The Society will hold its 1957 Annual Meeting in Princeton, New Jersey, on November 7, 8, and 9. The technical sessions will be held at the Textile Research Institute. An important feature of the meeting will be

the awarding of the Bingham Medal. This will take place on Thursday evening, Nov. 7th, at the Social Hour Smoker.

A detailed outline of the program for the technical sessions is included in this Bulletin together with abstracts of the papers to be presented. Blocks of room reservations have been made at both the Princeton Inn and Nassau Tavern. Members and guests desiring accommodations should communicate directly with the Inn or Tavern mentioning that the reservation is in connection with the Society of Rheology meeting or they may write to the local arrangements chairman, Paul C. Alford, Jr., Textile Research Institute, Princeton, N. J., who will be glad to take care of making reservations.

PROGRAM FOR FALL MEETING

Session I, 10:00-12:00 A.M., Thursday, November 7th.

"THE RHEOLOGY OF PEELING IN A NEWTONIAN LIQUID"

J. J. BIKERMAN, *Department of Civil & Sanitary Engineering, Massachusetts Institute of Technology, Cambridge 39, Massachusetts*

A metal ribbon was pressed against a rigid plate, the space between the plate and the ribbon being filled with a viscous liquid. Then the ribbon was peeled off, and the time t of separation measured as a function of the applied load W . An approximate rheological theory of the function $W = f(t)$ was developed, analogous to Stefan's theory for tensile separation. The equations derived were in satisfactory agreement with the theory as far as the modulus of elasticity of the ribbons, the viscosity of the liquid, and the sample dimensions were concerned. Thus, tackiness measured by peeling, similarly to tackiness measured by tensile pull, has no connection with the theoretical forces of adhesion.

"THEORY OF PEELING THROUGH A HOOKEAN SOLID"

J. J. BIKERMAN, *Department of Civil & Sanitary Engineering, Massachusetts Institute of Technology, Cambridge 39, Massachusetts*

When the adhesive is a Hookean solid and the adhesive joint between a rigid plate and a flexible ribbon is peeled, the force required for peeling is $0.3799 w \sigma (E/E_1)^{1/4} \delta^{3/4} \gamma_0^{1/4}$, if w denotes the width of the ribbon, σ the tensile strength of the adhesive, E and E_1 the moduli of elasticity of the ribbon and the adhesive, respectively, δ the thickness of the ribbon, and γ_0

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Bryce Maxwell, Editor
The Princeton University
Plastics Laboratory
Princeton, New Jersey

the initial thickness of the adhesive film. If $\delta = y_0$, the ratio of tensile force to stripping force needed for separation is of the order of l/y_0 , l being the length of the ribbon.

"THE COALESCENCE OF LATEX DISPERSIONS"

GEORGE L. BROWN, *Research Laboratories, Rohm & Haas Company*

The process of coalescence of discrete polymer particles into a continuous polymer film is governed by the flow processes of the dispersion and of the polymer. It is proposed that the particles are brought into juxtaposition and then fused under the influence of the evaporating water, which acts by virtue of the adhesive force (between the polymer surface and the water) and the cohesive (tensile) strength of the water. This "capillary force" must be sufficient in magnitude and duration to overcome the resistance of the particles to deformation. An approximate mathematical solution is proposed.

Session 2, 2:00 - 4:30 P.M., Thursday, November 7th.

"THE DYNAMIC MECHANICAL PROPERTIES OF SOME FLUORINATED ELASTOMERS"

K. E. OWENS and C. A. DAHLQUIST, *Central Research Department, Minnesota Mining and Manufacturing Company*

The dynamic mechanical properties of several fluorinated elastomers were determined by use of the double transducer of Fitzgerald and Ferry. The measurements cover a temperature range of -40° to 100°C . and a frequency range of 24 to 5200 cps. The elastomers are the acrylic 3M Brand Fluororubbers 2F4 and 1F4, and Dow Corning Silastic Rubber LS-53.

Master dispersion curves of the compliances at 25°C . versus time have been obtained using the reduced variables treatment of Ferry. The position in the time scale and extent of the dispersion regions are discussed. The apparent heats of activation per chain segment and relaxation distribution functions were determined and are discussed in reference to the reported values of non-fluorinated rubbers.

"MECHANICAL RESONANCE DISPERSION IN CRYSTALLINE SOLIDS AT AUDIO-FREQUENCIES"

EDWIN R. FITZGERALD, *Department of Physics, The Pennsylvania State University*

Measurements of the complex shear compliance ($J^* = J' - iJ''$) of various crystalline solids at closely spaced frequencies in the audio-frequency range have resulted in the discovery of multiple frequency dispersions of the resonance type. Values of the loss compliance (J'') have sharply defined maxima in the region from 100 to 5000 cps; values of the storage compliance (J') rise to a maximum and then drop to pass through a minimum as a narrow (50 to 100 cps wide) dispersion region is traversed in the direction of increasing frequency. Pure polycrystalline metals, crystalline polymers, and inorganic crystalline compounds have been found to exhibit the effect. The results indicate the presence of a dispersion mechanism different from those leading to the relaxation dispersions previously found for polymers and metals. The magnitudes and locations of the resonances depend on the static stress history and state of the material as well as temperature. In some cases the resonances are removed by annealing at a raised temperature (e.g. 150°C for lead) and can be reintroduced by slight cold working. The dependence of the effect on static stress history suggests that motions of dislocations or other imperfections in the crystalline structure may be important in producing this type of dispersion. At present, however, there is no satisfactory explanation for these phenomena. In addition to their theoretical implications the results are of considerable practical importance since they indicate that certain materials may undergo large changes in mechanical properties at a particular frequency or frequencies.

"THE LOW TEMPERATURE TRANSITION IN POLYTETRAFLUOROETHYLENE"

N. G. McCURM, *Polychemicals Department, E. I. du Pont de Nemours & Co., Inc. Du Pont Experimental Station, Wilmington, Delaware*

The internal friction and torsion modulus of polytetrafluoroethylene have been measured from -160° to -40°C . The experiment proved unambiguously that there is a transition in the region of -100°C (1 cycle per second) and that it occurs in the amorphous regions of the polymer. A comparison is made of the experimental measurements with the predictions of a standard linear solid model.

"A TORSION PENDULUM FOR DYNAMIC AND CREEP MEASUREMENTS ON SOFT VISCOELASTIC MATERIALS"

DONALD J. PLAZEK, M. N. VRANCKEN, and JOHN W. BERGE, *Department of Chemistry, University of Wisconsin, Madison, Wisconsin*

An instrument designed to measure the mechanical properties of soft viscoelastic material with low loss has been built and tested. It is used as a free vibration torsion pendulum for obtaining low frequency dynamic mechanical properties (0.02 to 10 cps) and as a torsional creep apparatus capable of measurements involving very low stresses (e.g., 100 dynes/cm²). Since the disc-shaped samples are held between two parallel surfaces by means of a normal force, measurements can be made on materials whose consistencies defy clamping. The maximum angular deformation of the sample can be varied from 0.5 to 1.5 deg. The accessible temperature range is -35° to +75°C. Detection of the motion is accomplished with a reflected light beam, a barrier-type photocell and a Sanborn chart recorder.

Dynamic measurements made on the widely studied National Bureau of Standards polyisobutylene sample compared favorably with previous measurements from this laboratory and elsewhere. Similar experiments on a 10% gel of polyvinyl chloride in dimethylthianthrene showed that moduli as low as 10⁵ dyne/cm² and loss tangents as low as 0.07 could be satisfactorily measured.

"THE DYNAMIC MECHANICAL PROPERTIES OF A MODEL FILLED SYSTEM: POLYISOBUTYLENE — GLASS BEADS"

ROBERT F. LANDEL, *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California*

The dynamic mechanical properties of three dispersions of 40mu glass beads in NBS polyisobutylene were studied in the rubber-to-glass transition zone. These dispersions contained 8.7, 20.3 and 36.7 per cent beads by volume. The real and imaginary components of the complex shear compliances were measured in a Fitzgerald Transducer Apparatus at frequencies between 24 and 6000 cycles per second and at temperatures between -45 and 70°C. The temperature shift factors required to superpose the compliance data for the three dispersions are nearly identical to those for unfilled polyisobutylene. The reinforcement in the long-time end of the transition zone is predicted by the Guth-Smallwood equation:

$$M = M_0 (1 + 2.5 \phi_1 + 14.1 \phi_1^2),$$

where M_0 is the modulus of the unfilled polymer and ϕ_1 is the volume concentration of the filler. However, the filler broadens the dispersion curves and so the equation does not hold at shorter times. Certain similarities between the properties of the dispersions and those of crystalline polymers are described.

Session 3, 9:30 - 12:00 A.M., Friday, November 8th.

"FLOW PHENOMENA WITH OLEOGELS"

A. BONDI, *Shell Development Company, Emeryville, California*

A peculiar characteristic of most oleogels is the time dependence of their flow properties. Time scales varying over several powers of ten are associated with changes

in resistance to deformation under constant load and with the recovery after shearing has ceased.

Experimental data will be presented to illustrate the phenomena associated with different time scales. The significance of the observations for some technical properties is discussed. A few experimental observations can be explained in terms of known structural features of the gels. Examples are given for the few instances where semi-quantitative interrelation of flow properties has been successful.

"THE STEADY FLOW OF A SLIGHTLY VISCOELASTIC FLUID BETWEEN ROTATING SPHERES"

WILLIAM E. LANGLOIS, *Polychemicals Department, E. I. du Pont de Nemours & Co., Inc., Du Pont Experimental Station, Wilmington, Delaware*

The following case is considered. An incompressible, slightly viscoelastic fluid is contained between two concentric spheres which rotate slowly about a common axis of symmetry with different constant angular velocities. The motion thereby produced in the fluid is quite different from that which would result if the space between the spheres were filled with a Newtonian fluid. In addition to the rotary flow about the axis of symmetry, a secondary flow occurs in the meridional planes. The feasibility of designing a rheometer based upon this fluid motion is discussed.

"A PHOTOGRAPHIC STUDY OF LIQUID FLOW IN A ROLL NIP"

JOHN C. MILLER and RAYMOND R. MYERS, *Lehigh University, Bethlehem, Pennsylvania*

A roll system consisting of a cone rotating without slippage on a circular glass plate was constructed for the purpose of observing the flow of liquids in a roll nip.

High speed (two microsecond) photographs and high speed motion pictures of the liquid in the entire nip area were taken through the glass disc. The mechanism of splitting consists of 1. contact by the wet roll surfaces, and the formation of a bank; 2. compression, accompanied by laminar shear of the material through the nip; 3. decompression, resulting in a backward flow of the free liquid boundary, and 4. filamentation at the free boundary.

When the velocity-viscosity product attains a critical value, the decompression phase is characterized by cavitation. The resulting bubbles enlarge as they approach the filamentation region.

Cavitation rate, bubble size distribution, and rate of bubble growth were measured quantitatively. These variables are influenced by roll speed, force applied to the rolls, and film thickness. A force analysis of splitting suggests that surface tension is the most important force resisting separation. In some applications the pressure of the gas in the cavities may also be important.

"USE OF VISCOSITY MEASUREMENTS FOR STUDY OF ENTANGLEMENT IN POLYMER SOLUTIONS"

S. H. MARON, N. NAKAJIMA, and I. M. KRIEGER, *Department of Chemistry and Chemical Engineering, Case Institute of Technology, Cleveland, Ohio*

Application of the Ree-Eyring theory to the non-Newtonian flow of polymer solutions permits separation of the contribution of solvent to the total viscosity of the solution. From a study of this solvent contribution as a function of polymer concentration it is possible to evaluate a "swelling factor," and to study the effects of solvent, polymer concentration, and temperature upon this factor.

Such a study has been made with solutions of polystyrene in a number of solvents, and at several temperatures. The results obtained permit deductions to be made with respect to the state of entanglement of the polymer chains as a function of the above variables in both dilute and concentrated solutions.

"FLOW EXPERIMENTS WITH SPECIAL CAPILLARIES IN THE MCKEE WORKER-CONSISTOMETER"

HOBART S. WHITE and HARRIET V. BELCHER, *National Bureau of Standards, Washington, D. C.*

The McKee worker-consistometer consists essentially of two coaxial steel cylinders and mating pistons with a capillary shearing element between them. The material being tested is forced repeatedly through the shearing element, back and forth from one cylinder to the other. A special shearing element with a tapered capillary has been constructed, and flow data obtained with it have been compared with data obtained with a uniform bore capillary and a uniform bore capillary chamfered at one end. With polyisobutene-cetane solutions, degradation occurs at lower rates of flow and persists for a greater number of passes with flow entering the smaller end compared to flow entering the larger end of the tapered capillary. When degradation occurs in both directions at high rates of flow the pressure is larger for flow entering the larger end though after degradation has ceased the pressure (used to overcome viscous resistance) is less for flow in this direction, compared to flow entering the smaller end in each case.

Session 4, 2:00-4:30 P.M., Friday, November 8th.

"COOLING TIME OF STRONG GLASS FIBERS"

O. L. ANDERSON, *Bell Telephone Laboratories, Incorporated, Murray Hill, New Jersey*

Simplified equations for the cooling time of glass fibers to the solid state are deduced from the well-known general theory of heat conduction. The approximations made are based upon a value of the order of 1 for Nusselts number. This value of N_U holds for comparable metallic fibers, as measured by Mueller, and is assumed to hold for glass fibers. The relation of pulling speed and

flow rate to cooling time is shown. Calculations of cooling time of typical glass fibers are made, and it is observed that they are of the same order as the Maxwell relaxation time of the glass at the orifice temperature. The consequence of this correlation is discussed in terms of the high strength of fibers, and the high "fictive" temperature of fibers.

"ON RELAXATION SPECTRA IN HIGH POLYMERS"

B. ALBRECHT and A. M. FREUDENTHAL, *Columbia University, New York*

The spectrum of relaxation times has been constructed for a fabric-filled phenolic of commercial type by combining the results of torsion tests on cylindrical specimens over a relatively wide range of strain-rates and temperatures. The resulting spectrum is not unimodal and extends over almost sixty orders of magnitude; thus the mechanical response of high polymers at a certain combination of strain-rate and temperature can be determined only by tests at this same combination. Prediction of such performance requires a knowledge of the spectrum over its entire range.

"STRESS RELAXATION IN GLASS"

I. L. HOPKINS, *Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

Successive stress relaxation experiments on glass both at and below the fictive temperature show that in the latter case there is a gradual change in the glass during the test, resulting in this particular instance in a change in the total viscosity of over ten times. If it is assumed that the change in the glass is a shift of the relaxation spectrum with time such that all the relaxation times are multiplied by the same function of time-analogous to the a_T of Ferry and the $K(T)$ of Tobolsky associated with a temperature change — it is possible to find the manner in which this factor changes with time.

If the glass is preconditioned at constant temperature, not under stress, for a time sufficient to reach approximate equilibrium and a relaxation test then made, the relaxation curve differs in shape from those obtained from successive runs on another specimen of the same material which has been continually under stress. The latter curves have a greater negative slope than the former. This suggests that some structural change — perhaps devitrification — is inhibited by the presence of stress.

"APPROXIMATE EQUATIONS FOR INTERCONVERTING THE VARIOUS MECHANICAL PROPERTIES OF LINEAR VISCOELASTIC MATERIALS"

THOR L. SMITH, *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California*

Approximate equations are given for calculating the storage modulus G' , the loss modulus G'' and the stress

relaxation modulus $G(t)$ from the relaxation spectrum H , and similarly for calculating the storage compliance J' , the loss compliance J'' and the creep compliance $J(t)$ from the retardation spectrum L . Also, several equations — approximations to the exact equations of Gross — are given for interconverting H and L . All approximate equations are based on the assumption that $H = k \tau^{-m}$ and $L = g \tau^n$ over a relatively narrow region of the time-scale. To show the accuracy of the approximate equations, numerous calculations have been made using published data for the NBS polyisobutylene. These calculations show that most of the approximate equations are reasonably satisfactory for interconverting viscoelastic data for materials with broad spectra.

“THE VISCOSITY OF GASES”

J. ROSS and R. V. HANKS, *Department of Chemistry, Brown University, Providence, R. I.*

Measurements have been made of the absolute viscosity of some gases in a new capillary flow viscometer as a function of temperature in the range of -78°C . to 100°C . and as a function of pressure in the range of 5-300 atm. The apparatus permits the determination of the viscosity as a function of flow rate at a given temperature and pressure. The precision of the measurements is of the order of 0.02% and the accuracy is estimated to be better than 0.1%.

Session 5, 9:30 - 12 A.M., Saturday, November 9th.

“ON THE MOTION OF PLASTIC MASS”

COSIMO TORRE, *Syracuse University, Syracuse, New York*

This paper discusses the three-dimensional problem and the plane problem of the motion of plastic mass. The five unknowns in the three-dimensional problem were the three velocities, the mean pressure, and the density. There were also five equations: three equations of motion, the continuity equation and a general limiting condition in terms of rate of strains. The dynamical problem of torsion of a round bar was investigated as a special case of the three-dimensional problem with a yield condition containing quadratic and also linear terms. Finally, the dynamical plane problem of an ideal plastic body and the plane problem of a plastic body with a general limiting condition in terms of velocities were investigated.

“THE CREEP OF SNOW UNDER COMBINED STRESS”

JOSEPH K. LANDAUER, *U.S. Army Snow Ice and Permafrost, Research Establishment, Wilmette, Illinois*

Experiments have been performed on the creep of sifted snows under uniaxial, hydrostatic and confined side compressive stresses. The dependence of creep rate on stress (in the range 4 to 40 psi), time (up to several thousand seconds), temperature (between -3.6 and -13.6°C) and density (from 0.36 to 0.63 g/cc) was investigated. For one group of tests stress was applied for constant time increments while, for another group, stress was continued until an arbitrarily selected small change

in density was reached. The results are discussed on the basis of an additive theory for combined stresses.

“TIME DEPENDENCE OF MECHANICAL BREAKDOWN IN BUNDLES OF FIBERS: THE POWER LAW BREAKDOWN RULE”

BERNARD D. COLEMAN, *Mellon Institute, Pittsburgh 13, Pa.*

The problem of calculating the relationships between the strength of a bundle and the strength of its constituent filaments is discussed. Detailed calculations are done for the case in which the filaments are drawn from a first-order ensemble with the special property that the average lifetime of the filaments, when tested separately under static loads, varies as a power of the applied stress: $(t)_{av} = c \rho$. For this special case it is possible to derive some results which are independent of the functional form of $S(t)$. It is shown that for bundles with no interfiber friction (“ideal bundles”) the variance in the lifetime distribution always decreases with increasing number of filaments per bundle, N , regardless of the time dependence of the total load, $S(t)$. It is also shown that if ρ is greater than 1, then for all $S(t)$ the average strength of a bundle is less than the average strength of its filaments; the average strength decreases monotonically with increasing N but is not zero for infinite N . An asymptotic expansion, valid for large N , is obtained for the distribution of bundle lifetimes under an arbitrary loading history.

“THE TENSILE STRENGTH OF GRS ELASTOMERS”

LAWRENCE M. EPSTEIN, ROBERT P. SMITH

Specimens of purified GRS were crosslinked with from 0.2% to 4.0% decamethylene-bis-methyl azodicarboxylate. The network activity (i.e. number of stress bearing chains per c.c.) calculated from the quantity of crosslinking agent and polymer molecular weight was somewhat lower than that determined by swelling and equilibrium tension measurements, especially at low degrees of crosslinking.

Ultimate strength and elongation were measured at 2" per minute and at 20" per minute extension rate. These were also measured at 2" per minute on sets of specimens which were swelled with 70% by volume of mineral oil, sets from which the soluble polymer was extracted, and sets from which the soluble polymer was extracted and replaced with an equal volume of mineral oil. Attempts were made to interpret the results according to theories previously proposed for amorphous crosslinked elastomers.

It was observed that despite wide differences in tensile strength among the sets which received the various treatments noted above, the ultimate elongation varied relatively little. A theory for the ultimate elongation is proposed which is in good agreement with the data. It is based on the assumption that breakage of a specimen occurs when the number of broken chains per unit volume reaches a critical value. These broken chains are those which in the undeformed network have end-to-end distances closest to their contour lengths.

"SHEAR RATE DEPENDENCE OF THE VISCOSITY AND ELASTIC COMPLIANCE OF POLYMER MELTS-CORRESPONDENCE WITH A HYDRODYNAMIC THEORY OF VISCOELASTIC FLOW"

R. H. BOYD, *Polychemicals Department, E. I. du Pont de Nemours and Company, Inc. Du Pont Experimental Station, Wilmington, Delaware*

The variation of viscosity and steady state elastic compliance with shear rate of several typical polymer melts has been measured. The results are compared with the predictions of a hydrodynamic flow theory proposed by Y. H. Pao (J. App. Phys. 28, 591 (1957)). The agreement is satisfactory.

Session 6, 2:00-4:30 P.M., Saturday, November 9th.

"FRACTURE OF NON-NEWTONIAN FLUIDS AT HIGH SHEAR STRESSES"

A. B. METZNER, *University of Delaware, Newark, Del.*

While the fracture of polymer melts during extrusion has been the subject of several recent papers, no similarly quantitative data have been reported on suspensions of solids in liquids. This paper presents such data on TiO₂ suspensions in water and syrups.

Theories of the fracture phenomena of fluids are reviewed in the light of all available data. No definite choice of only one theory may be made at this time, but several theories are shown to be at sufficient variance with experimental facts to warrant their rejection.

"FLOW BEHAVIOR OF CONCENTRATED (DILATANT) SUSPENSIONS"

A. B. METZNER and MALCOLM WHITLOCK, *University of Delaware, Newark, Delaware*

The purpose of this work was to study the factors influencing the flow behavior of concentrated suspensions; particular emphasis was placed on study of the factors which determine the conditions under which dilatancy may occur. The most important variables studied were solids concentration and viscosity of the suspending medium.

It was found that the frequently quoted observation that dilatant non-Newtonian behavior occurs when a suspension has dilated volumetrically sufficiently to appear to be dry visually is not quantitatively correct. Instead, visual dryness was found to occur at shear stresses well below those at which rheological dilatancy occurred, as determined by inspection of the flow curve. Rheological dilatancy was found to increase with increasing shear stress; the shear stress at which it first occurred was nearly independent of both solids concentration and viscosity of the suspending medium. However, the solids concentrations must generally be high in order for dilatancy to occur at any shear stress. The ranges of the variables studied were:

Viscosity of the suspending liquid:	1-43 centipoises
Solids concentration:	0-64 by volume
Shear rates:	2-1,000 sec ⁻¹
Shear stresses:	0.1-13 psf (50-6,000 dynes/cm ²)

Particle diameters were varied from 0.5 to 100 microns, although most of the work was carried out with the smallest particles.

"FLOW OF AN INCOMPRESSIBLE VISCO-PLASTIC LAYER ON AN INCLINED PLANE"

P. R. PASLAY and A. SLIBAR

The complete solution, stresses and velocities, of the flow of a Bingham plastic on an infinite flat plate due to gravity forces is given. This solution has practical application in emulsion coating and paint technology. Selection of appropriate material constants for incipient flow from experimental data is discussed in the Appendix.

"THE CAPILLARY EXPERIMENT IN RHEOLOGY"

W. PHILIPPOFF and FREDERICK H. GASKINS, *The Franklin Institute, Philadelphia, Pennsylvania*

In previous publications we have shown that the potential energy in flow can be calculated from the applied shear stress τ and the "recoverable shear s ." Here the concept of a potential elastic energy existing in a liquid emerging from a capillary gives a means of determining s from the predicted and experimentally-found linear relationship between τ and the L/R ratio. With polyisobutylene solutions the calculated recoverable shears correlate satisfactorily with the measurements previously reported. This condition of potential energy in flow has also been noted with molten polyethylene and solutions of aluminum dilaurate.

This work was carried out as part of a Contract with the U.S. Army Chemical Warfare Laboratories, Army Chemical Center, Edgewood, Maryland. The assistance of this agency is gratefully acknowledged.

"THE RHEOLOGY OF VARIOUS SOLUTIONS OF CELLULOSE DERIVATIVES"

F. H. GASKINS, W. PHILIPPOFF, J. G. BRODNYAN and E. LENDRAT, *The Franklin Institute, Philadelphia, Pa.*

An investigation of the rheological properties of solutions of various cellulose derivatives in different solvents has been carried out in order to correlate the measurements using different instruments. In each investigation several of the following instruments, representing a variety of geometrical configurations, were used: (1) a conical cylindrical viscometer, (2) a high-pressure capillary viscometer, (3) a birefringence tester, (4) a Weissenberg Rheogoniometer, (5) a McKee Consistometer, and (6) a Ferranti-Shirley Viscometer. The results clearly prove the independence of the mechanical properties of the solutions from any particular geometry when the measurements are performed in the same range of mechanical variables.

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