Role of ultra high molecular weight polyethylene in paper industry

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UMWHDPE is a high density polymer having average molecular weight of 4 million. Due to high molecular weight this polymer has got certain extraordinary properties which make it far more superior over conventional materials used in paper industries. The different clothing accessories of paper making machine need high resistance against abrasion, wear & tear, chemical attack and last but not the least moisture resistance. Conventional materials like wood, rubber, leather, etc. can not meet these stringent property requirements due to intrinsic material characteristics and hygroscopic nature. Hence constant search for a suitable material which can improve the performance of paper making machine has led into the development of this novel polyethylene material. Suction Box covers made from UMWHDPE for paper machines in which the screen carrying the wet pulp passes over these covers and dewatering takes place in stages. Despite the very high screen speeds, abrasive wear is slight. Advantages from the use of UMWHDPE include long screen service life and low power requirement because of good slip properties of the material, simple finishing operations and high impact strength.

The main idea behind this paper is to acquaint the paper makers with the development of this new material and its specific applications in the paper making machinery vis-a-vis its superiority over other conventional materials.

RELATIONSHIP BETWEEN STRUCTURE AND PROPERTIES

The properties of polyethylene are affected by a number of factors such as the degree of branching (hence crystallinity and density), variations in the average molecular weight and molecular weight distribution, the chemical constitution and on the presence of impurities, this latter fact pertaining to high density polymer where metal oxide catalysts are utilised.

The degree of crystallinity affects the density, melting point softening point under load, Young's modulus and surface hardness. In all cases, the higher the degree of crystallinity, the greater the value of these properties. The rate of oxidation is dependent on molecular structure. The greater the number of branched chains present the more sensitive it is to oxidation, the point of attack being at the tertiary carbon atom which occurs in branched structures. Anti-oxidants are, therefore, normally incorporated into the polymer to prevent this occurring.

Molecular weight affects tensile strength, elongation at break, low temperature brittle point and resistance to environmental stress cracking. Increasing the molecular weight results in an improvement in these properties. Polyethylene which is essentially a high molecular weight parafin. has excellent chemical resistance. Its non-polar nature confers excellent electrical properties on the polymer.

The power factor and dielectric constant remain virtually unchanged over a wide range of frequencies and temperature, making it deal for high frequency work. The hydryphobic nature of the polymer also ensures that the water absorption is negligible. Consequently, high humidities have a minimal effect on electrical characteristics.

There are no strong intermolecular forces and most of the strength is due to the fact that crystallisation allows close molecular packing. Because of the low molecular forces, the polymer is endowed with a fairly low softening point.

Properties Mainly Dependent on Molecular Weight

Tensile Strength
Elongation fracture
Low Temperature brittle point

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Tear resistance (Notch impact)
Environmental stress cracking resistance.

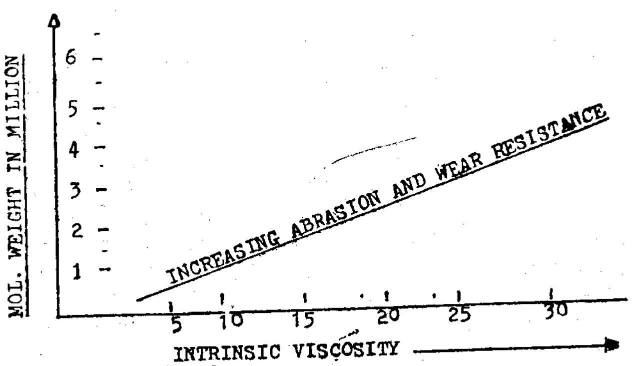
Properties Mainly Dependent on the Degree of Crystallinity

Density
Melting Point
Softening point under load
Elastic modulus
Stress and strain at yield point
Surface hardness
Permeability

Properties Virtually Independent of Molecular Weight or Degree of Crystallinity

Chemical resistance
Dielectric constant
Power factor
Electrical strength
Thermal conductivity
Thermal expansion
Specific heat.

As the molecular weight increases the intrinsic viscosity increases linearly as is evident from the following graph—



Intrinsic viscosity is a major physical property causing maximm resistance to wear and abrasion for which it has the advantage of usage over other engineering plastics, metals and wood. The subject material has the following properties

a) Light in weight.
b) Resistant to all attacking media, except strong oxidising acids.
c) No moisture absorption, does not swell and is resistant to the effects of weather.
d) Resistant to wear and abrasion.
e) Excellent sliding and self lubricating property.
f) High Notch-Bar toughness (High impact).
g) Can be used in the lowest temperature (-269°C, boiling point of Helium).
h) Best electrical properties.
i) Physiologically unobjectionable.
j) Readily machineable,

RAW MATERIAL

It is in the powder form. It is not indigenously available. There are mainly three manufacturers of this raw material in the world. The name of the manufacturers are –

a) Hoechst Dyes & Chemicals, west Germany.
b) Hercules In ernational Inc. U.S.A.
c) Mitsui & Co., Japan.

The trade name of the respective manufacturers are—

a) Hostalen GUR.
b) UHM—1900
c) HIZAX—Million,

Physical, mechanical, thermal and electrical properties of UHMW Polyethylene are given below. Our material which has been branded as SHALPLAST–4000 is based on Hostalen Gur and conforms to the properties as mentioned below—

a) Physical Properties

Property	Unit	Value
Density, moulded	g/cm³	0.94
Meld index	g/10 min	0.01
Bulk density	g/l	380—420

b) Mechanical Properties measured under standard climatic conditions of 23°C and 50%RH

Property	Unit	Value
Tensile Test Yield Stress (tensile strength)	N/mm²	22
Ultimate tensile strength	N/mm²	44
Break elongation	%	450
Limiting flexural stress	N/mm²	27
Torsional stiffness at+23C	N/mm²	250
at–40C	N/mm²	370
Ball indentation hardness 30 sec value	N/mm²	38
Shore hardness D	—	64 to 67
Notched impact strength	mJ/mm²	No failure

c) Thermal Properties

Property	Unit	Value
Dimensional stability under heat (Heat distortion temperature)	°C	95
Crystalline melting range	°C	135—138
Coefficient of linear expansion between 20 and 100°C	K^{-1}	2×10^{-4}
Thermal conductivity at 20°C	W/m.k	0.42
Specific heat at 20°C	kJ/kg.K	1.84

d) Electrical properties, measured under standard climatic conditions of 20°C and 45%RH

Property	Unit	Value Greater than
Volume resistivity	Ohm–cm	5×10^{16}
Surface resistance	Ohm	10^{13}
Dielectric strength	kV/cm	900
Bielectric constant at 2×10^{6} Hz	—	2.30
Dielectric loss factor at 50 Hz	—	1.9×10^{-4}

Volumetric wear for various materials in relation to SHALPLAST 4000 (=100) determined by the Sand Slurry Test—

Beechwood	PVC	Teflon	Mild Steel	Cast Iron	SHALPLAST–4000
2700	920	570	160	150	100

PROCESSING

Ram Extruder

Because of its high molecular weight and associated high melt viscosity, SHALPLAST-4000 cannot be extruded by ordinary methods, and as such, Ram Extrusion Process is generally employed. The operation is as follows :—

The powder is fed under gravity into the barrel of the ram extruder where it is compressed by a plunger. The compressed material in passing through the adjoining heated zone of the barrel undergoes plastication and finally emerges through the unheated end zone of the barrel, which acts as a sizing die. Here again the flow path must be designed so tnat on the hand no melt accumulation takes place and on the other hand rise in pressure occurs. The length of the heated zone depends on the profile dimensions and must be long enough for the powder to be completely plasticated throughout. The weld lines which occur with each plunger stroke fuse completely so that a homogeneous solid rod is formed. The processing temperature range is 180 to 200°C.

Press Moulding

The powdered material is compressed in a Hydraulic Press in the form of sheets/slabs using male and female type of mould boxes under specified temperature and pressure for a specific time needed for the individual thickness of the slab/sheets, and then allowing specific cooling time.

A certain amount of experience is required to achieve the optimum heating and cooling conditions, which are governed by the heat output of the press, the mould design, and the block thickness required.

Fabrication

Semi-finished material made from SHALPLAST-4000 can be sawn, turned, planed, milled, drilled, stamped and welded easily on wood working or metal working machines. The following general directions should be observed in these machining operations—

To obtain surfaces of high quality, tools should always be sharp; for most purposes normal tool steel is satisfactory though many fabricators use special steels.

The optimum cutting speed is between 250 and 1000 m/min. At lower cutting speeds cooling is not required, but at the higher cutting speed range, water cooling or the use of a cutting soluble oil as coolant is essential. In all cases care must be taken to avoid heat build-up in the machining operation, so that the workpiece does not smear the cutting edges. In milling and turning, the feed should not be too fast and the depth of tne cut should be greater than 0.3 mm.

APPLICATION IN PAPER MACHINE

Pulping and finishing operations requiring good wear resistance and low friction properties in both dry and wet environments make SHALPLAST-4000 an ideal material for clothing of paper making machinery. Typical application fields are listed below—

Bumper blocks	Pulp paddles
Chain guides	Pump channel linings
Contact rollers	Roll bearings
Conveyor slats	Screen Wire guides

Conveyor tracks	Screen wire strips
Deflector foils	Splitting wedges
Doctor blades	Stirrer blades
Felt suction lining	Suction box covers
Felt washer lining	Suction box linings
Forming boards	Suction roller packings
Gear wheels	Washer linings
Guide Rollers	Water lubrication bearings
Guillotine blocks	Water scrapers
Idler wheels	Wet side spur gears
Liners for paper pulp and gelling channels	Wire frame lining

Servicing and working

The use of SHALPLAST–4000 gives the paper makers the following advantages—

a) Substantial increase in wire life.

b) Reduction in power consumption on the paper machine, together with a simultaneous reduction of wire wear.

c) Outstanding abrasion resistance because of the extremely good coefficient of friction (0.08 to 0.09).

d) Resistance to all normal chemicals used in paper making.

e) Minimum maintenance and simple adjustments.

The material can be prepared according to the wishes of customers with any desired perforation, e. g. long round holes (also conical) herringbone or slots such as dovetail and other guides.

SHALPLAST-4000 for sealing mouldings, for round suction sleeves and suction rollers, bring particularly as compared with older materials, the following advantages—

No cracks, no fracturing and no armouring.

The material does not need servicing. It is not affected by any of the chemicals normally used in paper making and absorbs no moisture so that the quality and dimensional stability are maintained. Trimming and adjustments can be made the same way as on wood working machines.

Fixing is extremely simple-no roughening, no gumming, no LOSS OF TIME-only by pushing, fastening with sunken screws or with angle clips. Attention should be paid to the supporting bars to avoid sagging after long use. Care should be taken in erection to allow for a coefficient of expansion of 2×10^{-4} for each degree Centigrade (long holes etc.).

Tubular suction covers and their bars offer considerable advantages over previous profiles, in particular—

a) Quick mounting and changing when necessary.

b) A hardly measurable abrasion of the felt.

c) The special cover guarantee absolutely that no hair will be taken off and that there is no clogging or staining of the felt.

TECHNICAL COURSES

"A short intensive course on Heat Exchanger Design and Vibration Analysis will be held at Taj Mahal Hotel, New Delhi, March 19 to 21, 1984. Interested persons should contact".

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