The White Paper on the paper making process

(tissue and serviette paper industry)

A. Determinants in the process

A.1. Heat and thermodynamics

A.1.1. Specific Heat dynamics

Specific heat at the source and at the transfer zones is of vital importance in the paper making process; unfortunately it is **oft ignored** in the contemporary industry in the **context of the Kenyan industry** and hence is the primary cause of bringing in **production inefficiency**, **major equipment breakdowns** and finally in causing the **depreciation in the quality of the product**.

The managing points for the specific heat are the areas of interest in the white paper and shall serve to be instructive to the discerning process technician keen on improving on the operating fundamentals of both productivity and quality besides maintaining the optimized equipment performances.

Managing points for specific heat are enumerated as below:

a) Furnace volume utilization and combustion efficiency

a.i) The furnace defines the **volume of enthalpy** in the system. If the space is utilized at sub-**optimal levels of below 75%,** the consequences on enthalpy drops and fuel combustion quality are severely impaired leading to energy efficiency and more importantly on significant drops in the specific heat transferred to the paper making process.

a.ii) The **refractory lining** in the furnace is the vital **lifeline - determinant** for retention of heat and hence in achieving the peaks in the specific heat corresponding to the basic fundamentals of the enthalpy configuration. The typecast refractory lining would normally have 40-50% of alumina compounds and the balance made of silica. Alumina and silica differ significantly in thermal strains. Greater the Young's modulus of thermal strain, higher is the propensity to resist the heat differentials on a time axis and thus better is the insulating properties associated with effective heat retention and concomitant transfer of specific heat at source as well as at user points.

ILLUSTRATION – I - (A.1.1.a.ii) delineates the relationship graphically.

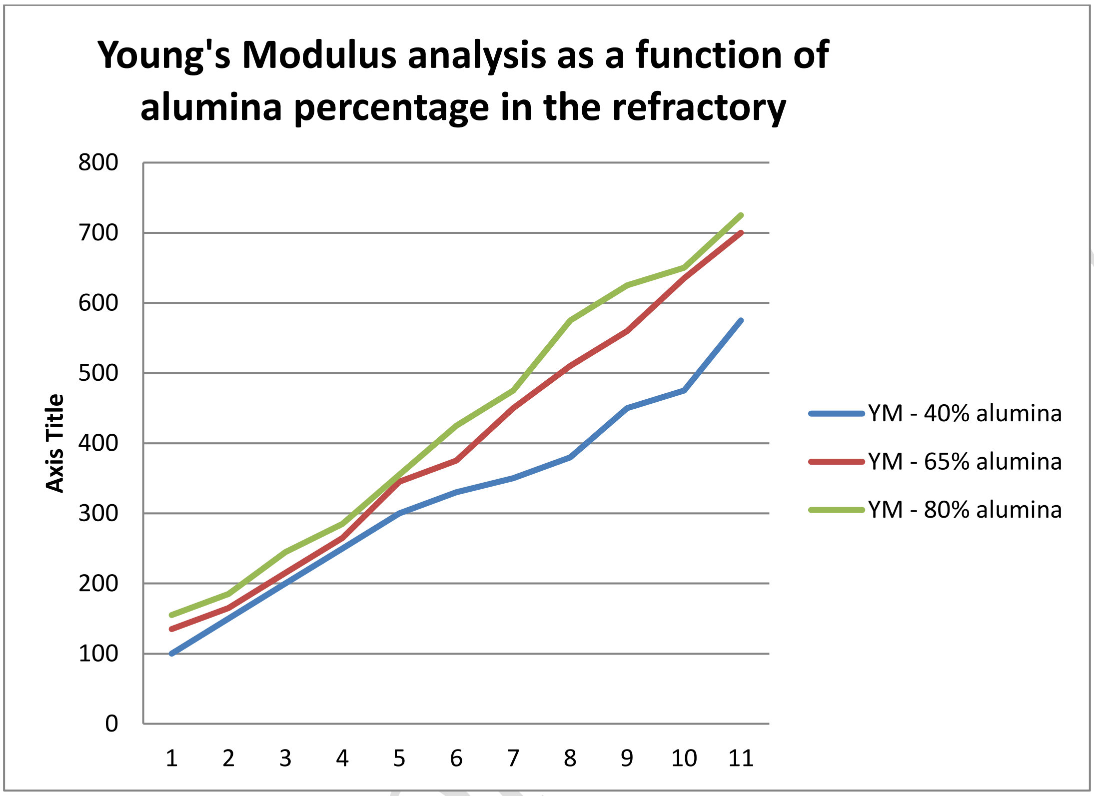
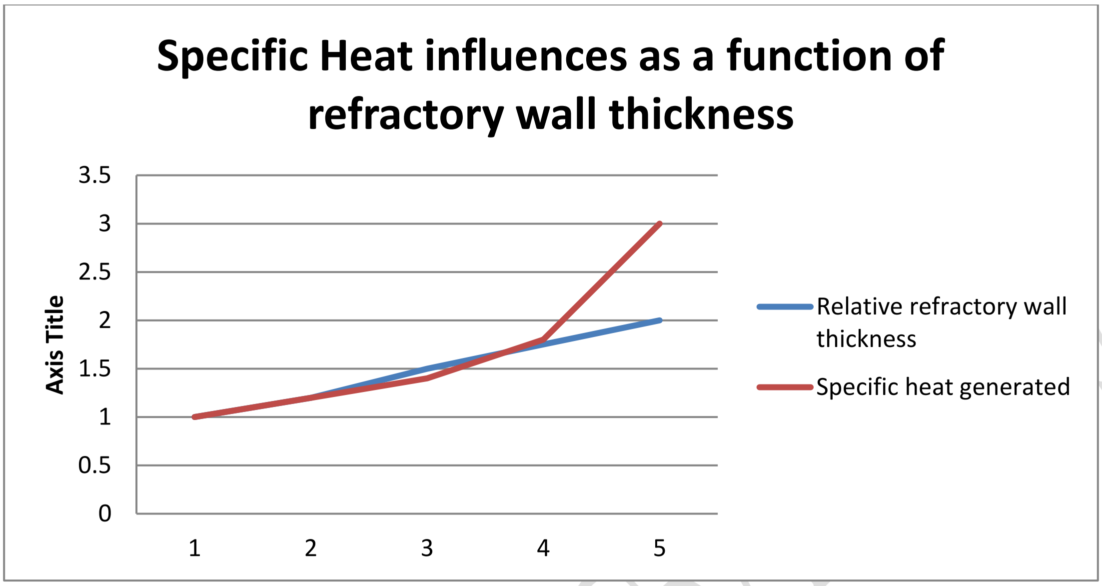
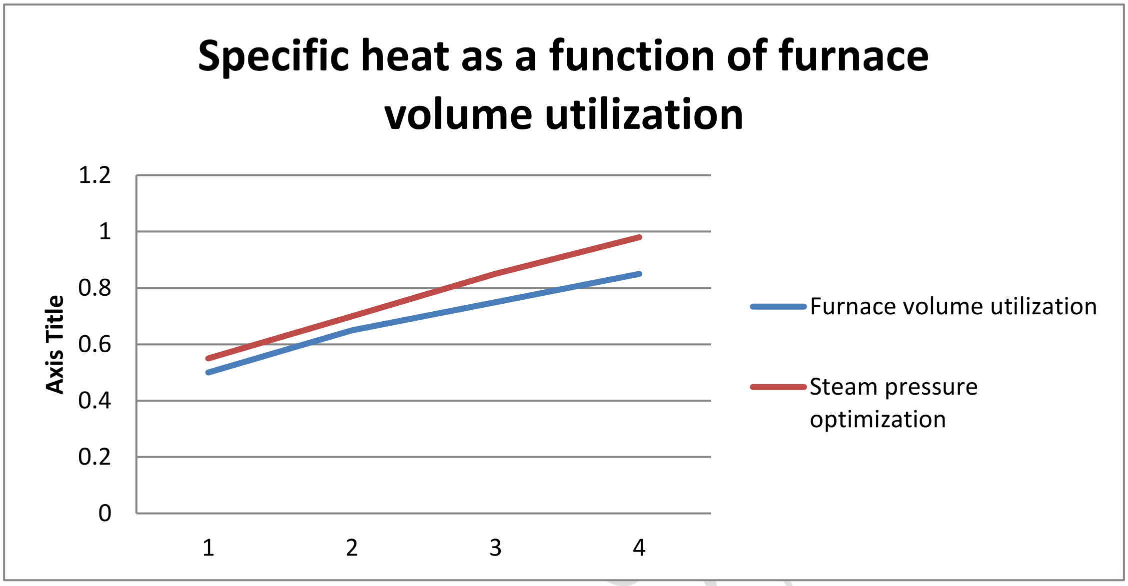


ILLUSTRATION – II (A.1.1.a.ii) portrays the impact of the wall thickness in defining the specific heat. Higher quantum of enthalpy is a function of heat retention; a determinant of the properties of the refractory lining as well as the fundamental thickness of the wall as is elucidated in the graphical representation hereunder.



a.iii) Influences of operating steam pressure on super-saturated steam, the distribution network and the losses in the network elements are the other important determinants for the specific heat dynamics. The utilization of furnace volume is an exponential mathematical function with the steam pressure generated since the heat is defined by the ignition point; the temperature at which the states change. The optimized furnace volume utilization is influenced strongly by the proximity to safety limits in the operating steam pressure as is evinced by the following illustration.

ILLUSTRATION – III (A.1.1.a.iii) portrays the relationship between utilization for furnace volume and the percentage of safety limits in the operating steam pressure.



a.iv) Frictional reduction in the passageway of biomass boilers is imperative to enable optimized enthalpy generation and distribution thereon. In the fossil fuel boilers, emphasis is required for minimizing the dielectric forces within the fluid systems through the neutralization of the static charges that result from the degradation of fluids and release of free radicals from the octane-rich hydrocarbons. Higher pathway friction in the fluid systems causes severe losses in combustibility, enthalpy volume and eventually the specific heat levels in the paper process; hence the dominating need to correct the disruptive influences.

a.v) Insulating medium is the last of the important determinants for the generation and maintenance of the specific heat requirements at the terminal points in the process. The best medium is the LRB – low resin bond that traps the heat effectively and prevents the dissipation to a large extent owing to the high glass transition temperatures of beyond 280 degrees Celsius (way beyond the 170-190 degrees Celsius) requirements for the actual ground conditions at peak heat transfer levels.

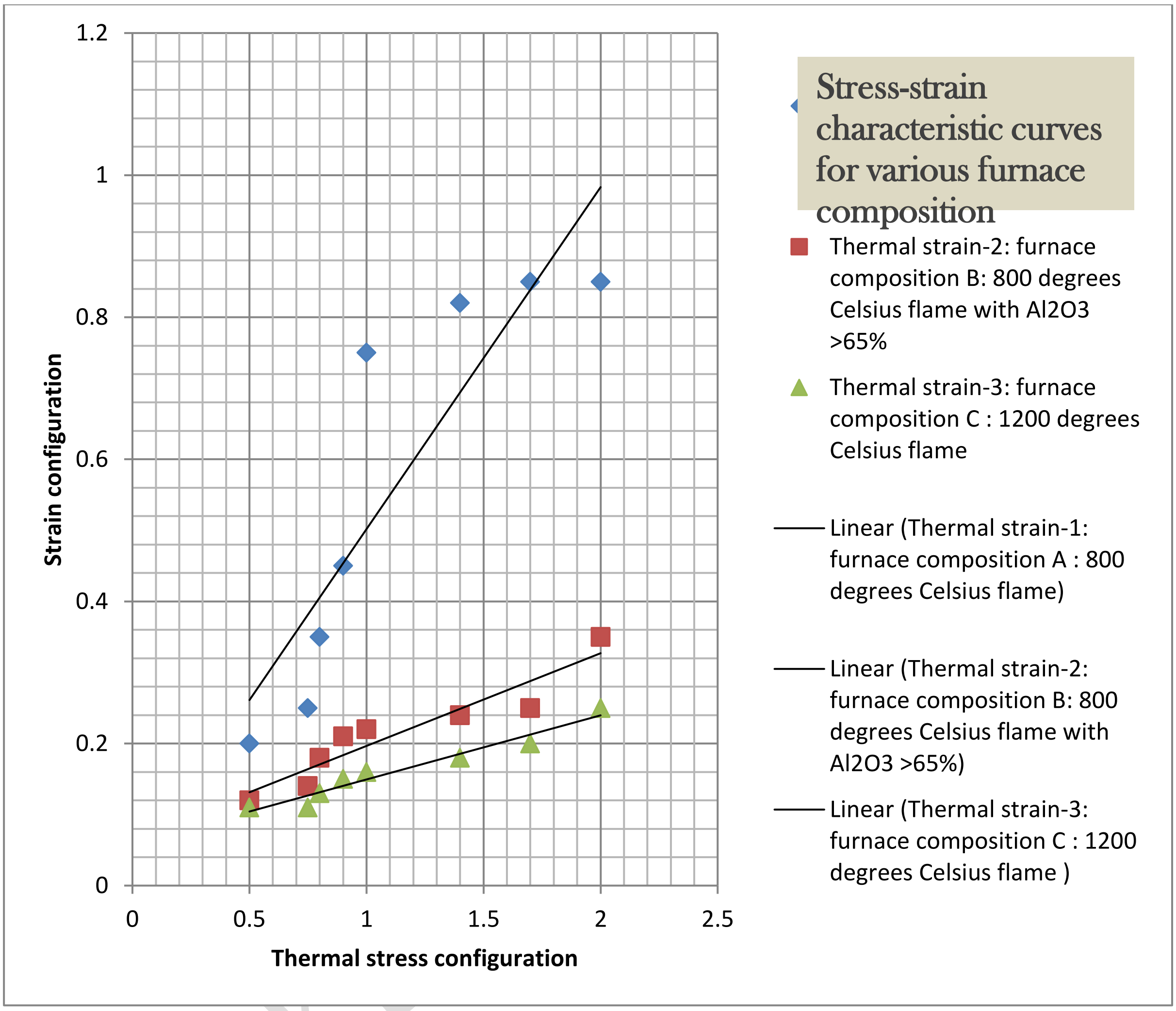
Combustion mechanism and stress-strain curves of the furnace material

Stress-strain analytical curves for furnace heats of various compositions - a comparative model

Thermal **stress** benchmark units	Thermal **strain-1: furnace composition A : 800 degrees Celsius flame**	Thermal **strain-2: furnace composition B: 800 degrees Celsius flame with Al_2O_3 >65%**	Thermal **strain-3: furnace composition C : 1200 degrees Celsius flame**
0.5	0.2	0.12	0.11
0.75	0.25	0.14	0.11
0.8	0.35	0.18	0.13
0.9	0.45	0.21	0.15
1	0.75	0.22	0.16
1.4	0.82	0.24	0.18
1.7	0.85	0.25	0.2
2	0.85	0.35	0.25

1_{stress}= Thermal stress on peak operating conditions

1_{strain} = Strain corresponding to permanent loss in thermal elasticity



Notes on the furnace composition:

1. **Young's modulus is a genetic value derived primarily by the metallurgical condition; more importantly the trade-off ratio between the alumina oxide and silica.**

2. **Characteristics of the stress-strain curves and the configurations therein define the retention of heat, the effective flame temperature, the concomitant combustion conditions and the resultant flue gas emissions characterization in terms of lost heat and carbon di-oxide, carbon monoxide and more importantly the excess air and oxygen content.**

3. **The ignition point for bringing in the state change in water would require energy states that would consume fuel as a function of the thermal curves of the furnace composition and hence remains a distinctly differentiating derivative governed by the furnace composition.**

Final conclusions:

A. **Alumina rich composition would be desired owing to higher strain resistance across and between heat peaks and troughs.**

B. **Composition meant for reheating furnaces of the tune of 1200 degrees Celsius would be ideal for improving substantially on the combustion characteristics and reducing heat losses, excess air characteristics and the concomitant loss in oxygen – the key burning component.**

C. **The effective burning shall reduce significantly the TDS levels in water going into the steam as is illustrated by the enclosed real time case study:**

Conditions for the case study:

1. **The empirical refractory states were considered after 1 year of run in the operations in the paper industry.**

2. **The refractory lining was changed to new with the original specifications in September – 2017 prior to the repeat study:**

So.No.	Characteristics	Requirement Limits	Results with empirical refractory states	Results after changing refractory lining
i)	Raw Water			
	a) *p*H value	8·5 to 12.0	9.4	9.3
	b) Total alkalinity‡ (as $CaCO_3$), mg/l, *Max*	300	-	-
	c) Residual sodium sulphite (as Na_2SO_3), mg/l	30 to 50		
	d) Total dissolved solids‡ mg/l, *Max*	1200	319	325

	e) Conductivity (micromhos/cm)	-	477	485
ii)	Boiler Water.			
	a) *p*H value	10·5 to 12.0	11.4	11.9
	b) Total alkalinity‡ (as $CaCO_3$), mg/l, *Max*	700	-	-
	c) Residual sodium sulphite (as Na_2SO_3), mg/l	30 to 50	32	41
	d) Total dissolved solids‡ mg/l, *Max*	3500	3296	**1334**
	e) Conductivity (micromhos/cm)	7000	4920	**1992**
iii)	Boiler *Condensate.*			
	a) *p*H value	8·5 to 9.5	8.6	10.3
	b) Iron	0.3	-	0.01
	c) Total dissolved solids‡ mg/l, *Max*	15	96	**10**
	d) Conductivity (micromhos/cm)	30 uS/cm	161	**17**

Conclusions:

1. **pH should be construed as the function of changes in chemistry in the pulp mill of the paper factory.**

2. **The significant changes in TDS validate the studies above and the concomitant changes in conductivity imply that the ionic imbalances are corrected through these measures.**

A.1.2. Enthalpy needs in the stock

The stock in the paper industry is least understood in the aspects of colloidal properties, the energy requirements for the transfer through the chests into the paper formation machine and more importantly, the final areas of heat exchange that are of paramount importance in the web creation at the dryer drum.

The emulsion in a colloid is influenced by the energy states within the system; entropy in the closed system influencing the eventual coordinates of the particles and the drift dynamics defined by the rate of transfer; the coalescing properties and the differentials in the surface tension that separate particles in the emulsion at different stages of the filtration process.

Mathematically, the enthalpy states in the emulsion are a function of the following expressions of properties:

$\sum(m)$ = summation of coalescing mass – a function of the quality of exhaustion of available bonding sites in the polymerization of the paper at the pulper.

$\mu(f_0)$ surface tension differential between the particles of unlike potential in the colloidal states

$\mu(f_S)$ = frictional values for the stock states(f_S)at energy states Δ^{e} = maxima and Δ^{e} = minima

$f(x)$ = degrees of freedom in the colloids for the stock particles at the interface of the dryer-felt-touch roller defined by medium m_2 and in the mould-felt interface defined by medium m_1.

$f(x) = \Big[\prod (\sum(m)) \; (\mu(f_0)) / (\mu(f_0))^{\Delta^{e}} \Delta^{e} \Big] \; k_S$ where **constant k_S is defined by the following factors:**

a) The heat in the domain – the maxima and the minima in the system that shall define the coordinates of the drift.

b) The entropy in the system; open systems shall have lower entropy and closed systems shall have higher entropy, fundamentally determines the predictability and reproducibility of the parameters in the paper manufacturing process. In other words, if the steady state equilibrium is achieved, the open system shall be approximated lowering entropy or the drift in the colloidal particles.

c) A less steady equilibrium in the colloidal states shall enhance the entropy and cause major drifts in the coordinates thereby causing significant loss in reproducibility and predictability in the process outcomes corresponding to a given family of parametric states in the process.

d) The values of friction as defined by $\mu(f_0)$ and $\mu(f_S)$ shall help bring in states of equilibrium; in effect, the mathematical entropy values in the system shall be arrived at. Thus it is imperative to appreciate the consistency in stock friction and that in the surface tension differential between the paper and the trash particles in the colloidal states.

e) The consistency in heat or the specific heat transferred is the other determinant for the constant k_S. **The domain of fluctuation in the specific heat at the transfer points in the web forming zone shall define the values of the constant on which the equation is founded.**

A.2. Polymerization quality

A.2.1. Genetic makeover of the stock

The genetic makeover of the raw material is of vital importance in defining the characteristics of the pulper. The presence of long and softer fibers would bring in higher density of the material or predict a higher coalescing mass in the equation - $\sum(m)$.

The presence of recycled paper defines the distribution of the amorphous and crystalline zones in the cellulosic structure of the paper and hence the availability of sites for bonding in the polymerization process. Greater the concentration of amorphous zones, higher is the propensity of weak structures coming in the way of reducing the $\sum(m)$ – an important derivative for defining the entropy in the equilibrium state of the stock at different states and stages in the process.

Managing points for the process are as follows:

CONCLUSIVE STEPS IN PROCESS FOR ENHANCED PLANT PERFORMANCE AND PRODUCTIVITY				
	Element in the formulation	**Quantity in Kgs / batch**	**Percentage**	**Strength resin percentage**
FUNDAMENTAL STEP = $\sum(m)$	Industrial Salt	14	2.0%	
	Caustic Soda	5	**0.7%**	
	WSR equivalent - Arbocel	3.5	0.5%	**0.9%**
	DSR equivalent - Arbocel	2.5	0.4%	
	H_2O_2	2.5	0.4%	
	OB - optical brightener	0.5	0.1%	

a) Caustic soda is an exhaustion agent and a cross-link polymer that forms bonds with the paper as well as with the other resins. The right usage of caustic soda helps exhaust a majority of the sites available for bonding. ***This is not understood by the paper industry at large – an unfortunate derivative for its persistent and consistent failures in performance across geographic boundaries in the paper industry.***

b) Polymerization needs a temperature of 85-90 degrees Celisus in the bath to create an effective linkage and extension of chains.

c) The wet strength resins are required to restore strength to an extent of 50% of the original dry strength on dilution and in the wet states in the process. This also influences coalescing mass and consequently the frictional properties of the stock.

d) The dry strength resins are effective at the web stage after the release of the moisture from the stock.

e) The bleaching agents are potential strength weakening agents and hence need to be used sparingly to protect the degradation of the structure.

A.2.2. Fundamentals of driving productivity and quality on the paper machinery

a) The availability of sites for bonding during the polymerization process and the probability of chain extensions determine the capabilities of a given genetic mix to enhance strength in the stock and bring in productivity and quality improvements in the process. ***Mathematical expression could be*** $\sum n$ ***= summation of potential bonding sites***

b) The combined bond strength in the stock distribution following the effective exhaustion through the cross-linking chains of caustic soda and the resins. Bond strength is the energy built into the structure at the sites whilst the chains get formed and extended. ***Mathematical expression could be*** $(x + a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$ ***where x = number of actual realized bond strength value and a = residual bond strength built in after the distribution as influenced by the dilution across the stock particles in the colloidal and k = the actual percentage of potential sites n that are converted into effective bonds***.

The mathematical expression in the creation of bonds in the paper substrate is fundamentally a binomial expression in that it is defined by the probability density in a discrete distribution.

c) The distribution of the bond sites in the stock all through the states of the process are important in defining the consistency in the paper formation; both the productivity and the quality factors that are built into the system**.** $f(x) = a_0 + \sum_{n=1}^{\infty}\left(a_n \cos\frac{n\pi x}{L} + b_n \sin\frac{n\pi x}{L}\right)$ ***is the mathematical expression explaining the periodic occurrence of high strength distribution in the***

stock at various states in the process. In this expression, a and b are the amplitudes in the wave configuration as determined by the dilution used in transferring the stock through the different stages of the process. Higher the magnitude of the dilution, lower is the amplitude of the wave; in other words there are significant declines in strength of the stock along the way.

This is a Fourier series used to express the distribution of bonded strength in the stock all through the process prior to the web formation.

KEY DERIVATIVES IN THE PROCESS AS ENVISAGED BY THE MATHEMATICAL EXPRESSIONS:

1. **DILUTION IS THE IMPORTANT PROCESS DETERMINANT IN DEFINING THE DISTRIBUTION OF BOND STRENGTHS IN THE STOCK.**
2. **HIGHER DILUTION SIGNIFICANTLY REDUCES THE AMPLITUDE OF THE WAVE; in simpler terms, the strength nodes in the stock reduce significantly with increasing dilution ratios.**
3. **THE CLEANSING OF THE STOCK NEEDS the progressive usage of surface tension differential following the bond strengthening and occupancy of potential sites to eliminate the trash and contaminants rather than subjecting the stock to hydromatic treatment as is wont in the paper industry.**

B. The equipment determinants in the paper making process

B.1.1. Dryer design with respect to steam distribution

The design features of the dryer need to be reviewed in the zone of steam distribution across the surfaces in order to establish consistency in the specific heat.

Current design includes the introduction of steam at one edge and distribution through steam channels across the surfaces laterally.

A. Flaws of the current design:

a) The specific heat transferred onto the dryer cannot be consistent as the source is unitary.

b) The line losses in heat reduce the intensity of the peak enthalpy being transferred and the accumulated declines across the heating surfaces mount to phenomenal levels.

c) The web formation quality is dependent on the efficiency in driving out the moisture from the stock at the interface of the felt-dryer-touch roller and hence requires consistency in the enthalpy being transferred onto to the drying surface; something that is not ensured in the current design.

B. Solutions:

a) The steam outlets should be machined across the dryer laterally to provide for the consistency in the quantum of heat transferred onto the coordinates and thus ensuring the heat per cross-sectional volume of paper is adequately high to dry up the web within the instantaneous timelines allotted by design.

b) The inlet and the outlet at the dryer needs to be redesigned to accommodate higher volume of steam for release and distribution.

c) The introduction of the pressure regulating valve in synchronization with the steam volume being released and the steam pressure coordinates through digital controls for the algorithm on the paper characteristics shall enable the dryer to function intelligently and bring in consistency in quality at elevated speeds.

C. Algorithm:

a) The first of the algorithm elements is tracking the substrate temperatures on the lateral axis for the stock on the felt as also on the longitudinal axes between the weir and the touch roller.

b) The second element is the measurement of vacuum pressure and the quantum of water being sucked in at time coordinates to enable the system to predict the dilution at the interface of the felt-dryer-touch roller.

c) The third and final element of the algorithm is the curvature of contact for the touch roller with the dryer to enable a higher cross-section of the stock for the pick-up and the simultaneous tensioning of the felt around the curvature of contact. These elements of the algorithm shall trigger changes in the felt tension corresponding to the dynamics computed in the summation of energy in the stock and the curvature coordinates of the interface of felt-dryer-touch roller.

B.1.2. Touch roller design

A. Flaws in existing design

a) The curvature of contact as explained above is too low.

b) Point pressure on the stock is too low causing dips in pickup volume density by the dryer.

c) The felt curvature changes differential are too sharp causing disruptions in the stock path.

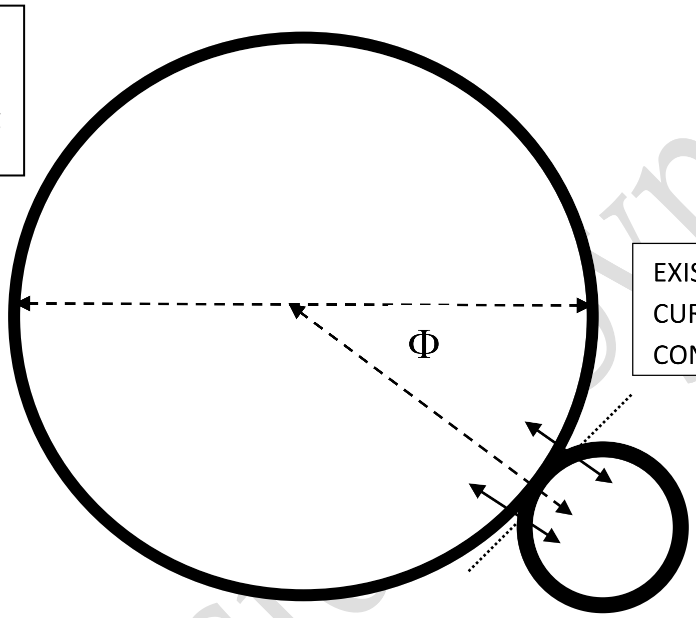
B. Solutions

a) Increasing the curvature of contact by around 45-50% from existing levels.

b) Point pressure reduction on the stock shall be extremely significant.

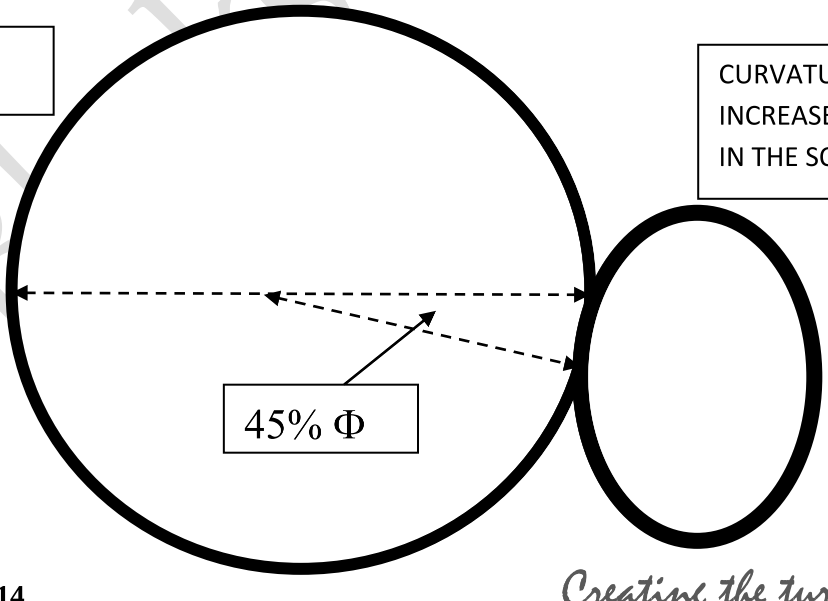
c) The trajectory turbulence around the dryer shall be radically low ensuring better felt tensioning controls and pickup consistency.

Design flaw of dryer-touch roller interface on existing model



EXISTING CURVATURE OF CONTACT

Solution illustration



CURVATURE OF CONTACT INCREASES SUBSTANTIALLY IN THE SOLUTION MODEL

C. Elements of the algorithm for process automation in the dryer region:

	C.1. Mixture Dynamics								
	Batch Number:	**1E2017/8**	Shift Supervisor	**DECODING BATCH NUMBER**	DIGIT 1	DIGIT 2	DIGIT 3	DIGIT 4	DIGIT 5
	Date				Serial number - chronology	Week number	Year	Hyphen to separate year and month	Month
	Shift			**KEY INITIATIVE**	batch nomenclature shall help traceability of process performances				
	Formulation	Quantity	Percentage	**Overall Batch 1E configuration**	**Dilution from mix**	**Additional water**	**Final stock concnetration @ pulper**		
Batch 1E1	Tissue Grade-A	21	3%	1.01%	33.09%	50,000	**2.72%**		
Batch 1E2	Tissue Grade-B	679	97%	32.10%					
BATCH 1E TISSUE GRADE	**WATER QUANTITY (liters)**	**350**	**35%**	16.54%					
Batch 1E3	Waste paper	715	100%	33.80%					
BATCH 1E WASTE GRADE	**WATER QUANTITY (liters)**	350	**35%**	16.54%					

C.2. PROCESS GRID						
Raw data - Pulper Process			**Inferential Statistics (t_0)**			
Timeline	**Zone**	**Temperature**	Parameters	A	B	C
t_0	AN	32	Standard	95	95	95
	AE	33	Average	33	37.25	41.25
	AS	34	Median	33	36.5	41
	AW	33	Variance	0.67	6.92	30.92
	BN	35	CV%	2.47%	7.06%	13.48%
	BE	37	Normalized value	-75.93	-21.96	-9.67
	BS	41	**DECISION**	**Unstable process**		
	BW	36	**QUALITY PARAMETER**	**Standard**	**Actual**	**Variance %**
	CN	48	**VISCOSITY**	14	15	-7%
	CE	43	**MR**	12	14	-17%
	CS	39	**pH**	10	12	-20%
	CW	35	**Inferential Statistics (t_1)**			

C.3. CBM SHEET

Electrical profile						Mechanical Profile					
Parameters	**Standard**	**Actual**	Variance	Influence weight	Weighted variance	**Parameters**	**Standard**	**Actual**	Variance	Influence weight	Weighted variance
kW	30	18.5	-38.33%	0.1	-4%	**Motor shaft**	35	50	-42.86%	0.35	-15%
PF	0.9	0.56	-37.78%	0.35	-13%	**Hub**	30	46.1	-53.67%	0.15	-8%
CF	1.45	1.4	3.45%	0.2	1%	**Coupling point**	32	36.3	-13.44%	0.25	-3%
THD% (current)	5	3.2	36.00%		0%	**Hub of impeller for stirrer**	55	72	-30.91%	0.15	-5%
tan	50	50	0.00%	0.15	0%	**Gear box**	40	52.2	-30.50%	0.10	-3%
phase angle	73	73	0.00%		0%					**1**	**-34%**
Amperes	54	46	-14.81%	0.15	-2%					**DECISION**	**Breakdown potential**
Voltage	400	400	0.00%	0.05	0.00%						
				1	**-0.1858812**						
				DECISION	**Routine CBM**						

BATCH NUMBER:	

C.4. Pulper analysis of performance data

CHEST 1 - DYNAMIC MODE ASSESSMENT - TISSUE GRADE BATCH 1E							**QUALITY ANALYSIS IN PROCESS**			**CORRECTIVE ACTIONS**
TIMELINE	**ZONAL TEMPERATURE**					**INFLUENCE ANALYSIS**	**QUALITY PARAMETERS**	**STANDARDS**	**ACTUAL**	
	flow point	**LHS**	**LHS-MIDDLE**	**RHS-MIDDLE**	**RHS**		**VISCOSITY**			
t_0	39.2	39.1	39.3	39.2	38.5	SHEAR THICKENING OF STOCK	**MR**			
t_1	44.5	43.3	43.1	43.2	41.7		**pH**			
t_2	46.8	45.6	45.6	44.1	43.5		**TRANSFER TIME TO CHEST**			
t_3	48.9	47.6	48.1	48.2	46.5					

BATCH NUMBER:						
C.5. DRYER DYNAMICS						
STAGEWISE ANALYSIS (actual current trends)	**ZONAL TEMPERATURE**					**INFLUENCE ANALYSIS**
	STEAM SIDE		**MIDDLE**	**FAR-END SIDE**		**PARAMETER**
REAR	40.1	40.3	39.2	38.3	37.5	Transfer efficiency of pulp onto the felt by the mold weir AND WATER EVAPORATION FOLLOWED BY PAPER AGGREGATION AND CONSOLIDATION
TRANSFER DRUM	35.5	35.2	35.1	34.1	33.8	
YANKEE DRUM	89.1	89.3	87.5	72.2	69.9	
REVERSING PATHWAY	40.1	40.3	40.1	37.3	38.1	

C.6. DRYER DRIVE ANALYSIS			
POWER QUALITY PROFILE		**MOTOR DYNAMICS**	
kW	15	Motor shaft	47.8
PF	0.4	Hub	53.5
CF	2.29	Coupling point	34.8
THD% (current)	85-96	Pedestal hub	43.1
tan			
phase angle		Steam entry point	94-102.3
Amperes	28-34		
Voltage			

C.7. PRODUCT QUALITY ANALYSIS

BATCH NUMBER:					
GSM ANALYSIS	LATERAL				
LONGITUDINAL	A	B	C	D	E
1	17.00	16.5	17.8	17.6	16.8
2	17.00	16.3	18.1	17.3	16.7
3	18.00	17.4	17.9	17.4	16.916.7
4	17.00	17.5	18.3	17.5	16.9
5	16.57	16.9	18.5	17.3	17.1
6	17.40	17.6	18.3	17.5	17.8
AVERAGE	17.16	17.03	18.15	17.43	17.06
MEDIAN	17.00	17.15	18.20	17.45	16.90
VARIANCE	0.24	0.30	0.07	0.01	0.19
NORMALIZATION	-0.33	-0.06	-4.32	-3.58	-0.14
GRADE	72%	94%	1%	3%	87%
OVERALL GRADE	51%				

BATCH NUMBER:					
STRENGTH ANALYSIS	LATERAL				
LONGITUDINAL	A	B	C	D	E
1	2.00	2.3	1.9	1.7	2.3
2	2.30	2.2	2.2	2.3	2.1
3	2.50	2.4	2.5	2.2	1.9
4	1.90	2.5	2.8	1.5	1.8
5	1.80	2.1	1.9	1.7	2.3
6	1.70	2.2	1.7	1.9	2.4
AVERAGE	2.03	2.28	2.17	1.88	2.13
MEDIAN	1.95	2.25	2.05	1.80	2.20
VARIANCE	0.09	0.02	0.17	0.10	0.06
NORMALIZATION	-0.54	0.57	-0.08	-1.01	-0.28
GRADE	58%	176%	92%	36%	76%
OVERALL GRADE	88%				

D. FINAL PERFORMANCE INDICATORS

D.1. CASE STUDY ON FINANCIAL BENCHMARKS: FORTUNA INDUSTRIES LIMITED, NAIROBI

FORTUNA INDUSTRIES LIMITED	Business Transformation Modeling		
Blackstone Synergy deliverables grid - 2017			
Parameter	**October**	**November**	**December**
PBDIT	19%	21%	23%
Reserves	4.41	7.09	8.35
Quality leadership	At par	+5%	+10%
Market share increase% from current levels	50%	100%	140%
Fuel in MT/ MT of production	0.6	0.5	0.4
kWH / MT	600	550	500
Water in m^3/ MT	35	30	30
Maintenance and repair costs	0.7	0.6	0.5
Yield in RM planning / 100MT of prodn.	120	115	110

D2. OPERATING BENCHMARKS

Performance indicators in plant performance					
S.No.	**Parameter**	**Benchmark**	**October**	**November**	**December**
1	Water consumption in m^3 / MT	35	35	30	30
2	Fuel in MT / MT of paper	0.6	0.6	0.5	0.4
2	kWH / MT	600	600	550	500
3	Maintenance and repair costs - 1.0 being historical best / month	1	0.7	0.6	0.5
4	Line productivity in MT/day	5	5	6	7
5	Yield in raw material planning / 100 MT of production	130	120	115	110

<u>Conclusions:</u>

1. **The pulp mill dynamics for polymerization is of paramount importance as explained in the white paper and is unfortunately ignored in the current industry practices with debilitating consequences on the financial health of the industry.** ***Recommended polymerization should happen in the pulp mill rather than in a retrograde manner in the final chest wherein the current practices never really bordered on the basics of polymerization.***

2. **The fundamentals of thermodynamics in paper manufacturing are not followed with disastrous consequences across the industry.** ***The details of heat engineering in the paper manufacturing process have been explained in detail for the references of the reader.***

3. **The flaws in the design of the dryer and the touch roller are far too obvious and have been discussed at length with solutions delineated.** ***The onus on creating an advanced process automation system lies with the scientists and engineers in the paper industry. The elements of the possible algorithm have been discussed in the white paper***.