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White paper on the realm of possibilities – HDPE, PVC extrusion, Injection and Blow Molding Industry

A. Delineating the drivers for the process – manufacturing excellence and GMP

A.1. Out lining the determinants for the HDPE and PVC extrusion processes and injection molding

A.1.1. Bond stability and flow properties of the molten polymer

a) The fundamental factors of establishing the bond strength and the exhaustion of the available sites for extending the chains and the linkages therein are influenced by the changes in the dielectric field of the polymer and the related breaking strength for the molecular disintegration.

b) The dielectric field in the polymer is of considerable strength and requires a threshold for disintegration; this value influences the MFI – molten flow index in a dynamic mode through the barrel and the extrusion pathway and hence is the nodal point of importance that requires regulation and monitoring to effectively engineer the product.

c) The trade-off between the crystalline and the amorphous regions in the structure of the polymer is the quality derivative that is functionally achieved in the polymerization process and has implications in the dynamic MFI controls; an oft ignored aspect in the industry with perilous consequences. The distribution of the potential bonding sites in the polymer structure is a mathematical expression influenced by the exhaustion, the conditions of temperature and molten state fluid pressure as also by the dielectric strength built into the system concurrently in the polymerization process.

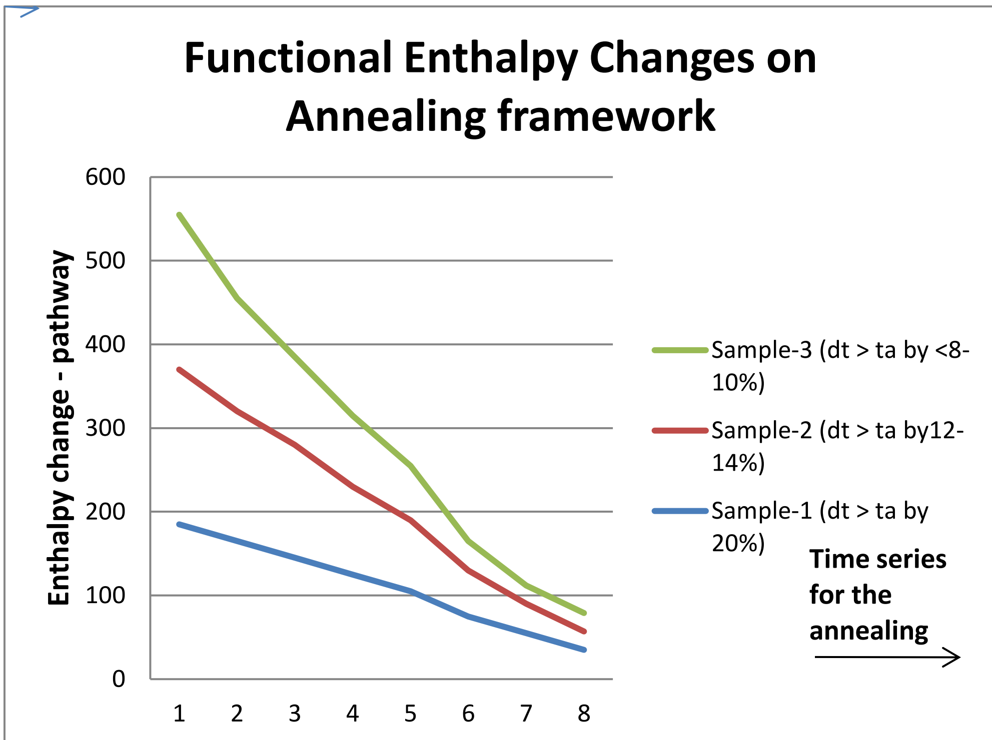
d) The shear line developed within the structure of the polymer shall be a definitive factor influenced by the bond strength and the relative distribution between the crystalline and amorphous regions that could merit a family of resistant frictional values in the flow parameters of the polymer at various stages of thermal kinetic energy in the proximity of the **t_α - the peak temperature wherein thermal agitation of the molecules and the bonds in the amorphous as well as crystalline regions are the highest in the zone below the melting point.** Structural changes in the polymer are influenced strongly by the visco-elastic behavior of the molten polymer at temperatures beyond **t_α**. These changes are permanent in nature and adversely affect the creep behavior to rupture of the extruded polymer;

influencing the secondary and tertiary coordinates quite radically. e) The strain properties of the structure exhibit radical changes with increasing temperature in the range of $\mathbf{t_m}$ and 15-20% higher bandwidth where $\mathbf{t_m}$ is the melting point of the polymer. The onset of thermal degradation reaches its maximum value at this zone and causes significant changes in the creep behavior of the extruded or injected polymer.

A.1.2. Annealing trajectory and the influences on secondary and tertiary creep points of extruded surfaces

Analysis of the influences of temperature differential over t_α on the enthalpy changes in the annealing of the polymer

Sample-1 ($\delta t > t_\alpha$ by 20%)	Sample-2 ($\delta t > t_\alpha$ by12-14%)	Sample-1 ($\delta t > t_\alpha$ by <8-10%)	Annealing time in ms^{-1}
185	185	185	$10 X (10)^{-3}$
165	155	135	$15 X (10)^{-3}$
145	135	105	$20 X (10)^{-3}$
125	105	85	$25 X (10)^{-3}$
105	85	65	$30 X (10)^{-3}$
75	55	35	$35 X (10)^{-3}$
55	35	22	$40 X (10)^{-3}$
35	22	22	$45 X (10)^{-3}$



Notes:

1. Rate of change in enthalpy as functionally caused by the release of heat during the annealing process defines the secondary and tertiary creep behavior of the extruded material – the key determinants for hydraulic stress and the overall rigidity in flexural attributes as well as the compressive strength besides recording the work done to rupture as a component of the elongation properties in the polymer. Accelerated rates of changes in enthalpies shall structure enhanced properties of the extruded pipes.

2. The residual stress within the structure is released owing to the annealing process and is directly influenced by the visco-elasticity pattern of the extruded polymer at $\boldsymbol{\delta t}$ – the key influence over the $\mathbf{t}_\alpha$ levels.

3. The shearing stress owing to the slides of the crystalline regions over each other at activated energy levels shall influence the key properties of flexural rigidity, torque at torsion – an important attribute that defines hydraulic stresses at bends and around elbows and finally the propensity to develop the micro rupture points across the cross-sections of the extruded pipes.

A.2.3. Draw and twist functions on the creep properties of the extrusion mechanism

Correlation of the fundamental factors of influence - extrusion and injection molding

Compressive Strength	Flexural rigidity	Stress at rupture	Elongation at rupture	δt	Barrel Time (minutes)
30	0.58	21.1	690	122	8
28	0.59	22.2	685	135	11
29	0.59	21.8	677	142	10
30	0.58	21.9	692	135	9
32	0.6	22.3	685	155	9
31	0.59	20.8	688	145	11
29	0.6	20.9	693	125	9
28	0.59	21.1	679	135	12
30	0.59	20.3	693	128	9
30	0.58	21.1	691	130	9
31	0.59	20.9	683	133	12
30	0.59	22.1	688	138	11

Notes:

1. The primary determinant in both extrusion and the injection molding process is the barrel dwell time and the **δ**t – the temperature differential between the $\mathbf{t}_\alpha$ and the final barrel temperature achieved in the critical mass of the molten polymer.

2. The properties of flexural rigidity and the stress at rupture and the elongation at break are all functionally determined by the draw and twisting properties of the extruded polymer in the barrel and hence are determined by the quality of frictional contact with the screw and the dwell time achieved. Shorter dwell times and effectively powerful driving forces of the screw shall bring in qualitative changes in the structural properties of the polymer thereby yielding better creep curves and qualitatively superior products.

3. The electrical drives are functionally important in achieving the best possible drive characteristics for the polymer during the extrusion and the subsequent injection molding process to ensure that the quality of impact never reduces in intensity.

B. Summarized road map on possibilities

SUMMARY OF GENERIC POSSIBILITIES - Business transformation models on a timeline					
Business Process Parameter	**Key Determinant**	**Impact in profitability**	**Recommended Changes**	**Performance Guarantee**	**Timeline for execution - validation - internalization loop**
Operations - costs of manufacturing	Dielectric Field of the polymer to achieve desired **δt**	40% reduction in costs of operations	Progressive usage of additives for controlling dielectric field	Within 3% tolerances	6 months or two financial quarters
	Drive quality - electrical		Regulating the temperature gradient and flow configuration of the molten polymer through improved drive quality		
	Injection quality - flux strength of hydraulic solenoids		Implementation of advanced engineering techniques for internalizing the CBM (condition based maintenance)		
	Barrel dwell time	30% line speed improvement			
	Annealing optimization				

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	Mechanical vibrations around mold	45% reduction in maintenance and repair costs inclusive of mold life	philosophy and radical improvements in quality of drives		
	Energy Management	30% reduction in energy bills	Harmonics reduction and PF improvements in the drives		
Strategic areas of financial re-engineering, brand development and product engineering	Sales Revenue	25%	Advanced Product Engineering and Sales Strategy	Within 3% tolerances	1 FY
	Costs of Sales	10% reduction			
	Margin growth	40%			
	Working capital debt reduction	50%			
	Long term liability reduction	20% over 1 FY			
	Equity and retained earnings management	Perpetual controls and higher order business process appraisal mechanism - internalizing MIS dashboard	Advanced statistical models for factoring online business process appraisals right through the organization	Shall validate effectiveness of the systems	

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<tr><th colspan="2">Consulting Team profile</th></tr>
<tr><td rowspan="2">Component-A: Operations</td><td>Debashish Banerjee - CEO - Blackstone Synergy with 1 project engineer</td></tr>
<tr><td>Credentials: Extensive manufacturing experiences with an integration of high end research on equipment design and engineering into the manufacturing strategy for retrofit solutions.

Credentials -2: Turnaround experiences across multiple domains</td></tr>
<tr><td rowspan="2">Component-B: Strategic areas of financial transformation riding on sales growth amid weakening macro fundamentals</td><td>Tanmoy Adhikary - Knowledge Partner at Blackstone Synergy</td></tr>
<tr><td>Credentials - Scripted high profile turnaround stories across multiple domains with over two decades of experience</td></tr>
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