101, VALLEY FIELD COURT, KOROSHO ROAD, off-Gitanga Road Kobil
petrol pump, NAIROBI – 00604, P.O. BOX: 23365

White paper on the realm of possibilities – Saroj Packaging Limited, Baddi plant

Abstract

The fundamentals of the operations shall be the key drivers in two major aspects of the business; the primary being in extending the brand perception and the secondary on improving the thresholds of operating performances on a radical note to lower the costs of manufacturing.

The assessment was executed to outline the roadmap on staggered steps of improvement at nominal levels of investments designed with a definite purpose to solve the problems on hand and hence should provide the insights to the management to eliminate the road blocks in bringing holistic changes to the fore on definite timelines riding on performance guarantees.

The assessment has factored in ground realities in the plant and the roadmap has been designed for the seamless implementation of the possibilities on the existing infrastructure and with the current constraints in the process.

The underlying assumption for the roadmap is the clarity in perception that additional investments in terms of manpower or the fundamental infrastructure of equipment shall not be required in establishing the causal links of process and product improvements in the business process.

A. Process determinants – the causal links for the business process excellence

1. Determinant-1: Product Mix

1.1. Illustration on the mixing dynamics corresponding to the given product mix.

The template given hereunder and the data acquired real time in the factory should be taken as major illustrations for the product mix compatibility for the ingredients and the states of polymerization achieved prior to dispensation.

The noted therein following the illustrations in the template shall clarify the meat of the matter in unambiguous terms to the discerning reader and the technical teams involved in the process.

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POLYMERIZATION DYNAMICS FOR GAUGE 35			
Ingredients	**Role**	**Quantity**	**Ratio**
PVC	Key process ingredient	50	47%
Resin	Monomer - polymerizing agent	50	47%
BA-20	Exhaustion agent	1.1	1%
B-22		3	
Epoxy	Binding agent	3	3%

Mixer performance analysis					
Temperature gradient	R	Y	B	**kW Rating**	**55**
56-58	44.9	46.5	43.3	77.8	79%
62-68	47.9	48.1	45.4	81.7	82%
75-82	48.6	48.9	49.1	84.6	85%
87-90	49.2	50.8	50.7	87.0	88%

Notes:

a) The product mix for PVC typically has the main polymer, the linking resin or monomer that builds the chain, the cross-linking polymers that form bonds with both the PVC polymer and the monomer to enable exhaustion of the available sites in the main polymer and finally the epoxy binders that build additional strengthening bonds for covering the reactions for chain extensions.

b) Primarily, the key drivers are determined by the ratios going into the product mix and would need a selection of advanced indicators for determining the veracity of the ingredients in achieving the quality differentiation that would eventually lead to higher line productivity and operating speeds as well.

Intrinsically optimized ratios in the product mix shall increase the rate of exhaustion of the polymeric sites leading to a sharper temperature gradient

Dynamics for the states of polymerization				
Time	**Actual progression of time**	**Sensor temperature**	**% change in process (polymerization) enthalpy**	**Polymerized surface temperature**
t_1	2	55	3.3%	95
t_2	3	58		
t_3	4	60	5.6%	
t_4	6	65		
t_5	7	68	5.6%	
t_6	8	73		
t_7	9	77	5.6%	
t_8	10	82		
t_9	11	88	2.2%	
t_{10}	12	90		

c) The product mix shall be defined by the level of quenching in the main polymer; in other words, the fundamentals of exhausting the available sites in the chain. A measure of quenching is the frictional resistance to the blades of the impeller of the agitator in the mixer. Higher the resistance, greater shall be the current registered as the polymerization progresses and vice versa. Therefore, the measurement of the current being drawn by the mixer motor is a measure of the level of polymerization with progression in the process cycle and is certainly the lead indicator in the determinant of product mix.

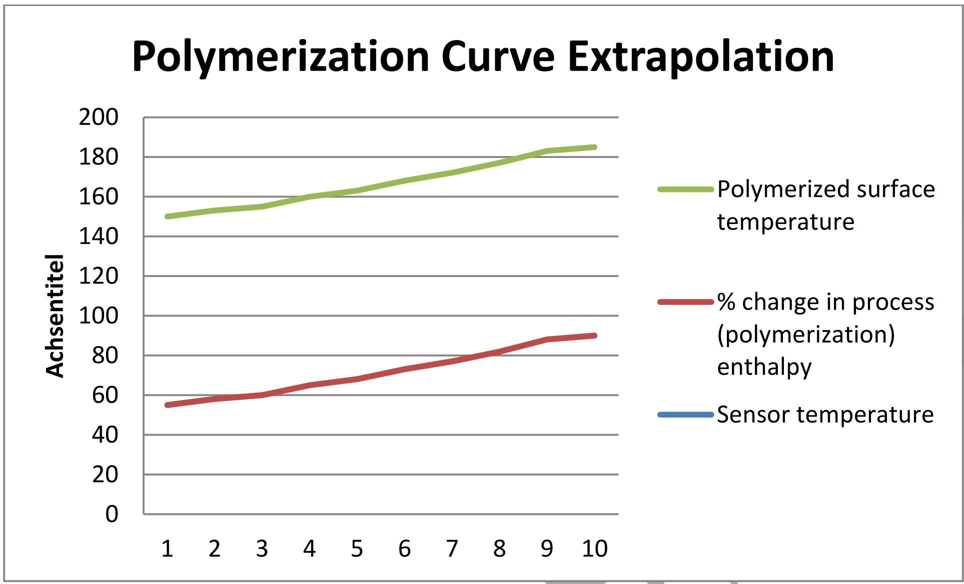
***Ideally, the recorded current in the mixer motor should progressively show lower values as the polymerization stabilizes to the equilibrium coordinates*.**

d) The time take to reach the polymerization cycle parameter of 90 degrees Celsius is the other important indicator for the product mix determinant. Lower is the time to reach process maturity; greater is the pace of exhaustion of available sites in the polymer and vice versa.

Graphical representation of the polymerization dynamics			
Actual progression of time	**Sensor temperature**	**% change in process (polymerization) enthalpy**	**Polymerized surface temperature**
2	55	1.7%	95
3	58	1.7%	95
4	60	2.8%	95
6	65	2.8%	95
7	68	2.8%	95
8	73	2.8%	95
9	77	2.8%	95
10	82	0.0%	95
11	88	1.1%	95
12	90	0.0%	95

e) The actual surface temperature on the mix as recorded prior to the dispensation is another important indicator for the product mix determinant.

The curve slopes shall define the rate of exhaustion and the gap between the sensor temperature and the surface temperature shall define the residual activity in chain building with the concomitant enthalpy changes within the structure as also the coordinates of enthalpy equilibrium built into the polymer structure at maturity prior to extrusion.



1.2.Final points of understanding for the polymeric process:

1. A steeper curve with abrupt changes in enthalpy should be preferred on tinkering with the product mix to appreciate the rate of exhaustion or quenching of sites.
2. The gaps between the sensor and the surface temperatures should be the primary determinant in understanding structural equilibrium. Larger gaps indicate higher residual enthalpy or implications of unstable polymeric chains leading to potential gauge and tensile differences between the cross-sections while narrower gaps would imply higher structural stability.
3. The discerning of this polymeric curve for each batch going into the product mix shall be the foundation for a broader and deeper understanding of the polymeric process and consequently shall help the teams to define the efficacy of the extrusion and the quality of the sheeting therein with higher thresholds of accuracy.

2. Determinant-2: Extrusion quality

2.1. Illustrations of the extrusion quality

Extruder Motor dynamics				
R	Y	B	**kW Rating**	**55**
84.6	82.8	88.3	147.7	149%
83.7	82.5	89.6	147.8	149%
84.8	87.1	89.6	151.0	153%
85.7	84.9	89.3	150.1	152%
Phase Imbalances		**3.05%**		

Drive roller dynamics				**Draft**
Coupling Temp.	**Shaft Temp.**	**Film Temp.**	**Surface speed in m/min**	
127	164	161-162	5.8	1.17
100	149	134-148	6.8	
119	157	131-138	7.5	1.10
110	163	122-126	8.2	
102	150	86-87	9.2	1.12

Notes on the illustrations:

a) The film temperatures should be a function of the glass transition temperature of the PVC in order to extract the best possible gauge and tensile properties with nominal drafts in the film prior to annealing.

b) At higher temperature gaps with respect to the glass transition, the degradation of the chains set in causing depreciation in tensile properties as also in the variances that shall be observed in gauge of the film after the completion of the annealing process.

c) The **major indicator** in the extrusion process determinant is the **film temperature achieved** immediately after the extrusion. Considering that the **PVC t_g or glass**

transition is 81^0 Celsius, the current film temperature is way more than the **scientific threshold of 20% higher values ideally.**

d) The extruder motor should be operating at 70% load and this can be achieved through a rewinding of the motor with wire specifications that are significantly different from the current design, lowering the barrel temperature to 25-40% higher than **the t_g of 81^0** Celsius and eventually installing the **RPC – reactive power controller** to control PF and assist in filtering harmonics in the system to achieve **THD% of <3% from the present levels of > 25%.**

e) **The draft** in the film should be ideally **close to 1 or less than 0.99** to achieve a **mechanically stable equilibrium <u>for the molecular coordinates in the structural lattice of the polymeric chain.</u>**

f) **Coupling temperatures** should **<u>never exceed 65^0 Celisus</u>** and the design flaws in the **Thermic fluid circulation system would need to be corrected through re-engineering initiatives**.

2.2. Final points for consideration on the extrusion quality