

2017

FOAM
MATTRESSES
LIMITED – group of
companies

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SUMMARIZING THE BUSINESS TRANSFORMATION MODELS:

**[BLACKSTONE SYNERGY
PROPOSALS - ENERGY,
OPERATIONS AND STRATEGIC
OVERHAUL OF THE BUSINESS]**

This is a treatise for the progressive business transformation modeling amid debilitating macro-indicators and varied challenges to the business dynamics in Kenya and much of East Africa

A. OPERATIONS:

1. Reworking on the key components of the energy and the process derivatives to quantify the product configuration in terms of measurable quality and the mapping of the process variables. This shall empower the process teams to work on quantified measures and improve and maintain the product lines on lower bandwidths of consistency over longer process run times.
2. Implementing the solutions to improve product profiles that can command higher pricing premiums, significantly change the cost dynamics of the various products through the improvements in the process yield and productivity in the run times for cycle completion and finally creating the reproducible formulation to establish product leadership with a greater degree of assured interventions.
3. Creating the robust process appraisal systems to establish the accountability grid with greater accuracy and assured returns on the investment on manpower.

B. STRATEGIC INITIATIVES IN PRODUCT ENGINEERING, BRANDING AND SALES:

1. Implementing the higher order product engineering techniques to build robust systems of evaluation of the product and establishing knowledge leadership amongst the market peers.
2. Effectively factoring the product consistencies and innovations within the given infrastructure to build on reliability and quality in the brand statement and articulate the same aggressively to the clientele and extract greater understanding of the superiority command over the peers in the realm of process engineering.
3. Building lasting roadmap to extract pricing premiums at various levels in the product range and expand the segments covered.

C. CREATING SHIFTS IN PARADIGMS FOR POSTERITY

1. Exhaustive business process appraisal for objective analysis by the apex management for long term decision making.
2. Reviving the dormant businesses through the sales and production strategies.

A. EXECUTIVE SUMMARY OF THE ATHI RIVER PLANT

<u>Business</u>	<u>Key challenges</u>	<u>Solutions</u>	<u>CTC – cost implications to the company</u>	<u>Timeline for implementation</u>	<u>Performance Guarantees</u>
ATR - foaming	Preparation of polymeric states	Stirrer design for 30% vessel volume occupancy with 200-400 rpm for polyols and 100 rpm for the TDI and other ingredients	200,000	1 week	20% pricing premium riding on quality
	Mixture motor	RPC – reactive power controller for harmonic controls <3% and correction of PF to >0.85 on the individual drive motors for stirrer, mixer and compressor and the generator	2,000,000	2 days for commissioning and 4-6 weeks for procurement	10% margin on reducing the polymer (polyol mixing) costs
	Structural consistency of the various density products	Advanced quality control through TGA, DSC measures and calibrating the right formulation with reproducible measurable quality parameters	50,000 / month for regular QC process at both sites – ATR and Kisumu	Institutionalizing in 1 month across the rank and file	20% improvement on process yield
	Re-bonding	Compressor overhaul to ensure that it works at 5 bar with the right dosage of the solvent onto the PU crumbs and get the right re-bonding product with structural density variation reduced to <5% from current levels of >20%	NA – routine maintenance and replacement of leaking pipes (<=150,000)	1 week	20% on energy savings on the compressor
	Spring Mattresses	The selection of coils within a given pitch and the resulting compressive strength needs optimization in a dynamic process	NA – routine procedures to be standardized	During actual process runs – real time	Pricing premium over the competition – 10%

B. EXECUTIVE SUMMARY OF THE KISUMU PLANT - FOAMING

<u>Business</u>	<u>Key challenges</u>	<u>Solutions</u>	<u>CTC – cost implications to the company</u>	<u>Timeline for implementation</u>	<u>Performance Guarantees</u>
Laader Berg and Chinese - foaming	Preparation of polymeric states	Stirrer design for 30% vessel volume occupancy with 200-400 rpm for polyols and 100 rpm for the TDI and other ingredients	300,000	1 week	20% pricing premium riding on quality
	Chilling Effectiveness	Optimizing the parameters of the cooling tower to enhance chilling effectiveness	NA – routine maintenance	2-3 working days	Polymer temperature of 20 degrees Celsius at the mixer point instead of current levels of 28 degrees Celsius
	Mixture motor	RPC – reactive power controller for harmonic controls <3% and correction of PF to >0.85 on the individual drive motors for stirrer, mixer and compressor and the generator	2,000,000	2 days for commissioning and 4-6 weeks for procurement	10% margin on reducing the polymer (polyol mixing) costs
	Structural consistency of the various density products	Advanced quality control through TGA, DSC measures and calibrating the right formulation with reproducible measurable quality parameters	50,000 / month for regular QC process at both sites – ATR and Kisumu	Institutionalizing in 1 month across the rank and file	20% improvement on process yield
	Re-bonding	Installation yet again for effective working and higher order efficiency	NA – routine maintenance	1 week	Pricing premium of 10%

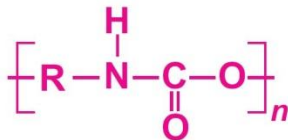
C. EXECUTIVE SUMMARY OF THE KISUMU COMPLEX – PLASTIC BUSINESS

<u>Business</u>	<u>Key challenges</u>	<u>Solutions</u>	<u>CTC – cost implications to the company</u>	<u>Timeline for implementation</u>	<u>Performance Guarantees</u>
Kisumu injection molding - Plastics	Preparation of PPR molten polymer	Dosing with strong anti-static agents and elimination of static electricity in the barrel to improve on the MFI – molten flow index	300,000 (one-off investment)	1 week	20% improvement in productivity with 15% increased strength
	Actual injected load <90% of the designed injected load	Overhaul of the hydraulic solenoids to achieve >95% of the designed injection load on the mold	300,000 at external site and from thereon on AMC – annual maintenance contract with reliable service providers	1 week	Working mold temperature shall be reduced leading to lower dimensional inaccuracies and lower vibrations shall reduce defects on the mold
	Extruder motor	RPC – reactive power controller for harmonic controls <3% and correction of PF to >0.85 on the individual drive motors for stirrer, mixer and compressor and the generator	2,000,000		20% improvement in mixing costs through improved yield
	Structural consistency of the various density products	Advanced quality control through TGA, DSC measures and calibrating the right formulation with reproducible measurable quality parameters	50,000 / month for regular QC process at both sites – ATR and Kisumu	Institutionalizing in 1 month across the rank and file	20% improvement on process yield and higher strength realization

The White paper on the foaming plants – Tuff Foam brand

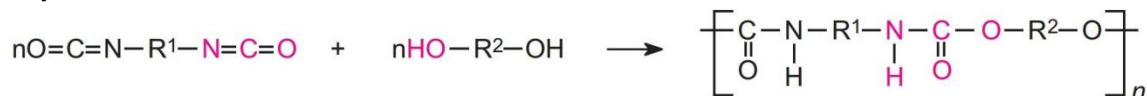
1. Properties of the polyurethane polymerization process

1.1. Chemistry



The polymeric materials known as polyurethanes form a family of polymers which are essentially different from most other plastics in that there is no urethane monomer and the polymer is almost invariably created during the manufacture of a particular object.

Polyurethanes are made by the exothermic reactions between alcohols with two or more reactive hydroxyl (-OH) groups per molecule (diols, triols, polyols) and isocyanates that have more than one reactive isocyanate group (-NCO) per molecule (diisocyanates, polyisocyanates). For example a diisocyanate reacts with a diol:



The group formed by the reaction between the two molecules is known as the 'urethane linkage'. It is the essential part of the polyurethane molecule.

1.2. Manufacture of polyurethanes

As polyurethanes are made from the reaction between an isocyanate and a polyol, the section is divided into three parts:

- a) production of isocyanates
- b) production of polyols
- c) production of polyurethanes

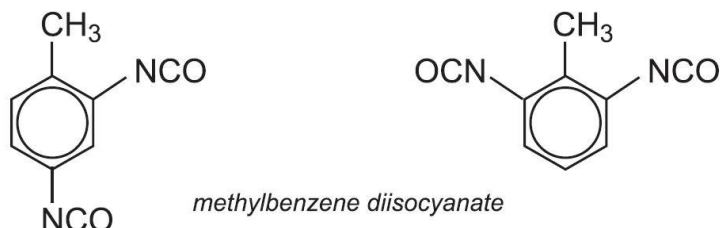
(a) Production of isocyanates

Although many aromatic and aliphatic polyisocyanates exist, two are of particular industrial importance. Each of them has variants and together they form the basis of about 95% of all the polyurethanes. They are:

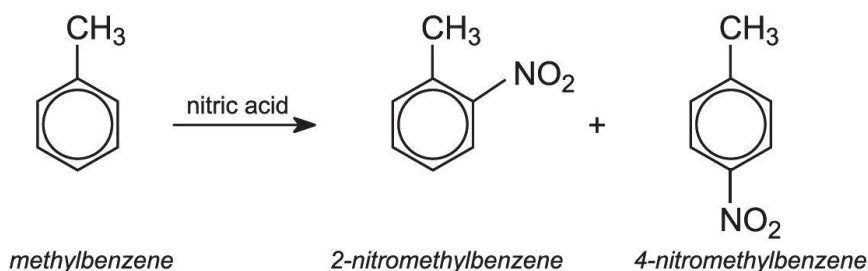
- **TDI** (toluene diisocyanate or methylbenzene diisocyanate)
- **MDI** (methylene diphenyl diisocyanate or diphenylmethane diisocyanate).

TDI was developed first but is now used mainly in the production of low density flexible foams for cushions.

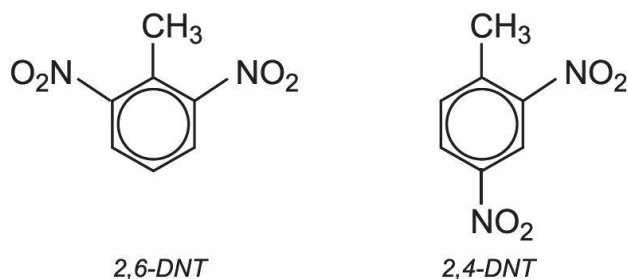
The mixture of diisocyanates known as TDI consists of two isomers:



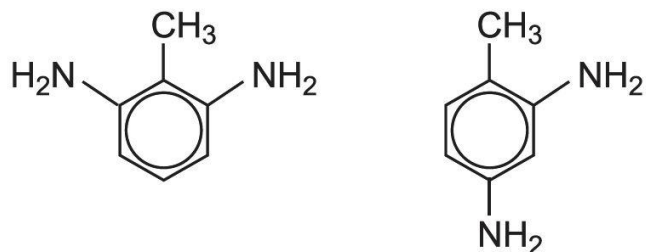
The starting material is methylbenzene (toluene). When it reacts with mixed acid (nitric and sulfuric), two isomers of nitromethylbenzene (NMB) are the main products.



If this mixture is nitrated further, a mixture of dinitromethylbenzenes is produced. In industry they are known by their trivial names, 2,4-dinitrotoluene and 2,6-dinitrotoluene (DNT). 80% is 2,4-DNT and 20% is 2,6-DNT:

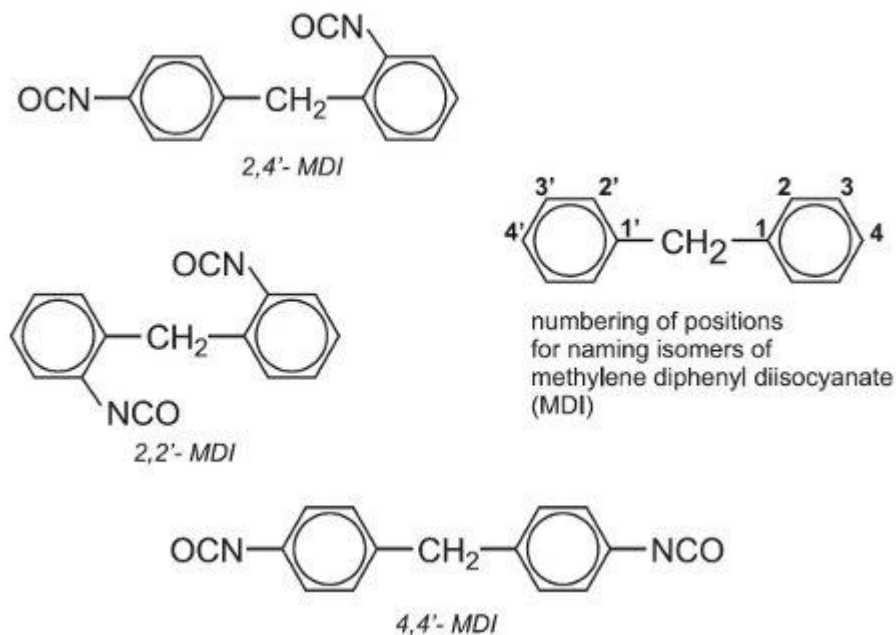


The mixture of dinitrobenzenes is then reduced to the corresponding amines:



In turn, the amines, known commercially as Toluene Diamines or TDA, are heated with carbonyl chloride (phosgene) to produce the diisocyanates and this process can be carried out in the liquid phase with chlorobenzene as a solvent at about 350 K:

MDI is more complex and permits the polyurethane manufacturer more process and product versatility. The mixture of diisocyanates is generally used to make rigid foams. The starting materials are phenylamine (aniline) and methanal (formaldehyde) which react together to form a mixture of amines, known as MDA (methylenedianiline). This mixture reacts with carbonyl chloride (phosgene) to produce MDI in a similar way to the manufacture of TDI. MDI contains the following diisocyanates:

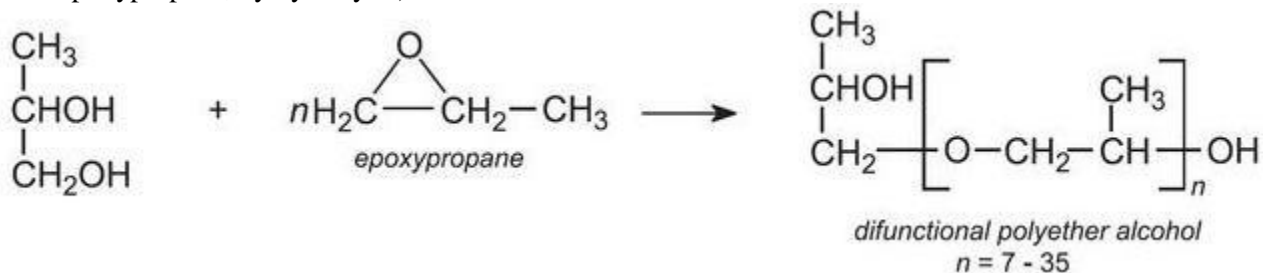


The term MDI refers to the mixture of the three isomers in Figure 3. They can be separated by distillation.

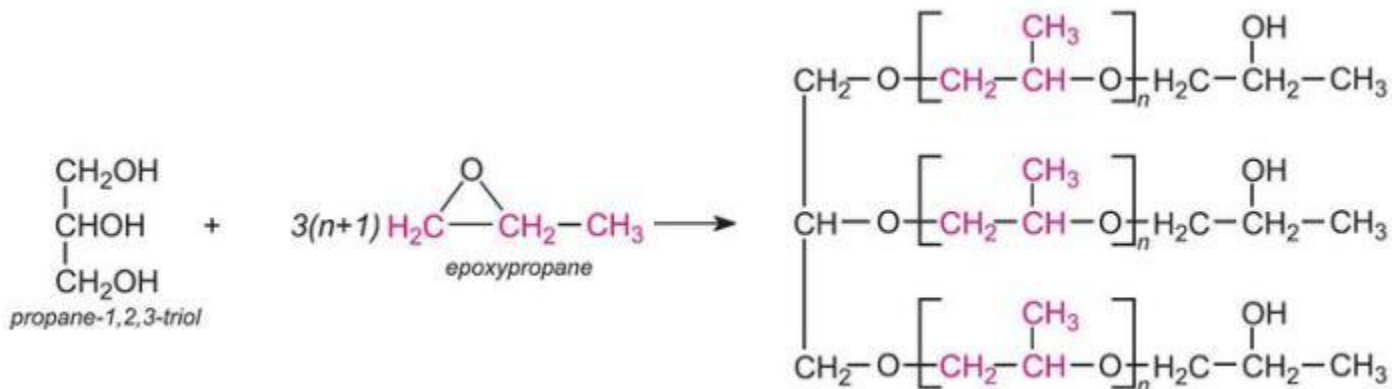
(b) Production of polyols

The polyols used are either hydroxyl-terminated polyethers (in about 90% of total polyurethane manufacture) or hydroxyl-terminated polyesters. They have been developed to have the necessary reactivity with the isocyanate that will be used and to produce polyurethanes with specific properties. The choice of polyol, especially the number of reactive hydroxyl groups per polyol molecule and the size and flexibility of its molecular structure, ultimately control the degree of cross-linking between molecules. This has an important effect on the mechanical properties of the polymer.

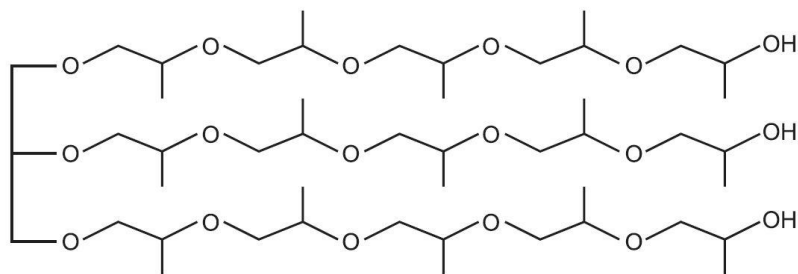
An example of a polyol with two hydroxyl groups (ie a long chain diol) is one made from epoxypropane (propylene oxide), by interaction with propane-1,2-diol, (which itself is formed from epoxypropane, by hydrolysis):



An example of a polyol which contains three hydroxyl groups is produced from propane-1,2,3-triol (glycerol) and epoxypropane:



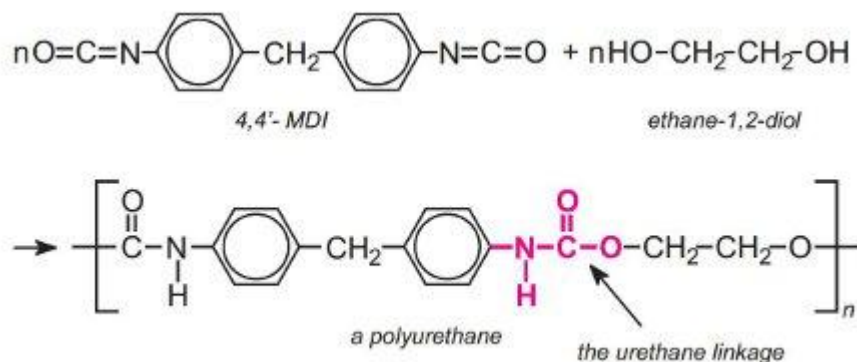
which may be represented as this idealised structure:



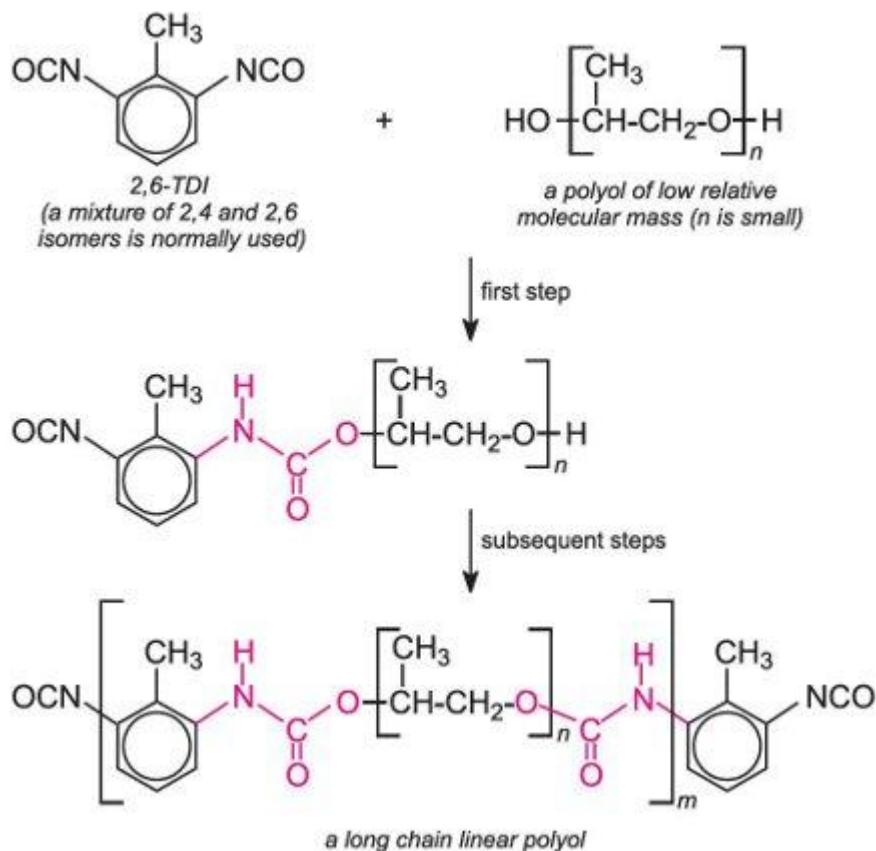
Soya bean oil contains triglycerides of long chain saturated and unsaturated carboxylic acids, which, after hydrogenation, can, on reaction with epoxypropane, form a mixture of polyols suitable for the manufacture of a wide range of polyurethanes. The use of these biopolols means that at least part of the polymer is derived from renewable sources.

(c) Production of polyurethanes

If the polyol has two hydroxyl groups and is mixed with either TDI or MDI, a linear polymer is produced. For example, a linear polyurethane is produced by reaction with a diisocyanate and the simplest diol, ethane-1,2-diol, a condensation polymerization occurs:



A much used polyurethane is made from TDI and a polyol derived from epoxypropane:



If the polyol has more than two reactive hydroxyl groups, adjacent long-chain molecules become linked at intermediate points. These crosslinks create a stiffer polymer structure with improved mechanical characteristics which is exploited in the development of 'rigid' polyurethanes. Thus a diisocyanate, such as MDI or TDI which reacts with a polyol with three hydroxyl groups, such as one derived from propane-1,2,3-triol and epoxyethane, undergoes crosslinking and forms a rigid thermosetting polymer.

As well as polyisocyanates and polyols, the manufacture of polyurethanes needs a variety of other chemicals to control the polyurethane-forming reactions and to create exactly the right properties in the end-product.

All practical polyurethane systems include some, but not necessarily all, of those described in Table 2.

Additives	Reasons for use
catalysts	to speed up the reaction between polyol and polyisocyanate
cross-linking and chain-extending agents	to modify the structure of the polyurethane molecules and to provide mechanical reinforcement to improve physical properties (for example, adding a polyisocyanate or polyol with more functional groups)
blowing agents surfactants	to create polyurethane as a foam to control the bubble formation during the reaction and, hence, the cell structure of the foam
pigments	to create coloured polyurethanes for identification and aesthetic reasons
fillers	to improve properties such as stiffness and to reduce overall costs
flame retardants	to reduce flammability of the end product
smoke suppressants	to reduce the rate at which smoke is generated if the polyurethane is burnt
plasticisers	to reduce the hardness of the product

Manufacturing

As an example, consider the manufacture of a moulded item that might otherwise be made from a thermoplastic polymer by injection moulding. To make it of polyurethane, it is necessary to mix exactly the right masses of the two major components (polyisocyanate and polyol), which must be liquids. The reaction starts immediately and gives the solid polymer. Depending on the formulation, the catalysts used and the application, the reaction is typically completed in between a few seconds and some minutes. In this time, therefore, it is essential to dispense the reacting liquid mixture into the mould and also to clean the combined 'mixing and dispensing' equipment ready for the next operation. The exothermic chemical reaction is completed within the mould and the manufactured article can be taken from the mould immediately.

Foamed polyurethanes

When the two liquids react, a solid polymer is formed. The polymer may be elastic or rigid. However, it may also contain bubbles of gas so that it is cellular - a foam.

When producing a foamed polyurethane, there are two possible ways to generate a gas inside the reacting liquid mixture. The so called chemical blowing uses water that may have been added to the polyol which reacts with some of the polyisocyanate to create carbon dioxide:



Alternatively (physical blowing), a liquid with a low boiling point, for example pentane, is mixed into the polyol. The reaction is exothermic and so, as it proceeds, the mixture warms up and the pentane vaporizes.

A tiny amount of air is dispersed through the mixture of polyisocyanate and polyol. This provides nucleation seeds for the multitude of gas bubbles that are produced throughout the polymer. Heat makes the bubbles expand until the chemical reaction changes the liquid to solid polymer, and the available gas pressure cannot create any further expansion.

A shoe sole, for example, may be 'blown' to double the volume of solid polymer. This process is so versatile that the expansion can be taken much further. In low-density foams for upholstery or thermal insulation less than 3% of the total volume is polyurethane. The gas has expanded the original volume occupied by the liquid by 30 to 40 times. In the case of cushions, only just enough solid polymer is needed to ensure that we can sit comfortably.

In thermal insulation, it is the gas trapped in the cells which insulates. The polymer that encloses the cells reduces the insulation efficiency, so it makes sense to have as little of it as possible.

1.3. Enthalpy and effects of particle size on the polymerization process

Foam is a colloidal suspension of a gas in a liquid created by agitation. Foams are cushiony materials formed by the creation of gas bubbles in a base material such as natural rubber, synthetic rubber or other elastomeric materials. A plastic or also known as polymeric foam material consists of a gas phase dispersed in a solid plastic phase and derives its properties from both. The dispersed phase of the foam is usually called the internal phase (air or gases), whereas the continuous phase, external (polymeric material). The solid plastic component forms the matrix. The gas phase is contained in voids or cells and is often referred to as the blowing or foaming agent. However, the blowing agent used in the production of foams is not always gaseous and chemically identical with the gas component. Some blowing agents are solids and some are liquids. The term cellular plastic, a synonym for plastic foam, is derived from the structure of the material.

The cell structure depends on the process used for the production of the foamed plastic. In some cases, both flexible and rigid foams may be produced with either open or closed cells. Generally, no foam has entirely one type of cell structure.

Open- or closed-cell structure implies that the number of cells in the foam is predominantly open or closed, respectively. Open-cell structure foam contains pores, which are connected to each other to form an interconnected network. This kind of foam has a comparatively lower density and a sponge-like appearance. Open-cell foams have sound absorbing properties and, when flexible, cushioning characteristics.

Closed-cell structure foam does not have a network of connected cells. It is a solid foam material. Normally this kind of foam has higher compressive strength due to its structure. This kind of foam has a higher dimensional stability, absorbs less moisture and has higher strength when compared to open-cell foam. Its structure makes it have a harder surface feel and makes it better at absorbing impacts. In this type, we have the syntactic foam - a special class of foam that contains hollow particles embedded in a matrix material.

Polymeric foams may be flexible, semi-flexible (or semi-rigid) and rigid, depending on chemical composition and the rigidity of the resin used as a matrix and the type of cross-linking that exists between the molecules. Flexible foams have a glass transition (T_g) below room temperature, whereas rigid foams have one above room temperature.

The matrix is made up of the base resin and other compounding ingredients that may include plasticizers, stabilizers, surfactants, dyes and pigments, fire retardants and fillers. The composition of the plastic matrix plays an important role in determining foam properties such as chemical resistance, thermal stability, flammability, specific heat, transition temperature and rigidity. With respect to the base resin of the matrix, plastic foams may be either thermoplastic or thermosetting.

Thermoplastic foams are based on linear or slightly branched (non-cross-linked) polymers and thus have properties normally associated with thermoplastics. They exhibit a definite melting range and are generally susceptible to attack by organic solvents. With thermoplastic foam systems the

polymerization of the base resin is generally completed first, and the polymer then compounded, melted and foamed. In contrast, thermosetting foams the matrix of these foams is based on cross-linked polymers so that, like the bulk plastics from which they are derived, they have generally good resistance to solvents and most chemicals. Although some show limited plastic flow at elevated temperatures, thermoset foams do not usually exhibit a melting range and can often be used at higher temperatures than thermoplastic foams (there are exceptions).

Thermosetting foams include: Polyurethane has very high thermal resistance for given thickness, low water absorption and low water vapor permeability; good thermal stability and good adhesion.

Versatility of polyurethanes comes from the unique synthesis of them, which is owned to the reaction of a range of isocyanates as well as a wide range of polyols.

Energy within the polymeric dispersion is a function of the reactive groups and is defined by the nature of the termination of the cross-links and the concentrates of the chain extenders working on these. In the case of polyurethane formation, the isocyanate groups $=\text{NCO}$ work with the polyols to terminate the linkages and form relatively softer cells and then the amines $=\text{NH}_2$ groups work on the terminated links to form what are known as polyurethane-urea substrates and these are the hard cells that change the mechanical properties of compressive load and reduce the visco-elasticity properties. Hence the catalysts help form the cell structures and build a combination of soft and hard cells thereby yielding the various grades of the PUD (polyurethane diols).

The formation of the PUD is fundamentally a multi-step decomposition process characterized by the thermal processes that are unique to each step and define the structural set-up as defined by the DSC (differential scan calorimeter) – principally mapping the changes in the enthalpy states in the thermal decomposition process and building of the molecular weights resulting in the structural changes in the cell.

The blow to gelation ratio – an important part of the process gets affected and can be captured through the thermogravimetric analysis (TGA) and DSC methods.

2. Key determinants of efficiency – qualitative and productivity

2.1. State of the polyols and the TDI – toluene diisocyanate

a) Particle state dynamics – the pre-polymeric preparation for the poly condensation processes and chain-linkages:

The polymeric enthalpy and thermal states for cross-linking activity are dependent on the particle state in the colloidal and would be influenced strongly by the stirring quality – principally defined by the revolutions per minute of the stirrer rod and the power transmitted into the colloid during the stirring mechanism.

b) Stirring power – the key property determinant for the polymeric mixture:

The power transmitted into the colloid is a function of the volume occupied by the stirring medium as a percentage of the vessel volume and is effectively the key determinant for the state of the colloid in the aspect of particle size in microns and the resulting affinity for the chain linkage processes and establishing the equilibrium conditions for the changes in the internal enthalpy. Ideally, the polymeric process settles in and builds up the heat within the structure while releasing the excess unbalanced heat; essentially an indicator of **R_p** – the rate of polymerization and the **MWD** – molecular weight distribution in the complex as the cross-links build up and the chain linkers and extenders get structured within the polymeric substrate. The release of heat in the exothermic reaction process is the key determinant of the pace and quality of the polymerization as defined by the quantitative measures of R_p and MWD.

c) Managing sensible heats within the polymeric substrates:

The sensible heats within the polymeric components – polyols and the isocyanate compound in the PUD formation are the key determinants for the preparation of the pre-polymeric states and shall be required to be monitored and controlled through the stirring process prior to the transfer to the mixing motor states; this determines the rate of polymerization and the effectiveness of the catalysts, the chain extenders and linkers as well as the roles played by the blowing agents and surfactants in defining the configuration of the soft and hard cells and the eventual building of the desired mechanical properties of resilience, abrasion-resistance and thermal stability within the foam structure besides the key shared properties of both rigidity and flexibility. The miscibility of the competing agents of the polymerization as well as the reactivity of the main chain building blocks are the fundamental derivatives of importance in this process of judicious selection of the ratios going into the substrate.

d) Internal heat management in the polymeric substrate:

Internal heat of the components of the polymer – the polyol and the TDI define the work done in transferring the states into the mixing site and are influenced by the relative states of the transferring media; in the case of most factories the very piping network and the residues within the same shall decide the frictional field in the mechanical realm and shall influence the mechanical work done for the transfer to be effective through the pumps.

e) Static charges and flux equilibrium at lower points:

The electrolytic equilibrium in the substrate; both in the stand-alone states of the individual polymeric components and the polymeric states concomitant with the surfactants, the blowing agents, the catalysts and the chain extenders and linkers define the resultant electrical field (static) and the capacitive forces within the system thereby influencing the electrical friction field that needs to be overcome and hence decide the quantum of work done by the pumping system within the distribution network right through the mixing motor.

The medium friction is a composite of mechanical and electrical friction as explained above and the pressure on the mixer motor is influenced strongly by the traction of the forces in the polymeric substrate as well. Hence it is imperative to neutralize the electrolytic imbalances within the network through flushing with chlorides and other potent salts rich in ionic concentrations prior to each process run. The reduction in concentrates shall go a long way in significantly reducing the quantum of work done in the network and establishing the thermal equilibrium in the run-up to the polymeric reactions and chain building – an important derivative for establishing consistencies in polyurethane properties of the resultant foaming process.

2.2. Gelation dynamics

a) Chain linkers and extenders – the generic roles in the polymeric states:

The amines have the amino group – NH_2 serving to extend the chains and linking the isocyanate terminated polymeric chain helping shape the cell structure; effectively defining the absorption-release ratios of the enthalpy states within the localized sites of the polymeric chain and the pace of achieving the relative saturation of the available reactive sites of the main components of the polymeric compounds; hence effectively shaping the foaming structural properties.

The right concentration of the amines shall decide set the speed of the polymeric chain building reaction process and hence is an important determinant for the overall ease and consistency of gelation in the run.

b) Surfactants and catalysts – the generic roles in the polymeric complex

The polymeric reactions progress to soft cells defined by the urethane and the hard cells wherein the amines have combined with the isocyanate-polyol complex to form the urea; the surfactants like the acetate groups (typically the TIN or stannous ocatate)and the silicon emulsion now form the cross-links and inhibit the formation of the urea to its rigid state thereby altering the cellular structure and the properties therein related to the apparent trade-off between rigidity and flexibility and defining the resilience and abrasion resistance to a large extent.

The surfactants also help regulate the absorption-release of enthalpies within the system and consequently establish the equilibrium states of the polymeric reaction and the progression of the states. Together with amines, the structural properties and the enthalpy systems within the substrate are defined by the concentrates used for the surfactants and the emulsion states going into the mixture and hence have critical qualitative and productivity roles in as much as defined by the factors determining the pace of gelation and blowing .

c) Blow-gelation ratios – the primary derivatives of the relative concentrations of the catalysts, surfactants and the blowing agents

The structural dynamics of the foaming process are intrinsically linked to the blow-gel ratio – an important factor that is definitive for the swelling up and structural formation process and the determinant for the possibilities of a collapse at the other extreme of non-performance of the mixture.

Water is the main blowing agent in the polyol-isocyanate polymerization process and influences the volume growth in the polyurethane complex within the time gradient and hence is an important quality determinant. The blowing agent plays a critical role in filling-in the spaces in the polymeric process; effectively inhibiting the urea formation at a cross-section of sites thereby delaying the rigidity and fostering flexibility and finally altering the enthalpy dynamics within the substrate and establishing the systemic thermal equilibrium.

2.3. Productivity indicators in the foaming process

a) Mechanism

Thermal decomposition is the pace setter in the process and there are several – essentially three major and two minor steps in the mechanism for achieving the thermal equilibrium in the polymerization process for polyurethanes. Each process in the series of steps leading to the basic reaction between the polyol and the isocyanate leads to building of the internal heat within the structural system and the corresponding release of heat thereby forming the level of the exothermic reaction state. With increasing consolidation of the cross-links the reactive sites in the polyol and the OCN=CNO combines get saturated thereby increasing the internal heat levels and with the concomitant release of the excess heat thereby causing the exothermic reaction to propagate.

The pace of transition between the levels of thermal decomposition defines the productivity in the polymerization process and is guided by the right concentration of the catalysts, surfactants and the blowing agents.

b) Determining the productive mixture:

The right mixture can be arrived at through a series of TGA – thermogravimetric analysis for a given set of parametric conditions in the process and the given formulation.

The increments in the molecular weights, the distribution of the molecular weights (MWD) and the configuration of the increments in the internal heat and progressive loss in weight form the battery of lead indicators on the saturation states of the polymeric process. The rate of achieving the T_g is the measure of the rate of polymerization as defined by R_p .

c) Blow to gel ratio:

The determinant is the rigidity level of the product (decided by medium, high or low density requirements) and the corresponding right blow to gel ratios employed as a function of the relative

concentrates of the catalysts family and the blowing agent. The right blow to gel ratio as guided by a series of TGA curves for the family of variants in concentrates corresponding to set-piece parametric conditions eventually homing in on the right mixture.

2.4. Quality indicators in the foaming process

a) Structural properties of compressive strength, tensile properties, abrasion resistance and resilience

The thermal decomposition dynamics in terms of time and the temperature gradient implying the changes in the internal enthalpy therein determine the aggregation in the material clusters and are reflected in the DSC – differential scanning calorimeter.

The characteristics of the various phase changes within the polymer structure and the temperature gradients are recorded with this method and graphically represented for an easier analysis and grasping of the core fundamentals of the foaming process.

The DSC scans of several runs shall illustrate the compatibility of the ratios employed of the various agents of the polymeric reactions and the related polymeric material to establish the reproducibility of the desired properties within the substance.

Formulation strength corresponding to the properties of the intended product can be universalized through these scans and compilation of the relevant process data. Hence the DSC is a quality tool that can be used objectively to arrive at the right formulation and process conditions.

b) Process capability and reliability indices

The Cpk – the process capability and Ppk – the process performance indices can be evaluated real time and monitored for enhanced performances within the existing infrastructural set-up through the extensive use of both the TGA and DSC as explained above.

Creation of statistical indices to measure the process performances shall be the fundamental steps to achieving the sustained excellence in the manufacturing standards in the foaming business with higher reproducibility.

c) Product classification and brand differentiation

The statistical measures in the process shall help establish the process and product reliability and add features in the product with higher levels of consistency and quantitative certainty thereby leading to a shift in the brand and marketing paradigms. That in turn shall trigger sales peaks and forays into uncharted segments at an unprecedented pace.



The implications of the quality derivatives on the marketing and branding fundamentals are far reaching with enormous potential impact on the commercial viability of the plant and the products therein on a sustainable timeline.

The changes in reliability in the product engineering features need to be factored in the brand strategy through a series of commercial interventions to articulate the positive intent of the product onto the purchasing psyche of the clientele with the emphasis on the unique paradigms.

2.5 Structuring the changes in the business process model

a) Product yield and cost implications

Advanced systems of evaluation of the product and the structural features of the foams as evinced from the extensive use of the TGA and the DSC shall help determine the precise yield in the process and factor the same in the cost-sheet calculations and thus help define the process appraisal scores in an unambiguous quantitative measures – the all important business process modeling strategies sought to be incorporated for a scaling up of the profitability.

b) Management accounting and accountability mapping within the structured teams

The conversion of the process into quantitative measures shall help bring in a semblance of management accounting into the system. The process appraisal systems can be conceptualized around these derivatives on a quantitative mode and used extensively for accountability mapping and delivery systems within the existing manpower accountability framework.

c) Customer support systems can be strengthened around the product engineering measures that help identify the causes of quality outliers and complaints and help redress the issues satisfactorily and with clear mandates of non-repeats in such outliers.

3. Current states of the process at the three foaming lines

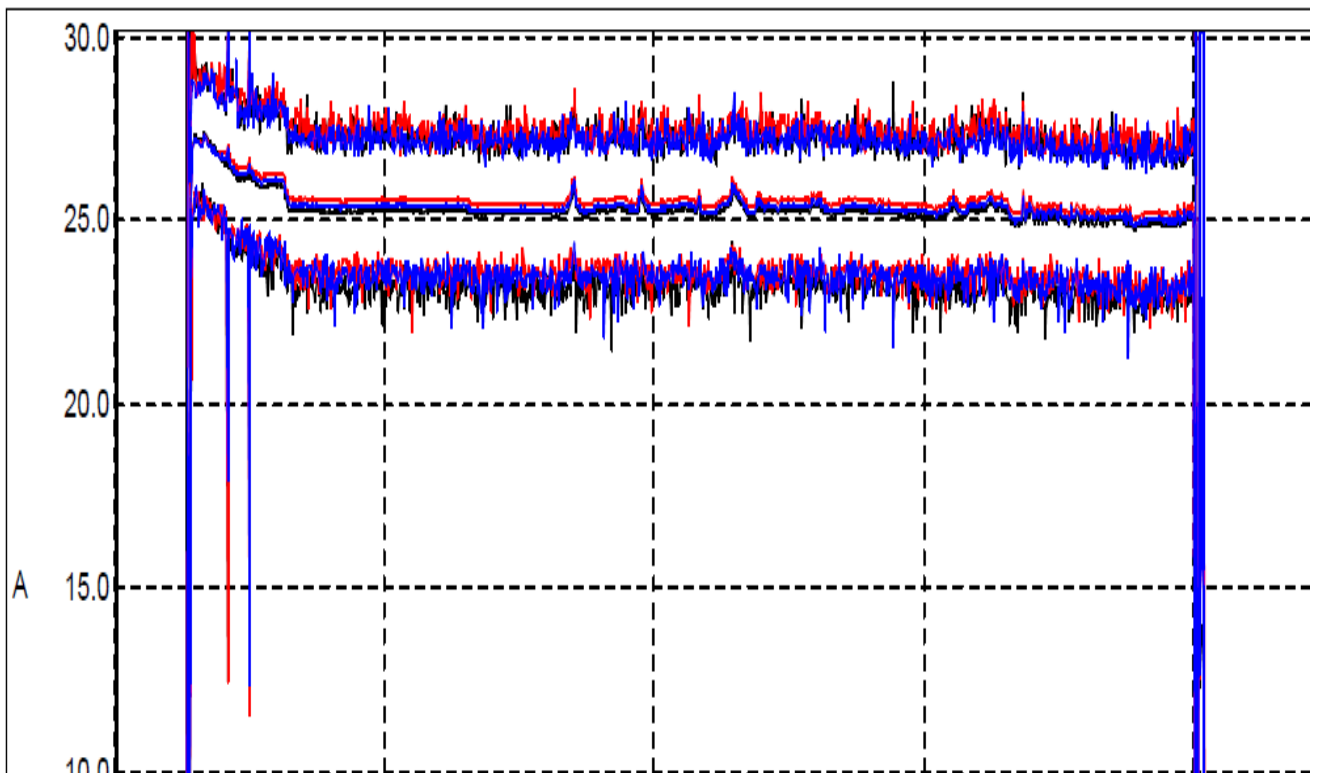
<u>Process line details</u>	<u>Polymer pre-run condition</u>	<u>Attributes</u>	<u>Causal links</u>	<u>Sustainable solutions</u>	<u>Impact in the business</u>
ATR	Polyol	Emulsification – low in dispersive strength	Stirring strength is low	Stirring rpm - 200-400 to be designed with volume – 30% of the vessel to achieve smaller-particle dimensions in the dispersive state	Formulation consistency and better yield
		Inconsistent temperatures as described by the internal heat			Product characteristics for key quality indicators
		Flow rates – need monitoring and controls			Product economy with higher percentage of inorganic fillers
		Compatibility with catalysts, surfactants and chain extenders-need formulation controls		Wrap a water jacket around the vessel and force compressed air (6 bar) in to establish cooling to levels of 20-21 degrees celsius	Enhanced possibilities for product differentiation

<u>Process line details</u>	<u>Polymer pre-run condition</u>	<u>Attributes</u>	<u>Causal links</u>	<u>Sustainable solutions</u>	<u>Impact in the business</u>
ATR	Catalysts, surfactants, chain linkers & extenders	Emulsification – low in dispersive strength	Pre-mixer controlled stirring is non-existent	Stirring rpm - 100 to be designed with volume – 30% of the vessel to achieve smaller-particle dimensions in the dispersive state	Formulation consistency and better yield
		Inconsistent temperatures as described by the internal heat			Product characteristics for key quality indicators
		Flow rates – need monitoring and controls			Product economy with higher percentage of inorganic fillers
		Compatibility with catalysts, surfactants and chain extenders-need formulation controls		Wrap a water jacket around the vessel and force compressed air (6 bar)in to establish cooling to levels of 20-21 degrees celsius	Enhanced possibilities for product differentiation

<u>Process line details</u>	<u>Mixer Motor analysis</u>	<u>Attributes</u>	<u>Causal links</u>	<u>Sustainable solutions</u>	<u>Impact in the process</u>
ATR	CF	1.65-2.9	High thermal stresses are implied	RPC – reactive power controller recommended to be commissioned to filter the harmonics and correct for <3% THD% and follow it up with PF controls for >0.85 on the motor – this shall ensure better mix compatibility and significantly enhanced stable thermal decomposition in the polymeric process	Formulation consistency and better yield
	THD%	35%	Non-linear load in driving the polymeric mixture		Product characteristics for key quality indicators
	Amps-phase imbalances	at peak levels, B is 54% higher and Y is 28% higher than R	Phase imbalances are extremely high at peak values implying onset of thermal stresses in the cables		Product economy with higher percentage of inorganic fillers
	PF	0.42 – centered values	Low generic efficiency in the mixture drives		Enhanced possibilities for product differentiation
	Phase angle	-0.028 – obtuse angle	High incidence of motor impedance		Enhanced energy efficiency

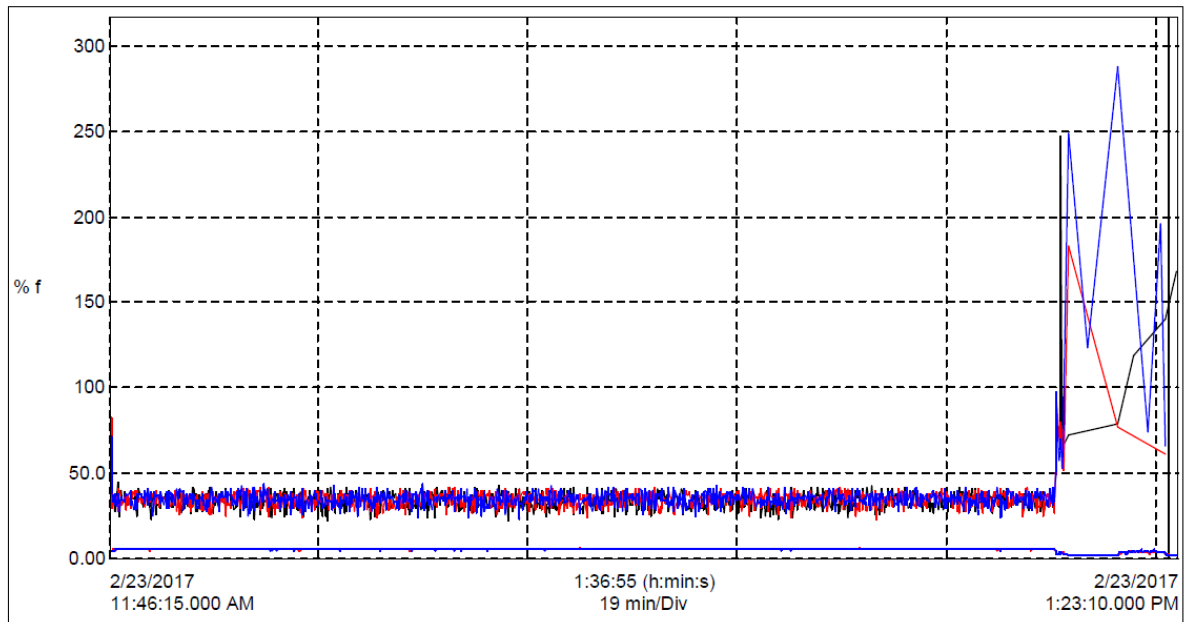
RMS current analysis for the RYB phases:

Name	Date	Time	Avg	Min	Max	Units	Duration	Units
A1 rms	2/23/2017	11:40:00.000 AM	21.903	0.000	71.060	A	1:55:05	(h:min:s)
A2 rms	2/23/2017	11:40:00.000 AM	22.149	0.000	91.940	A	1:55:05	(h:min:s)
A3 rms	2/23/2017	11:40:00.000 AM	22.010	0.000	110.260	A	1:55:05	(h:min:s)



Current THD% (total harmonic distortion percentage):

Name	Date	Time	Avg	Min	Max	Units	Duration	Units
A1 THDf	2/23/2017	11:46:15.000 AM	34.805	21.900	247.300	% f	1:37:00	(h:min:s)
A2 THDf	2/23/2017	11:46:15.000 AM	35.190	23.500	183.300	% f	1:36:00	(h:min:s)
A3 THDf	2/23/2017	11:40:30.000 AM	35.977	23.400	287.800	% f	1:41:45	(h:min:s)

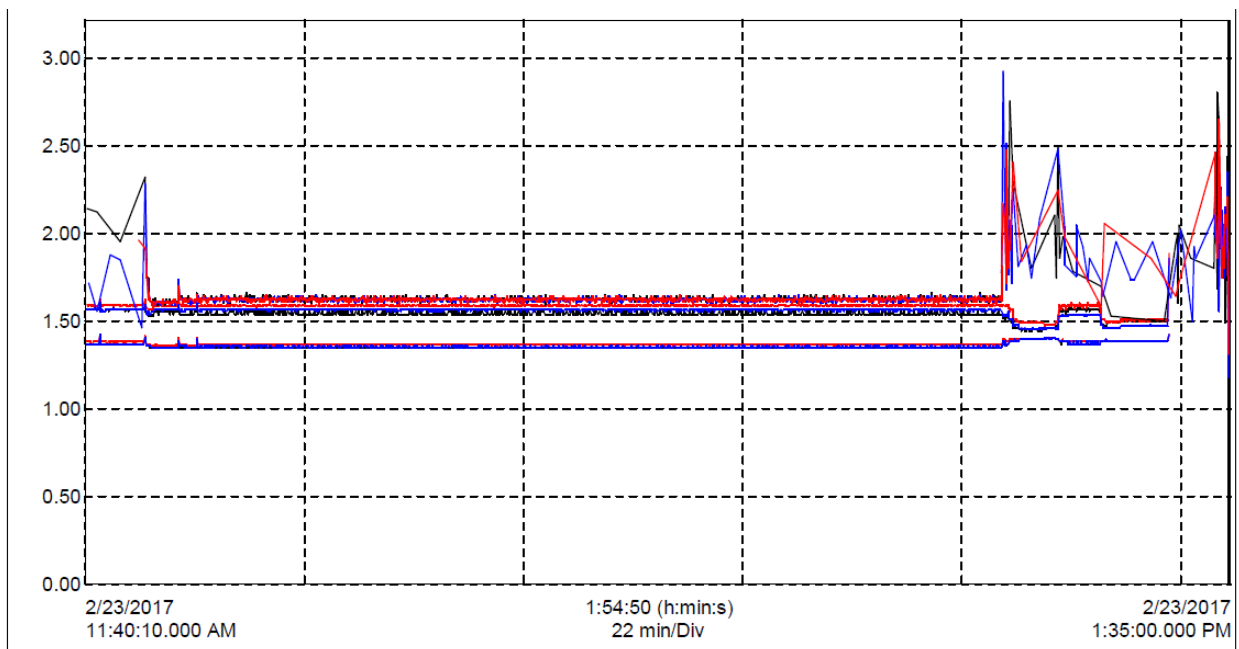


Notes:

1. THD% or the total harmonic distortion percentage is the distortions on the fundamental since curve characteristics at the fundamental or baseline frequency and also on the odd and even multiples as well; with the odd multiples having a larger impact owing to the negative direction of the vector of the energy forces.
2. High THD% lead to fatigue on the cables, progressive reduction in PF and irreparable damage to the drives

CF dynamics”

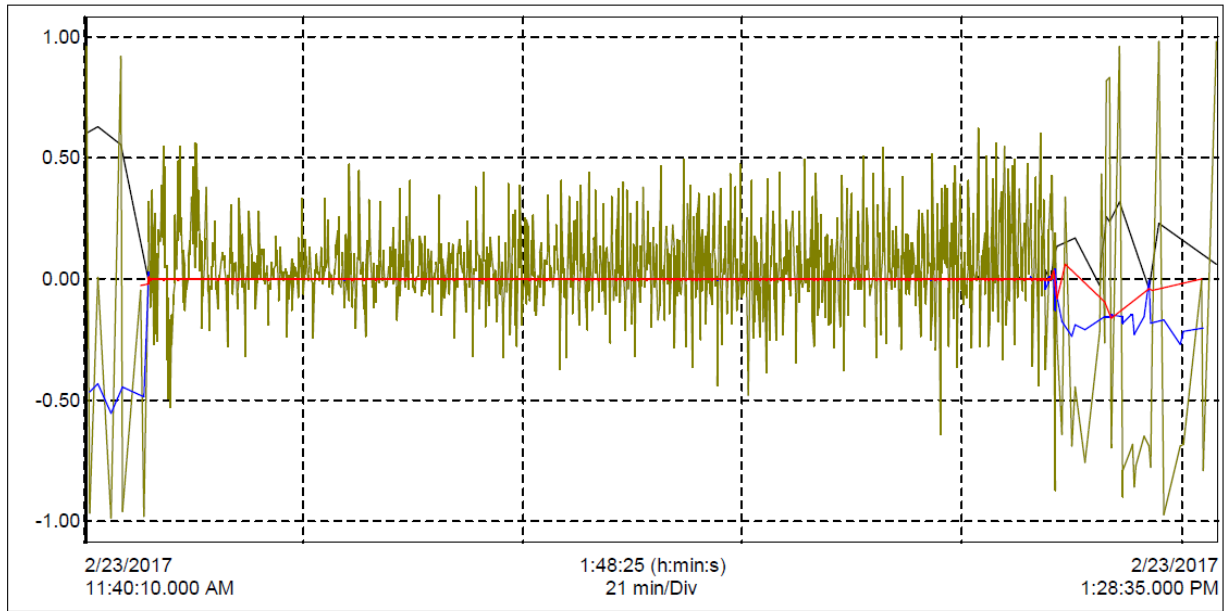
Name	Date	Time	Avg	Min	Max	Units	Duration	Units
A1 CF	2/23/2017	11:40:10.000 AM	1.641	1.490	2.800		1:54:55	(h:min:s)
A2 CF	2/23/2017	11:45:25.000 AM	1.633	1.310	2.650		1:49:40	(h:min:s)
A3 CF	2/23/2017	11:40:30.000 AM	1.636	1.180	2.920		1:54:35	(h:min:s)



Notes:

1. The CF or crest factor is a measure of the peak – RMS current average and has implications on the thermal stresses within the system.
2. High peaks of > 2.0 CF actually do impair the cables through the onset of thermal fatigue and lead to qualitative damages in the electrical systems with large impact on the drives and hence in the quality of the polymerization process itself.

PF dynamics:



Notes:

1. The critical measure of the drive efficiency is the power factor and values lower than 0.7 are substantially inefficient in generating the right loads for the pumping by the mixer motor.
2. The lower PF adversely affects the quality of the mix and the miscibility as well as the compatibility for the polymerization process to proceed thereby influencing the configuration of the structural dynamics of the foaming compounds of PU.
3. The impact on the PFC bank and hence on the performances of the generators is severe in the lng run and can lead to expensive electrical breakdowns.

<u>Process line details</u>	<u>Polymer pre-run condition</u>	<u>Attributes</u>	<u>Causal Links</u>	<u>Sustainable solutions</u>	<u>Impact in the business</u>
Both Chinese and Laader Berg	Polyol	Emulsification – low in dispersive strength	Stirrer strength is low	Stirring rpm -200-400 to be designed with volume – 30% of the vessel to achieve smaller-particle dimensions in the dispersive state	Formulation consistency and better yield
		Inconsistent temperatures as described by the internal heat	Chilling effectiveness is 22% - implying low energy efficiency and extremely high work being done on the polymeric material to		Product characteristics for key quality indicators
		Flow rates – need monitoring and controls	increase the internal energy levels for sensible heat of 27-28 degrees Celsius at mixer motor point	Product economy with higher percentage of inorganic fillers	
		Compatibility with catalysts, surfactants and chain extenders-need formulation controls	Chilling effectiveness to be enhanced to >65% through maintenance OH and operating mix temperature to be brought to desired levels of 20 degrees Celsius	Enhanced possibilities for product differentiation	

Process line	Polymerization states	Attributes	Causal links	Sustainable solutions
ATR	Starting temp: 44 with 7 degrees lateral gradient (29 degrees Celsius for the polymeric mix)	Exothermic equilibrium achieved at 35 within 30% of span length	Formulation and mix ingredient states is defining the thermal decomposition configuration	Piping network needs overhaul for the mixer
Chinese- Kisumu	41 degrees with no gradient (28 degrees Celsius for the polymeric mix)	Exothermic equilibrium is around 39 degrees	The formulation and the mix ingredient states are fundamentally different from ATR although the input temperatures are almost identical	Mixer motor energy optimization
Laader Berg	41 degrees with no gradient (28 degrees Celsius for the polymeric mix)	Exothermic equilibrium is around 39 degrees		Chilling / compressed water circulation to ensure desired polymeric temperature
All sites	Starting exothermic temperatures should be around 35 degrees with no gradient	Exothermic equilibrium should be around 30 degrees Celsius to get the right structural configuration	Flow stability shall be influenced by the preparation and the pumping characteristics as optimized by the mixer motor energy implications	Stirrer – 200-400 rpm for polyols and other ingredients – 100 rpm

4. CONCLUSIONS:

1. The operating paradigms need to shift to quantitative models to bring in real time assessment of the problems, evaluate the options of arriving at lasting solutions and validating the implementation quality through real –time monitoring of data and performance indices.
2. The progressive linkage of the operating fundamentals and product derivatives in the realms of quality need to be integrated with the brand statement and should extract the benefits in enhanced sales and margin growth.
3. Product leadership amongst peers is sought to be achieved through the series of measures vouchsafed for in this treatise.
4. Establishing the process appraisals real time on quantitative measures shall help formulate accountability indices in a fool proof manner thereby eliminating all ambiguity in the judgment process and empowering the management teams to act on informed decisions.
5. Profitability engineering and cascading the effects of higher order strategic initiatives is the fundamental objective of the exercise undertaken. The performance guarantees spelled out are the explicit measurable indices in this program for the business transformation models.

5. NOTES ON THE WIRE DRAWING SECTION:

1. The wires need to be configured for optimized paths through the extensive use of additional pulleys on fixtures to enable minimized traction and providing efficient pre-tensioning systems.
2. The die for the drawing of the wires needs to be housed in a metallurgy that matches the tensile properties – possibly gun metal can be used to fabricate the housing and taper bushing might have to be designed to reduce the axial loads and increase the die life effectively while ensuring quality.
3. All the drives are to be connected to the RPC for reducing the harmonic distortions to < 3% and for ensuring that the effective PF is higher to get the right dimensions with significantly reduced frictional values.

Submitted by:

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The 5th day of March, 2017, Sunday
Kisumu, Kenya