TATA STEEL
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Webinar Module on

Simulate and Optimize the Utilization of Resources in a Steel Company Lime Plant Feeding Circuit

By TATA STEEL

Productivity Services Dept.

TATA STEEL

Tata Steel group is one of the world's most geographically diversified steel producer with an annual crude steel capacity of **34 million** tonnes per annum (MnTPA)

Tata Steel, together with its subsidiaries, associates, and joint ventures, is spread across five continents with an employee base of over **65000**

The group recorded a consolidated turnover of INR 1,56,294 ~ **US $ 21.2 billion** in the financial year 2021

The first integrated Steel Company in the world to win **Deming Grand Prize in 2012**

Tata Steel recognized among **India's Great Place To Work: Large Organization in 2020**

We are the first steel manufacturer in India to receive **CII's GreenPro certification** for four of our products

Great Place To Work® Certified
DEC 2019-NOV 2020
INDIA

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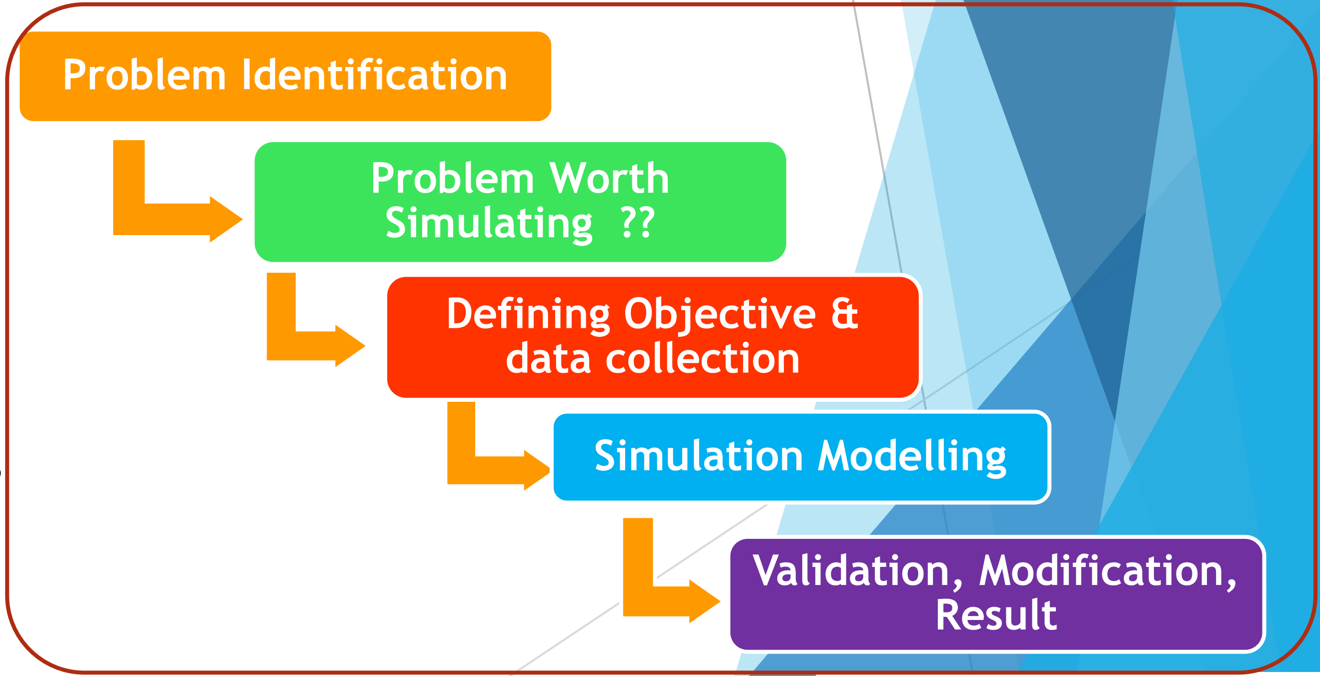
Problem Statement & Approach

Background

Lime is the most important flux used in the LD steel making process. The development of LD Process, calls for stringent control on the quality and a steady supply of Lime. Tata Steel Lime Plant has 9 Kilns. Limestone is sourced from Jaisalmer, Dubai, Oman & Fujairah and Vietnam

Limestone reach in Wagons from source and unloaded in **Tippler**. From Tippler it sends to **Primary Screening house** by conveyer Belts and passes through **Double Deck screening process**. After Screening, material is transferred to storage bins and then in **Surge Bins**. From Surge Bins it again passes through **Single deck screening process** and then transfer in **Weigh Hoppers**. From Hoppers, material is dropped in Kilns from top via **skip buckets**. Currently this feeding circuit seems to be underutilization and runs for 24 hours unnecessarily.

Problem Solving Approach:



Objective & Deliverables

- **Optimize** and **schedule** the Limestone reclaiming to maximize the utilization of feeding circuit as well as to reduce running hours

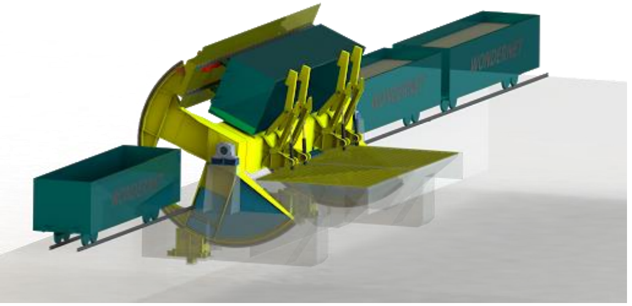
Introduction

- Lime kiln is used for the calcination of limestone (calcium carbonate) to produce the form of lime called **quicklime** (calcium oxide).
- Calcination of lime is a chemical process. When heated above 900 C, the carbonate decomposes. The reactions in the burning zone are as follows:

  Fuel gas combustion: CO (coke oven gas) + O_2 = CO_2 + (heat)

  Lime calcination: $CaCo_3$ = CaO + CO_2 + 753 kcal/kg of CaO
- Coke oven gas & Blast Furnace gas are used as fuel in Kiln
- The lime produced must meet the requirements of *high CaO availability, high reactivity for faster dissolution, and low LOI(Loss of Ignition) for reduced consumption.*
- There are 9 Kilns and Kiln capacity varies from 300-600 TPD

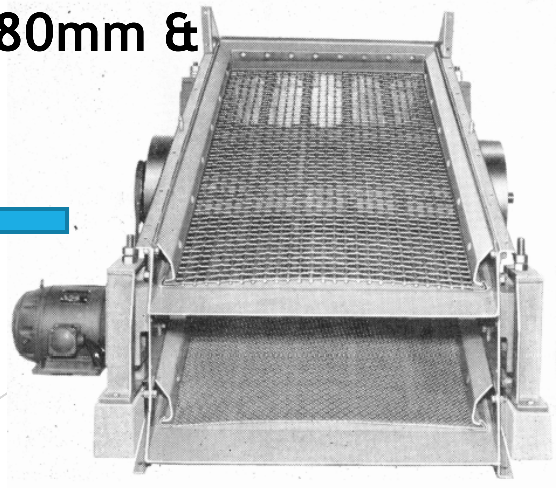
Limestone Conveying circuit

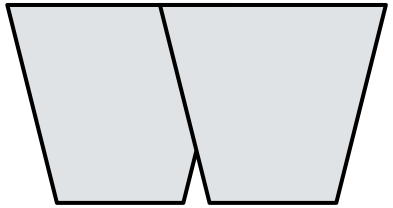


Tippling of Limestone Wagon

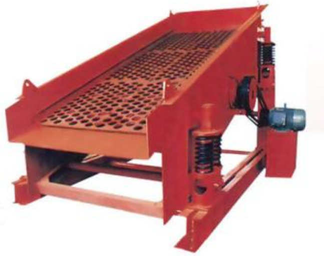
Stacking and Reclaiming at Limestone Yard

Double Decker Screen(80mm & 25mm)





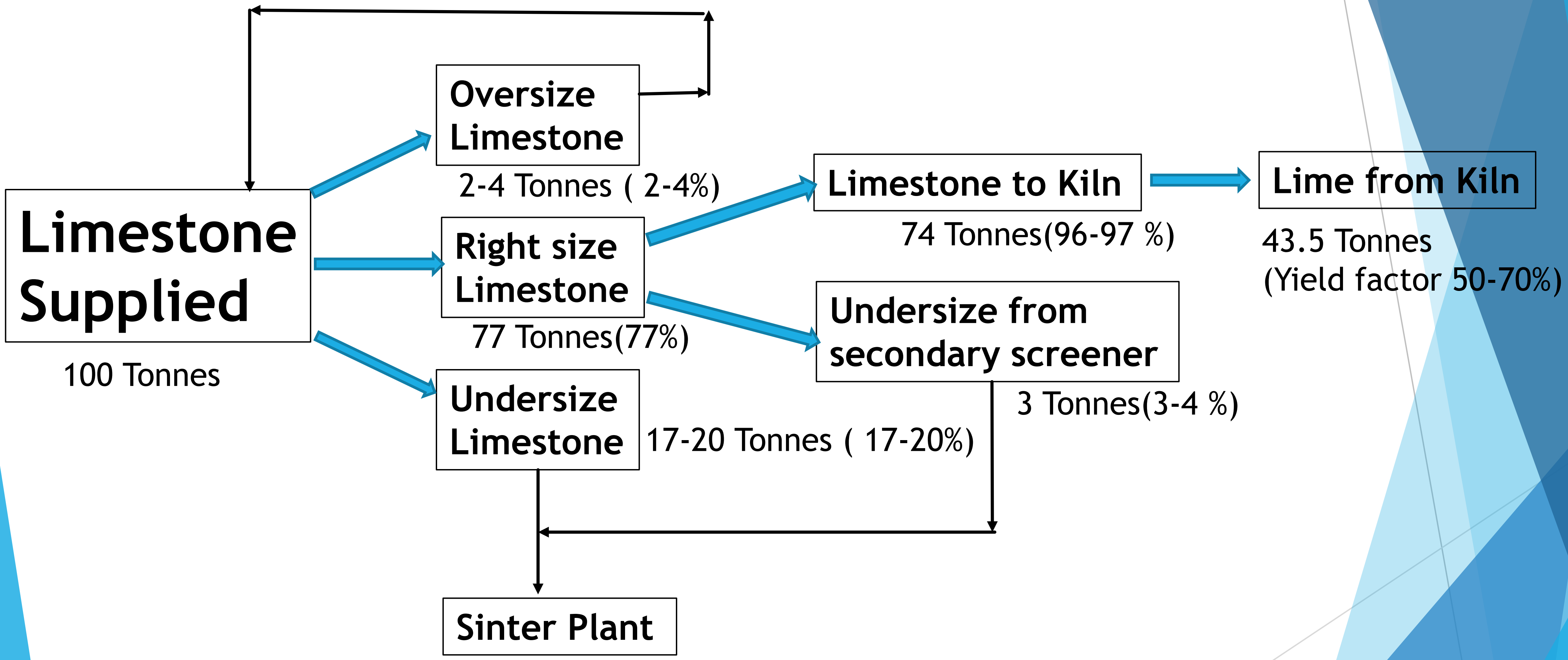
Limestone Storage & Surge Bins



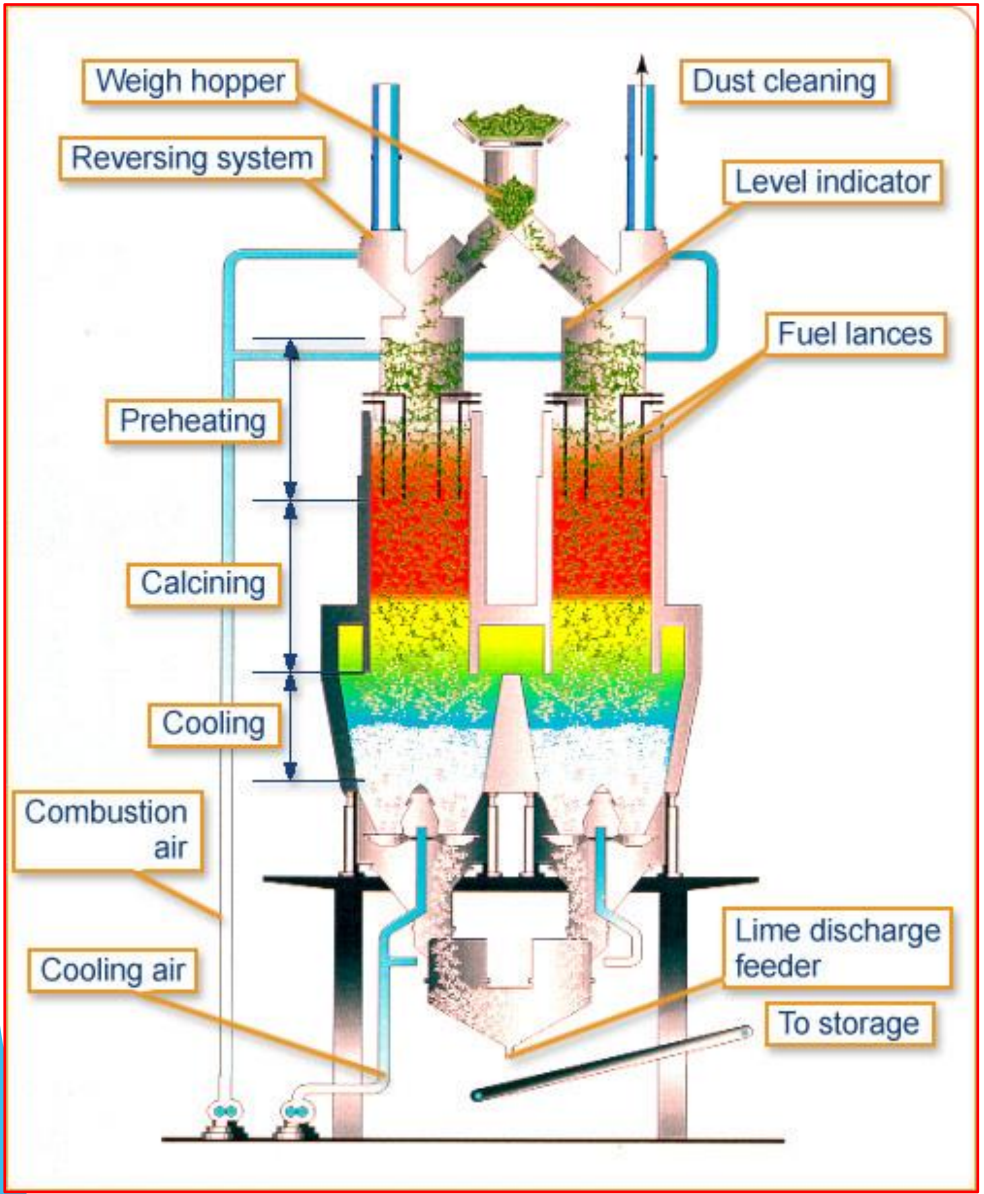
Secondary Screening Before Kiln (25mm)

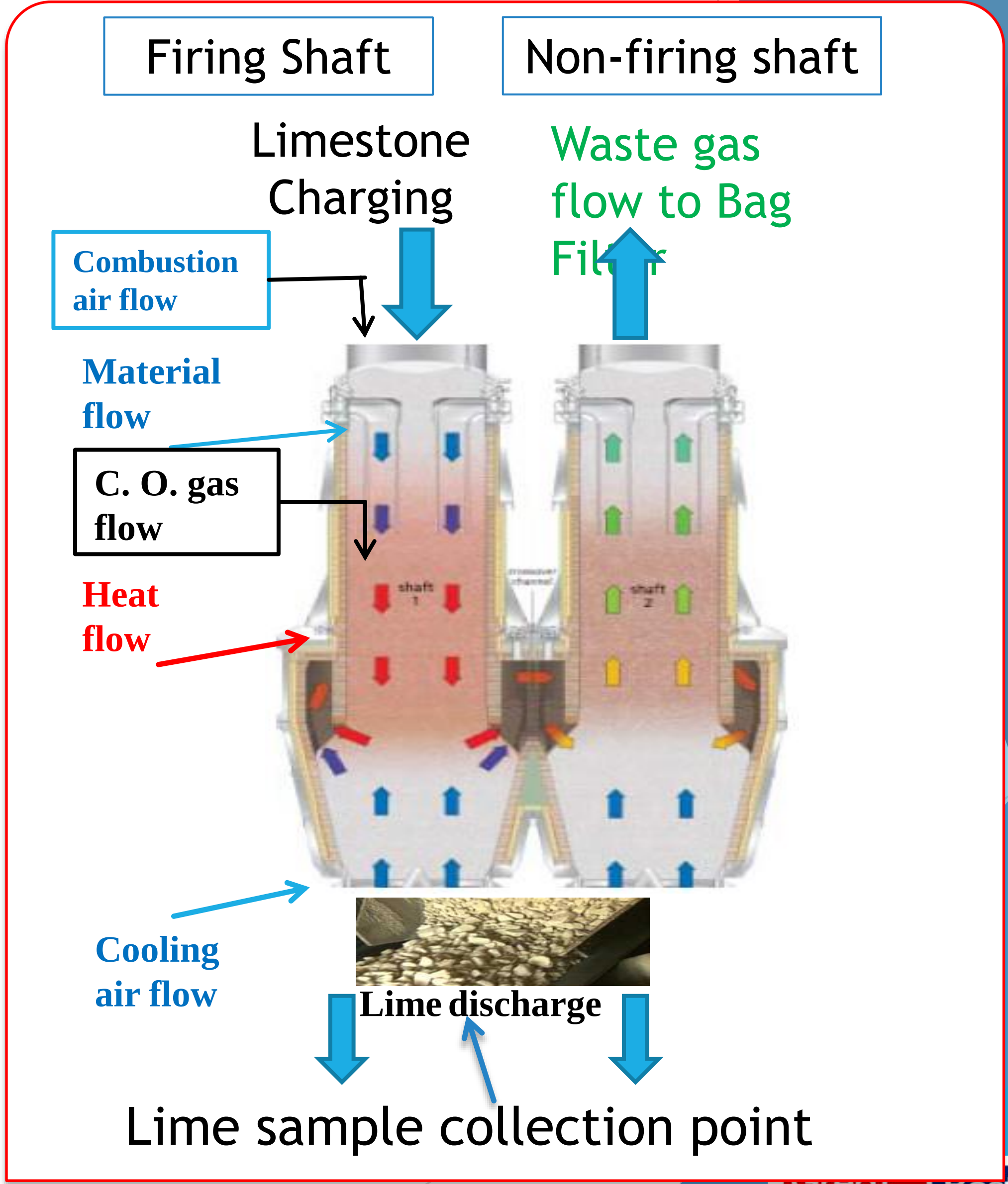
Lime Kiln

Limestone Balancing

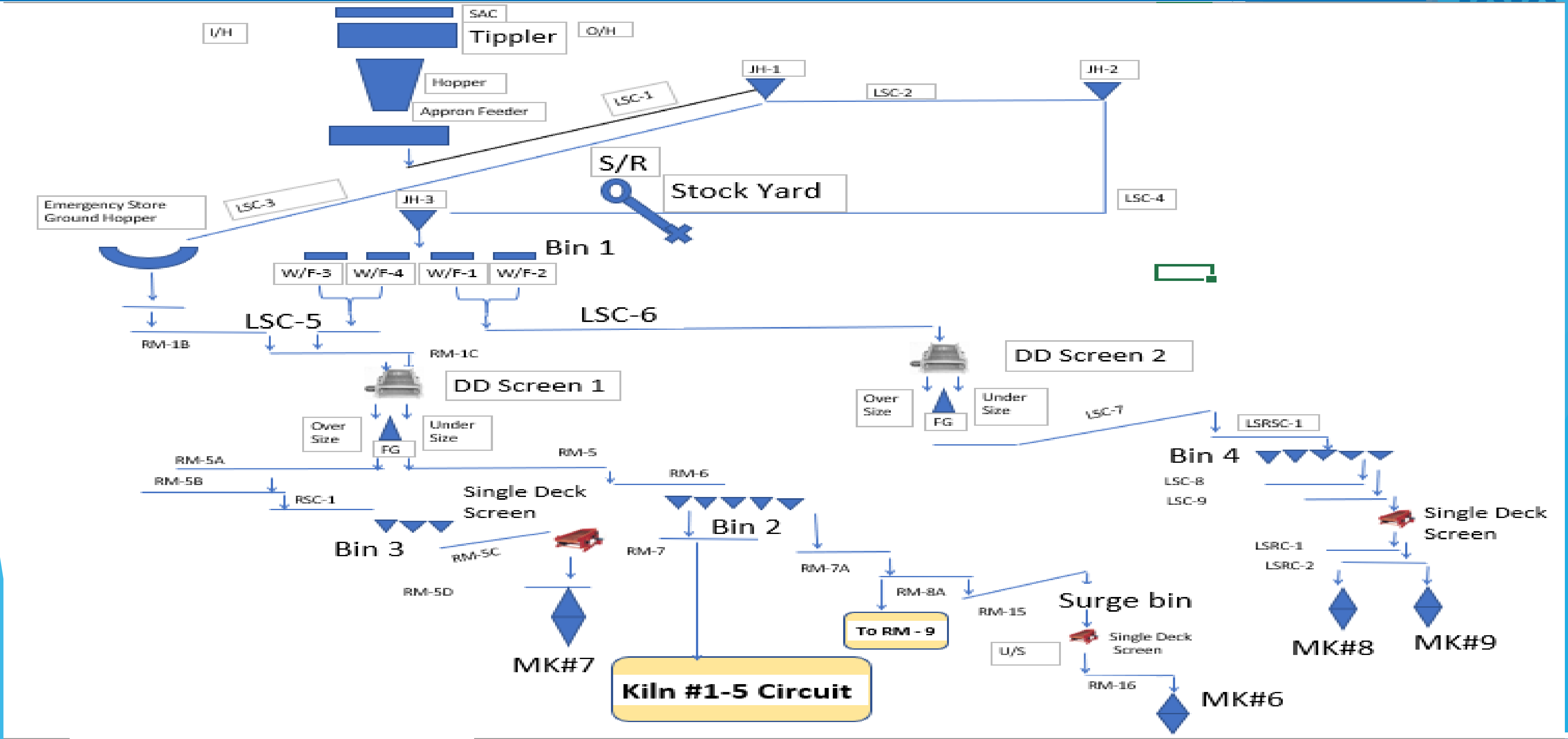


Kiln structure and process

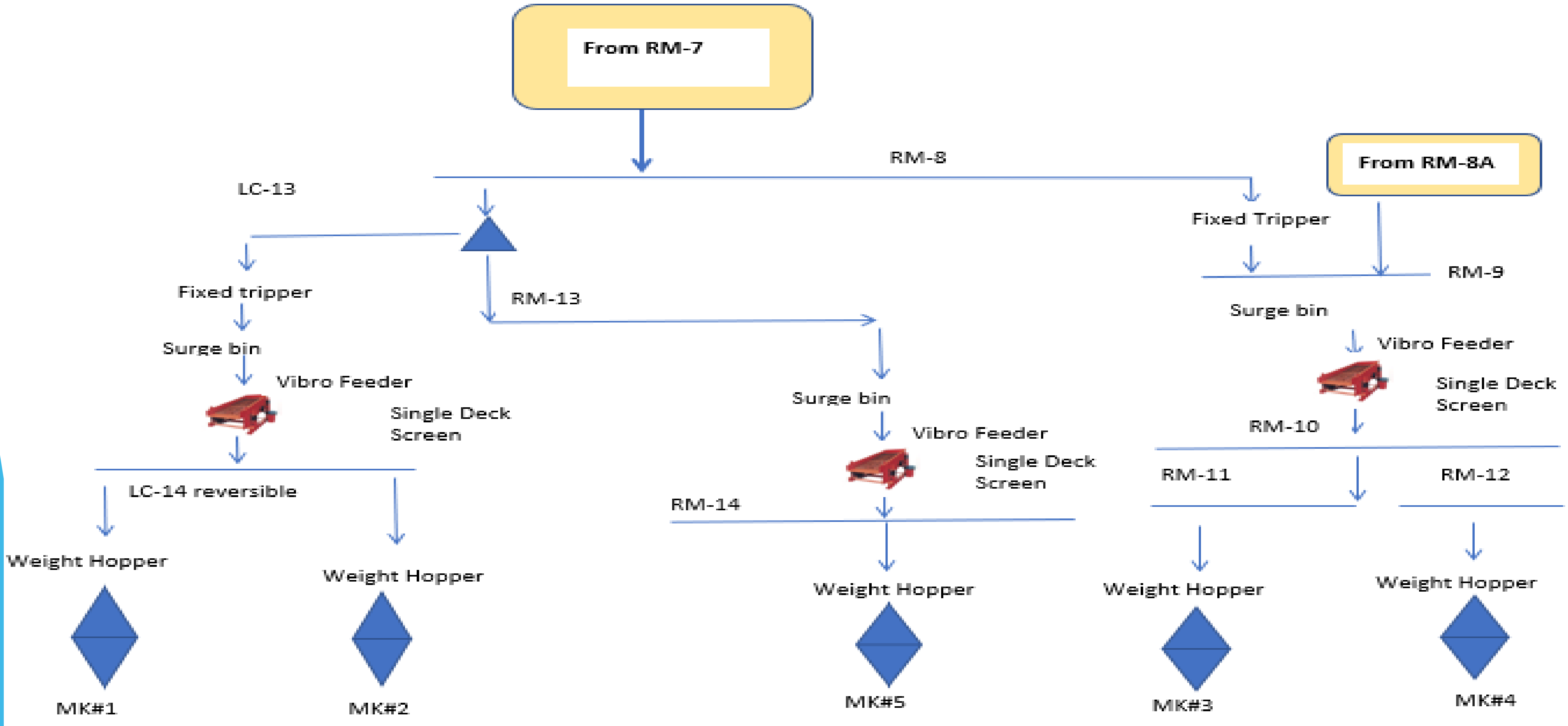




Lime Plant Feeding Circuit Layout (1/2)



Lime Plant Feeding Circuit Layout (2/2)



Lime Plant feeding circuit Bins detail

Storage Bins

Bin	Serve to Kilns
Bin 1*	Kiln# 1 - 9
Bin 2	Kiln# 1 - 6
Bin 3	Kiln# 7
Bin 4	Kiln# 8 - 9

Surge Bins

Bin	No Of Bin
Kiln# 1-2 Surge Bin	2
Kiln# 5 Surge Bin	1
Kiln# 3-4 Surge Bin	2
Kiln# 6 Surge Bin	1

* Bin 1 is not considered as a storage Bin, It is just used for passing material

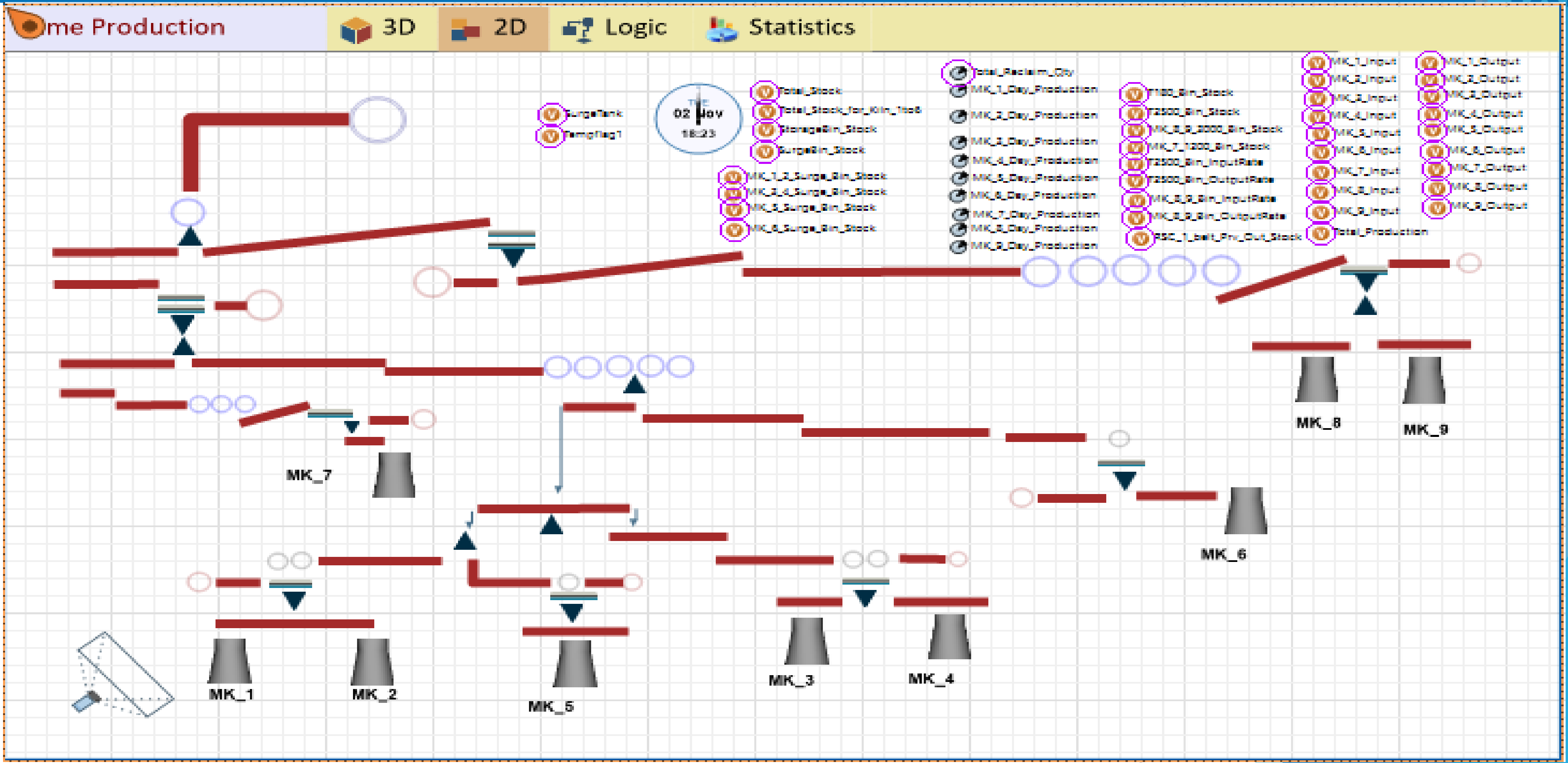
- Kiln # 7, 8 and 9 are directly connected to storage Bin

Lime plant feeding circuit Conveyer belts TPH

From	To	TPH
Lime Tippler	Bin 1	***
Bin 1	DD Screen 1	***
Bin 1	DD Screen 2	***
DD Screen 1	Bin 3	***
DD Screen 1	Bin 2	***
DD Screen 2	Bin 4	***
Bin 2	MK#1,2 Surge Bin	***
Bin 2	MK#3,4 Surge Bin	***
Bin 2	MK#5 Surge Bin	***
Bin 2	MK#6 Surge Bin	***

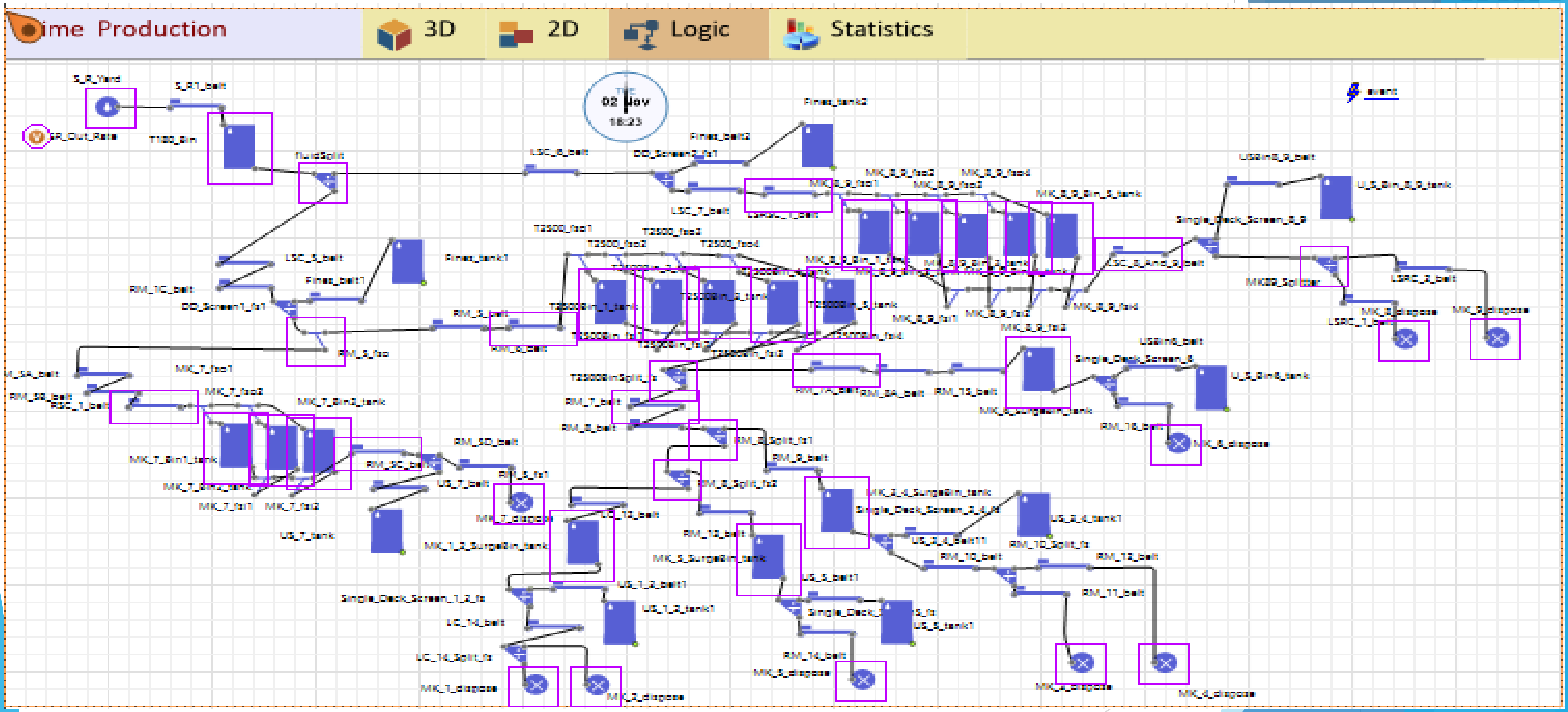
Conveyer Belt TPH varies from 200 to 1200

Simulation Snapshot (1/2)



AnyLogic is used for Simulation

Simulation Snapshot (2/2)



Model is developed with Fluid library (bulk material)

Logics implemented in Model

- In the Circuit Bin1 has two outflows, but in AnyLogic, Tank block has one outflow only, so FluidSplit block is used after Tank block
- FluidSelectOutput and FluidSelectInput blocks are used to change from one Tank to another in same location which are considered as source as well as destination in the Model
- FluidSplit is used to separate larger and smaller size Limestone from Screening process

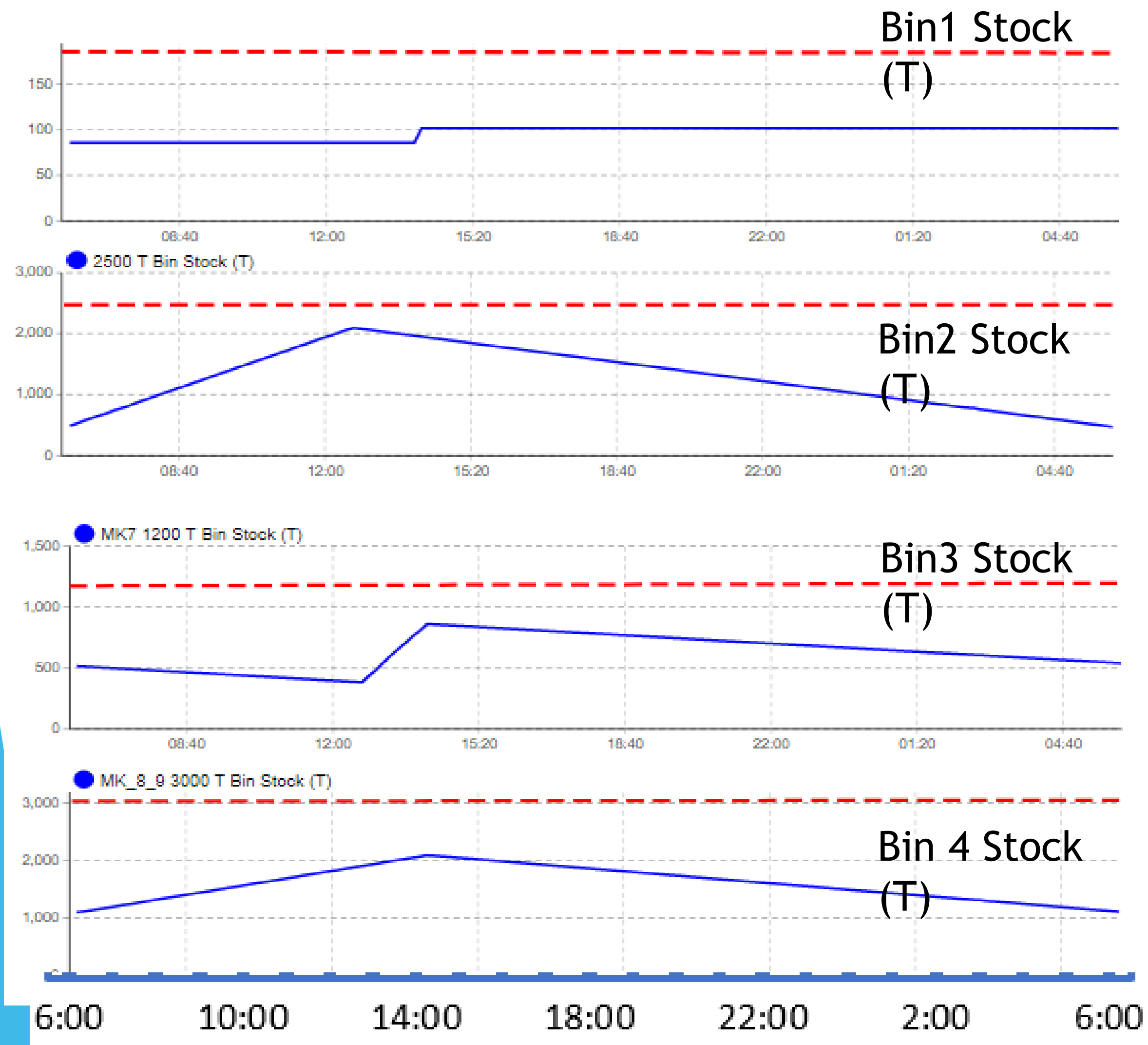
Observing parameters

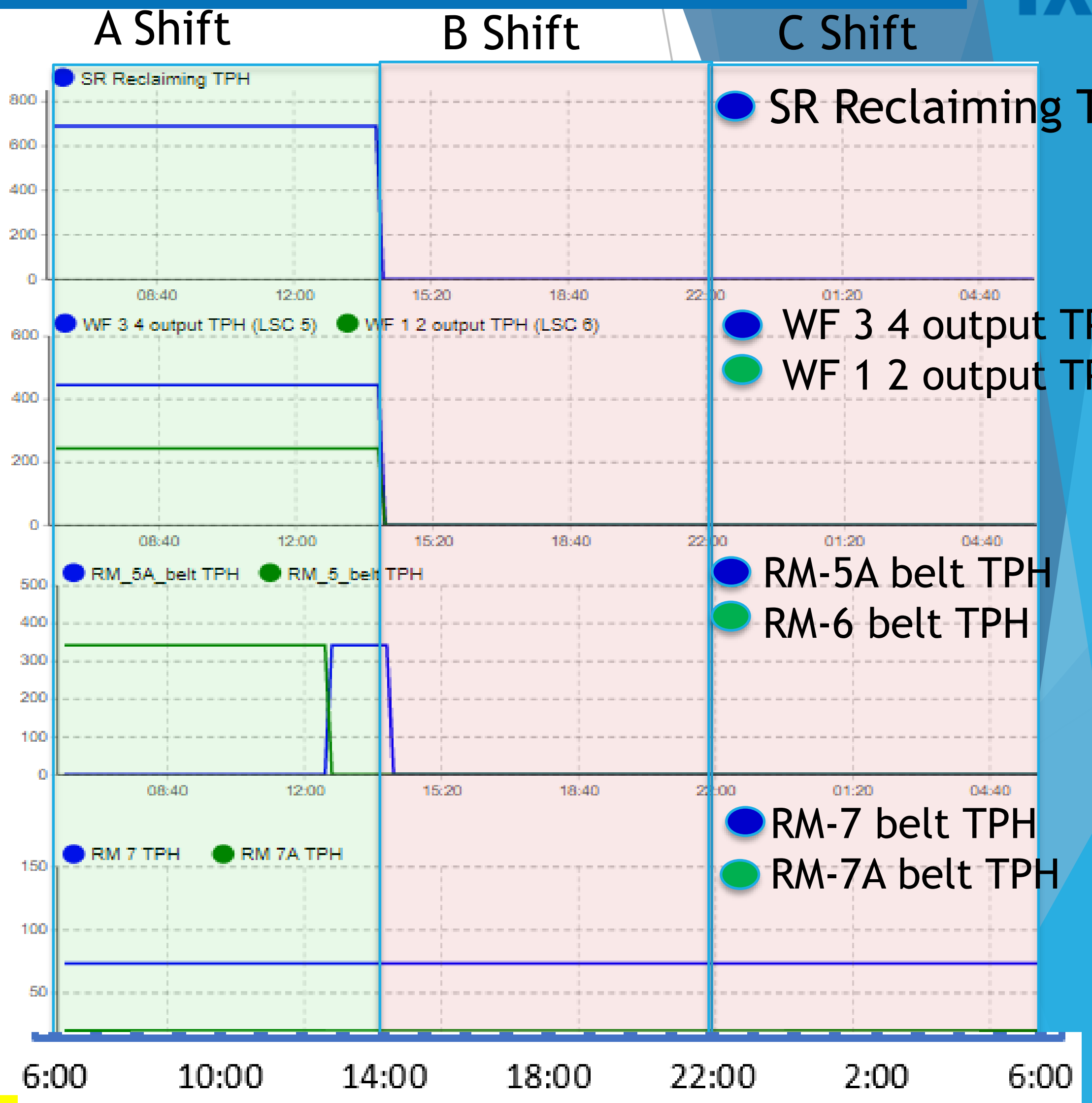
- Storage Bin status
  - Bin 1
  - Bin 2
  - Bin 3
  - Bin 4
- Surge Bin status
- Specific conveyer belts running status and TPH
- Material distribution
- Total available stock
- Production rate

Case1: Scenario

Case 1 (As-Is) : With average current production in one day from all Kilns (Average current production is calculated from plant data)

Case1: Simulation Result (1/2)



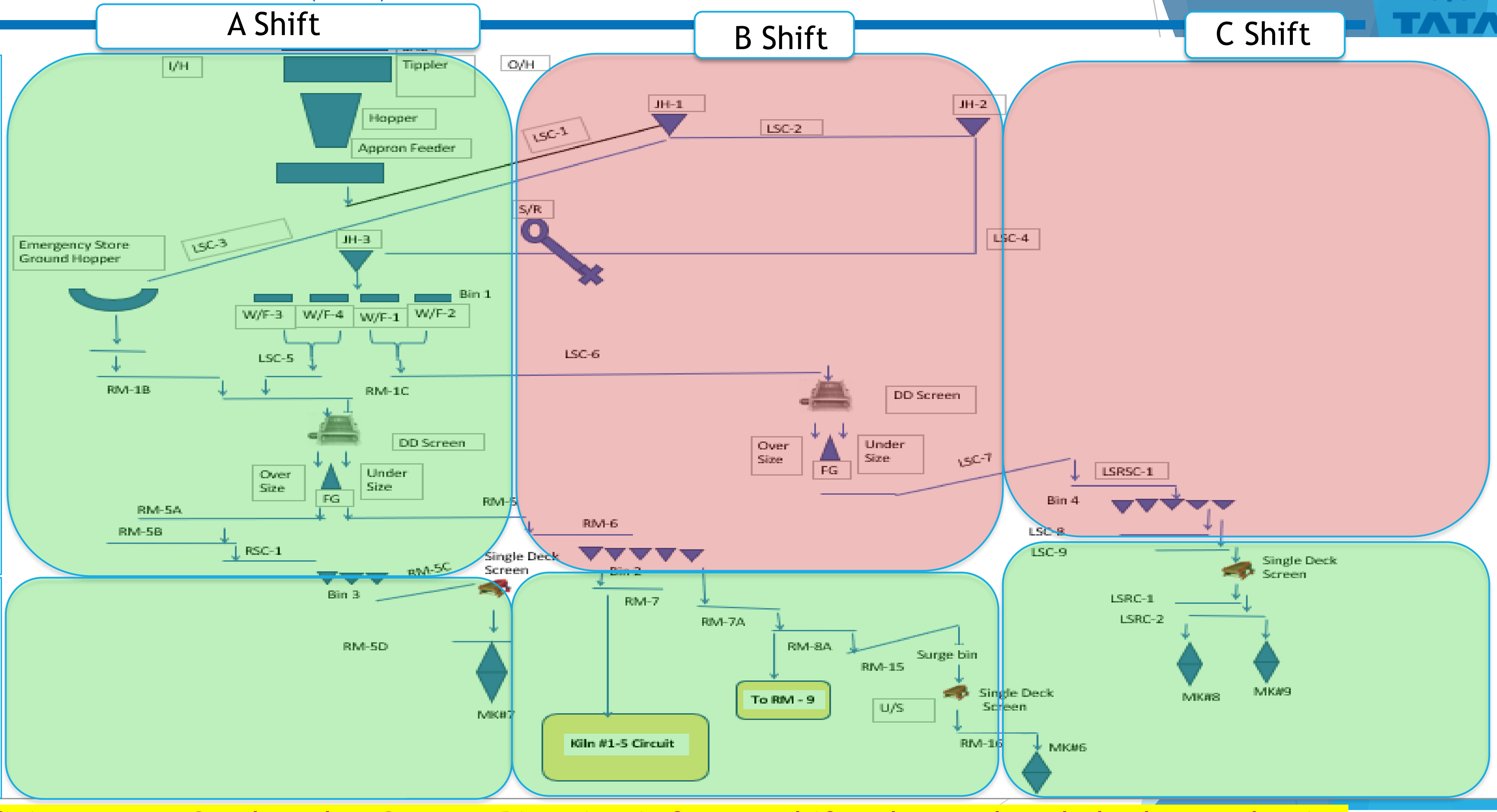


- Production at current rate can be easily taken with one shift reclaiming only
- All Bins are maintained within 20 % to 100 % capacity

Case1: Simulation Result (2/2)

Stockyard to Storage Bins

Storage Bins to Kilns



It is sufficient to run Stockyard to Storage Bins circuit for one shift only to take whole day production

Case2: Scenario: Bottleneck finding in circuit

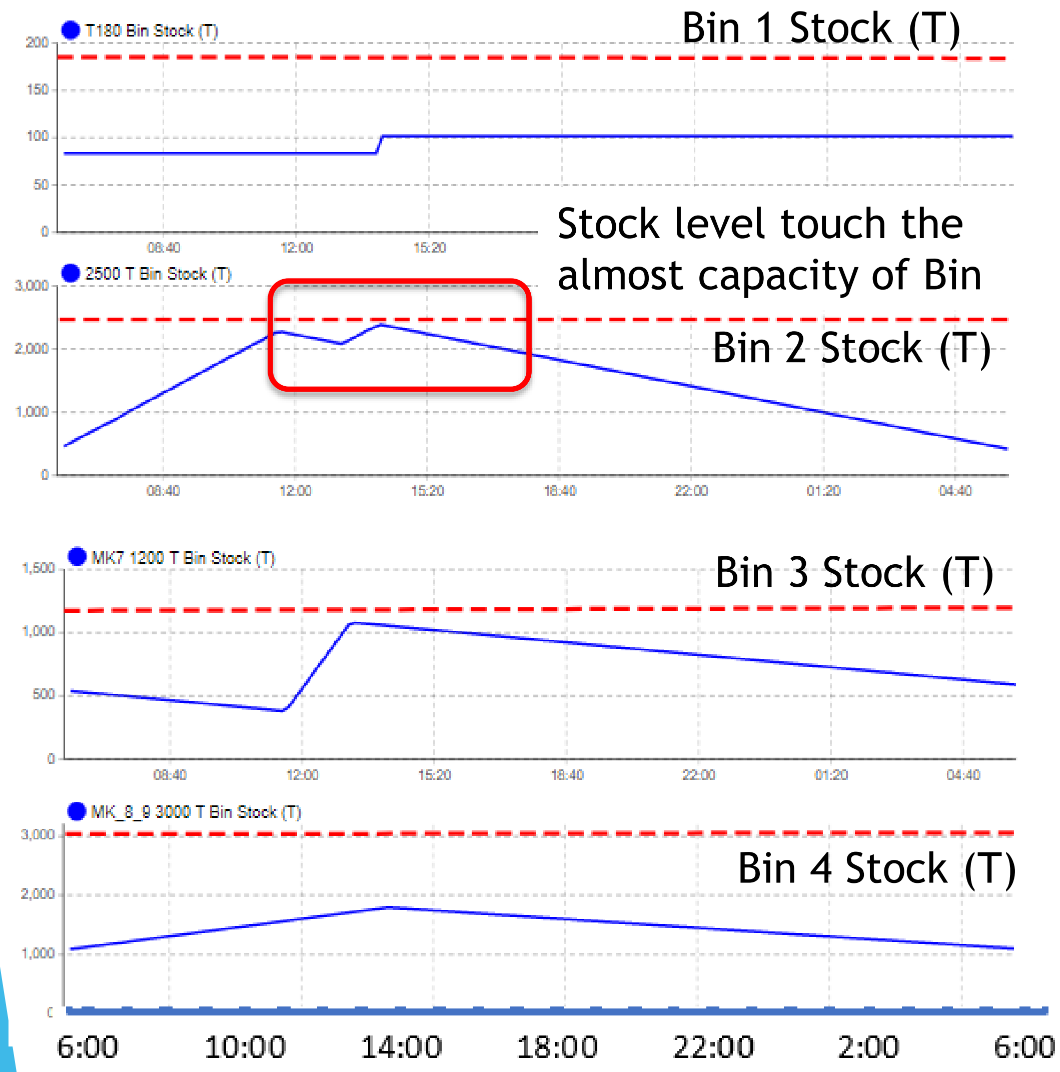
Case 2 : With *** T of Production from Kiln # 1 to 6, *** T from Kiln # 7 and one Kiln shutdown from 8 & 9.

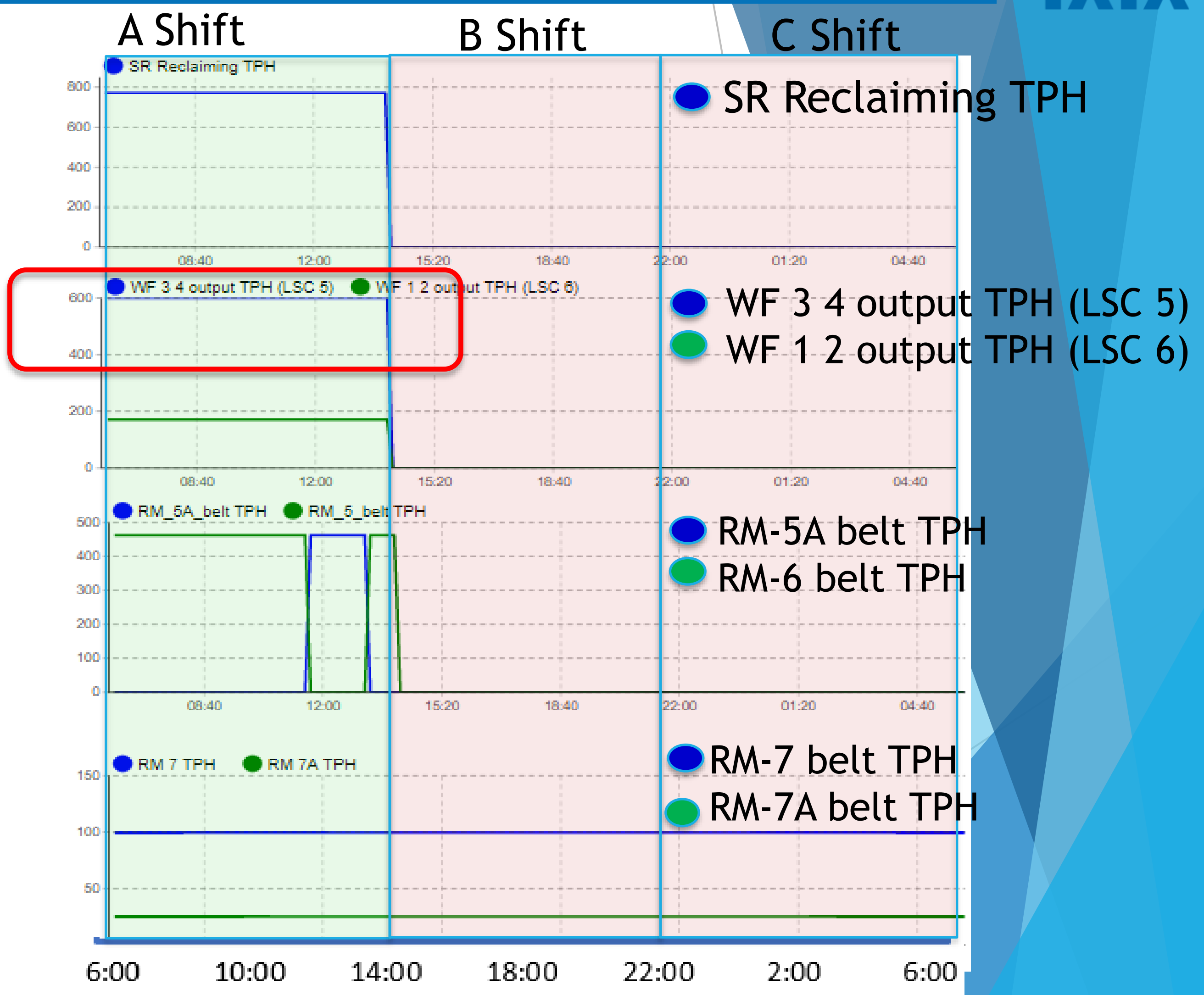
Remark:

- After running many simulation, it is derived that how much production can be taken from Kiln# 1 to 6 with 1 shift reclaiming because of **Bin2 constraint** (without utilizing Surge Bins)
- It is also find out that how much maximum production can be taken form Kiln# 1 to 7 with 1 shift reclaiming because of **Weigh Feeder 3 & 4 limited feeding rate capacity**

Surge Bin utilization is not considered in this case (We are transferring Limestone from Storage Bins to Kilns at the required TPH)

Case2: Simulation Result



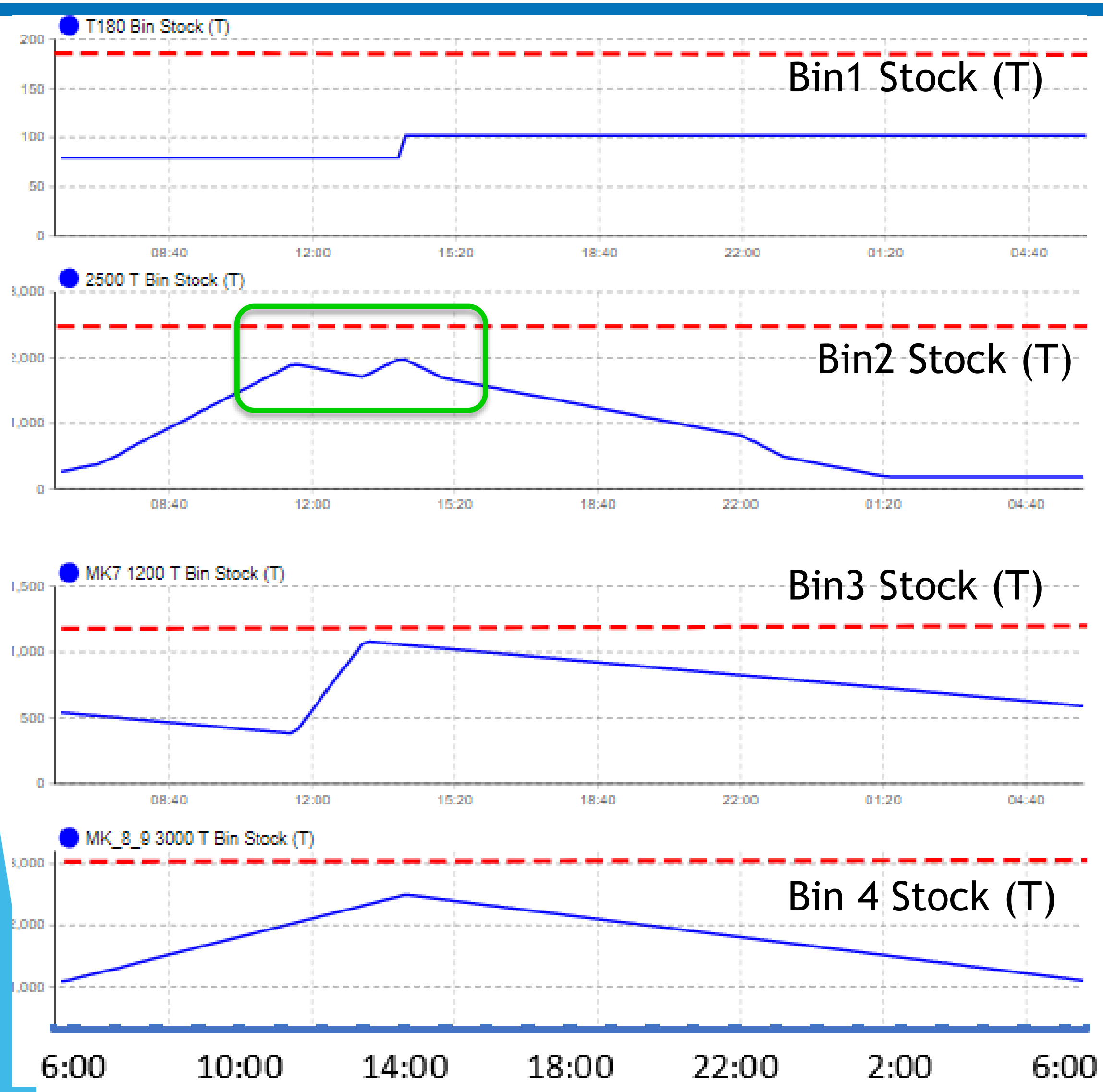


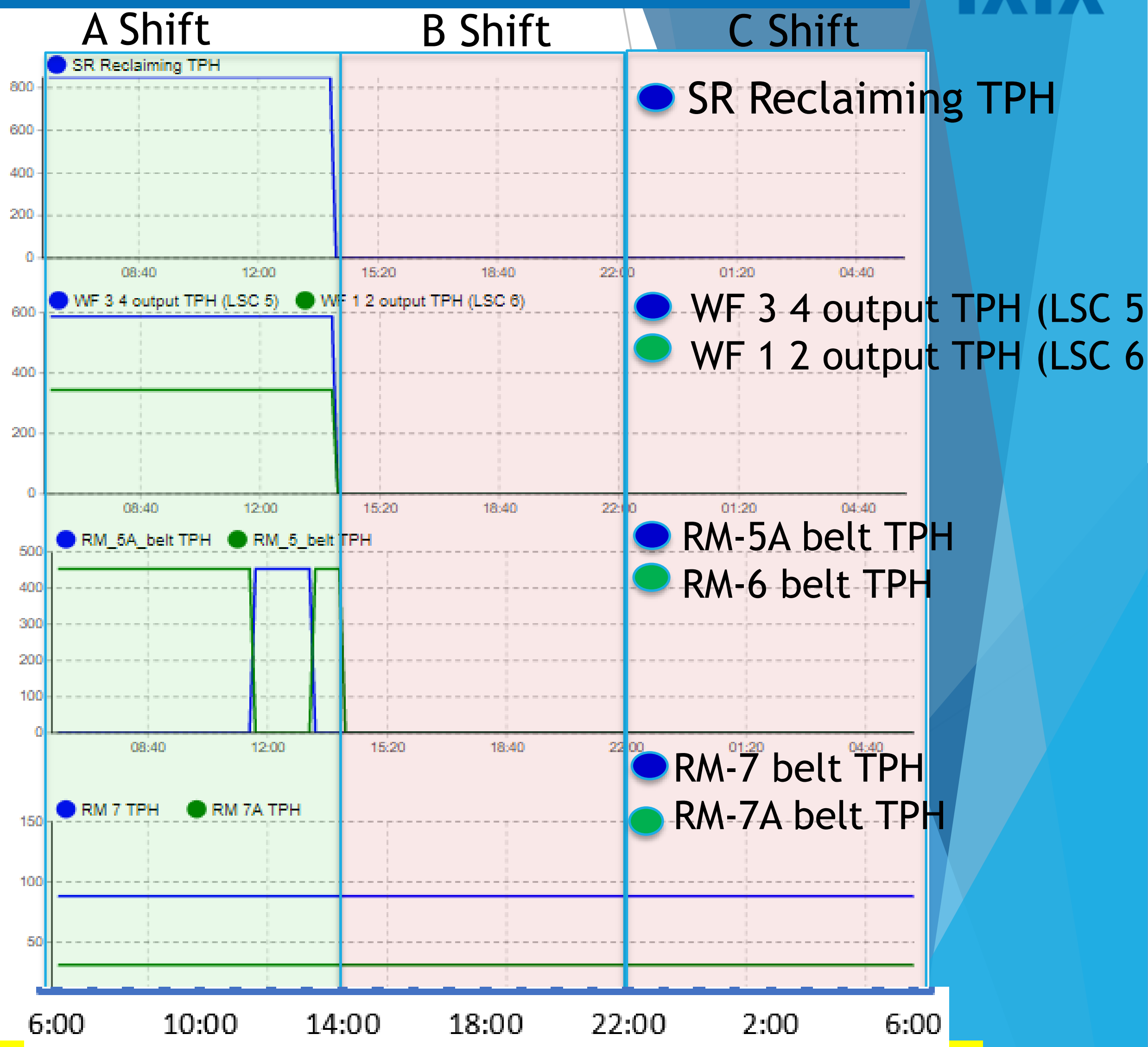
- Bin2 capacity and WF 3 & 4 TPH are bottleneck for the feeding circuit

Case3: Scenario: Surge Bin Utilization

Case 3 : Maximum possible production with both constraint and with utilization of Surge Bin

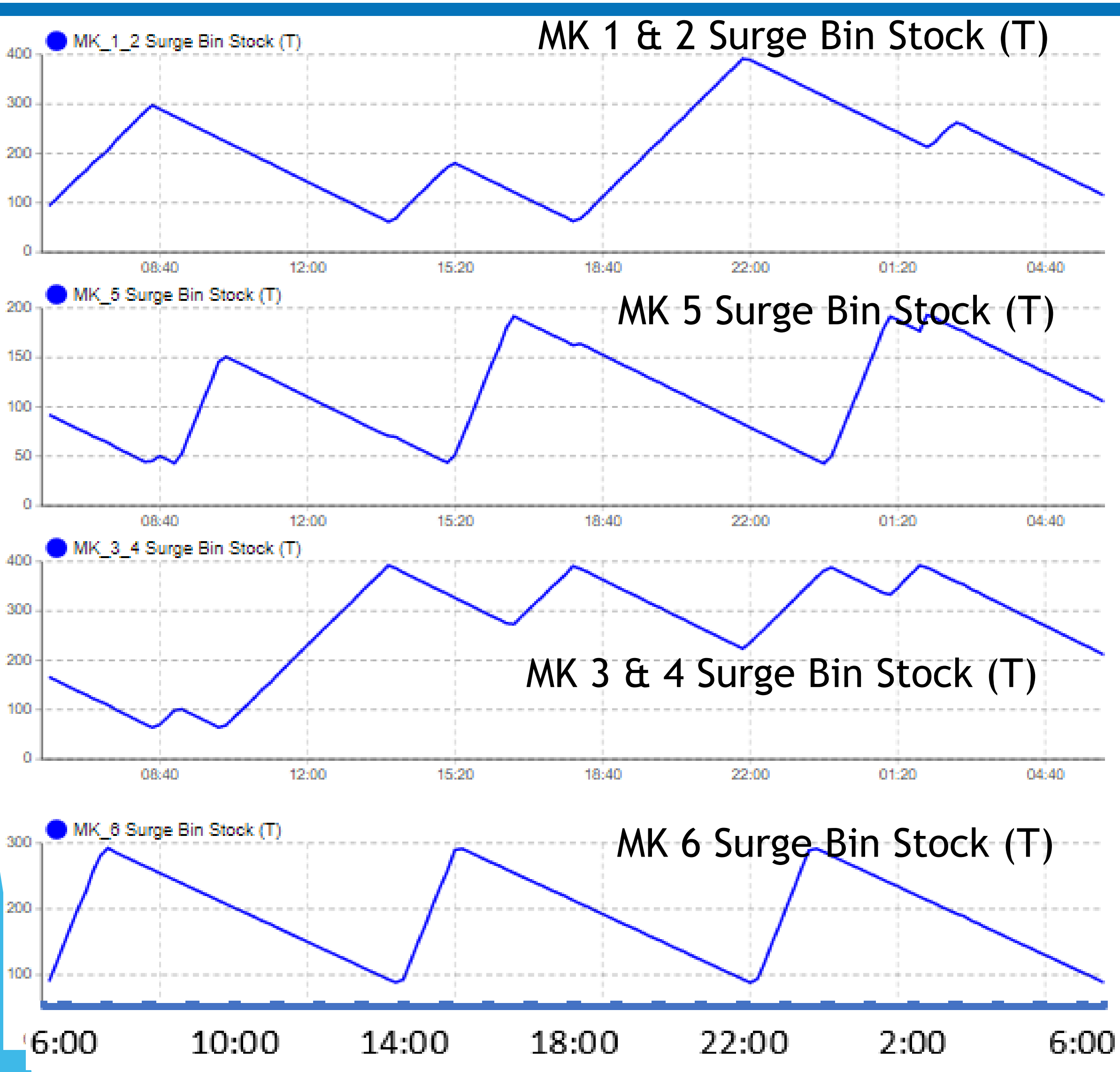
Case3: Simulation Result (1/2)

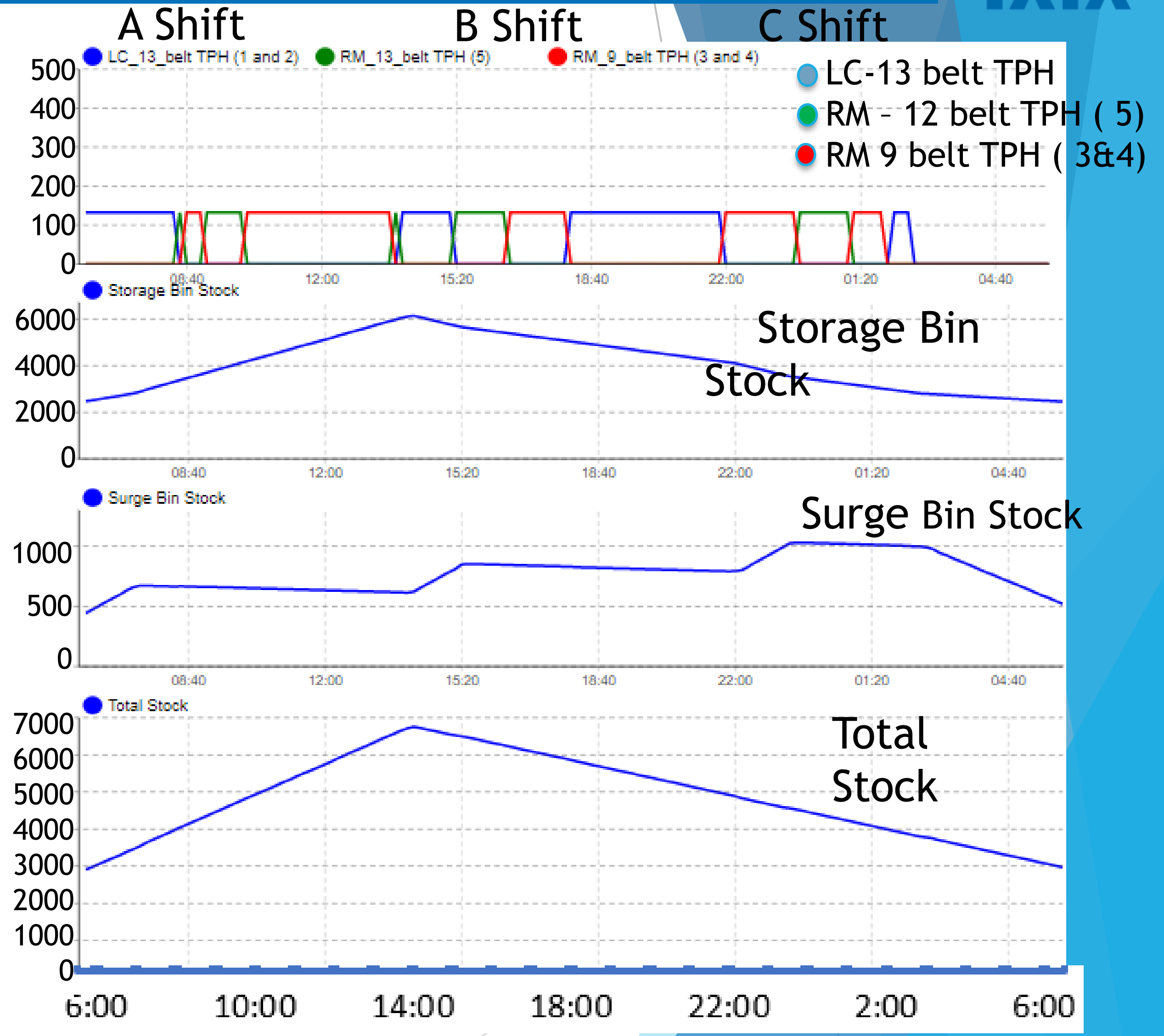




- As Surge Bin are available, Bin 2 stock can be transferred to Surge Bins simultaneously so Bin 2 is no more constraint (provided space available in Surge Bins at the starting of A shift) and we can increase production

Case3: Simulation Result (2/2)





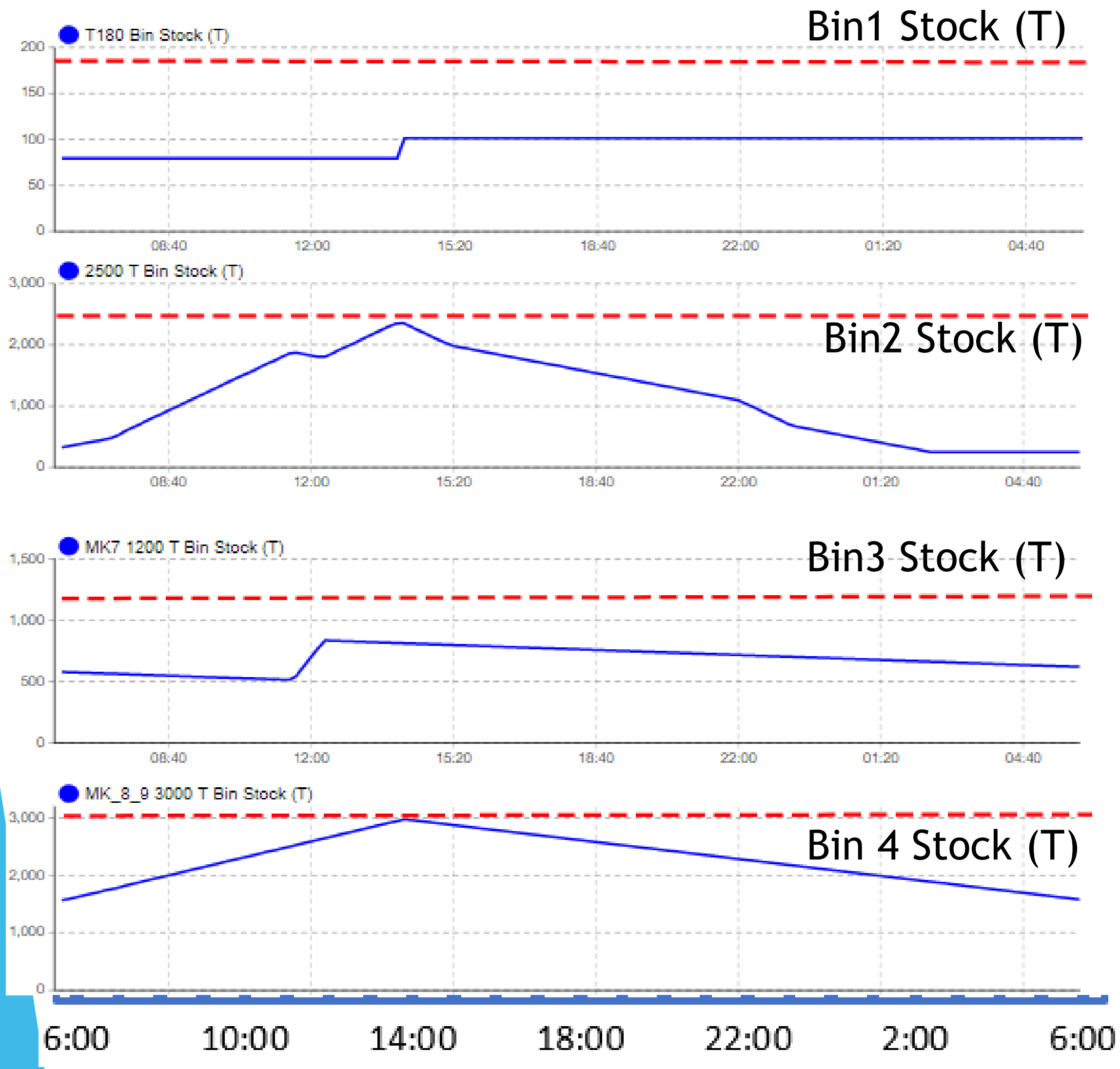
- Surge Bin (1-5) stock is only sufficient to take 6-hour production, after 6-hours they again must be refill

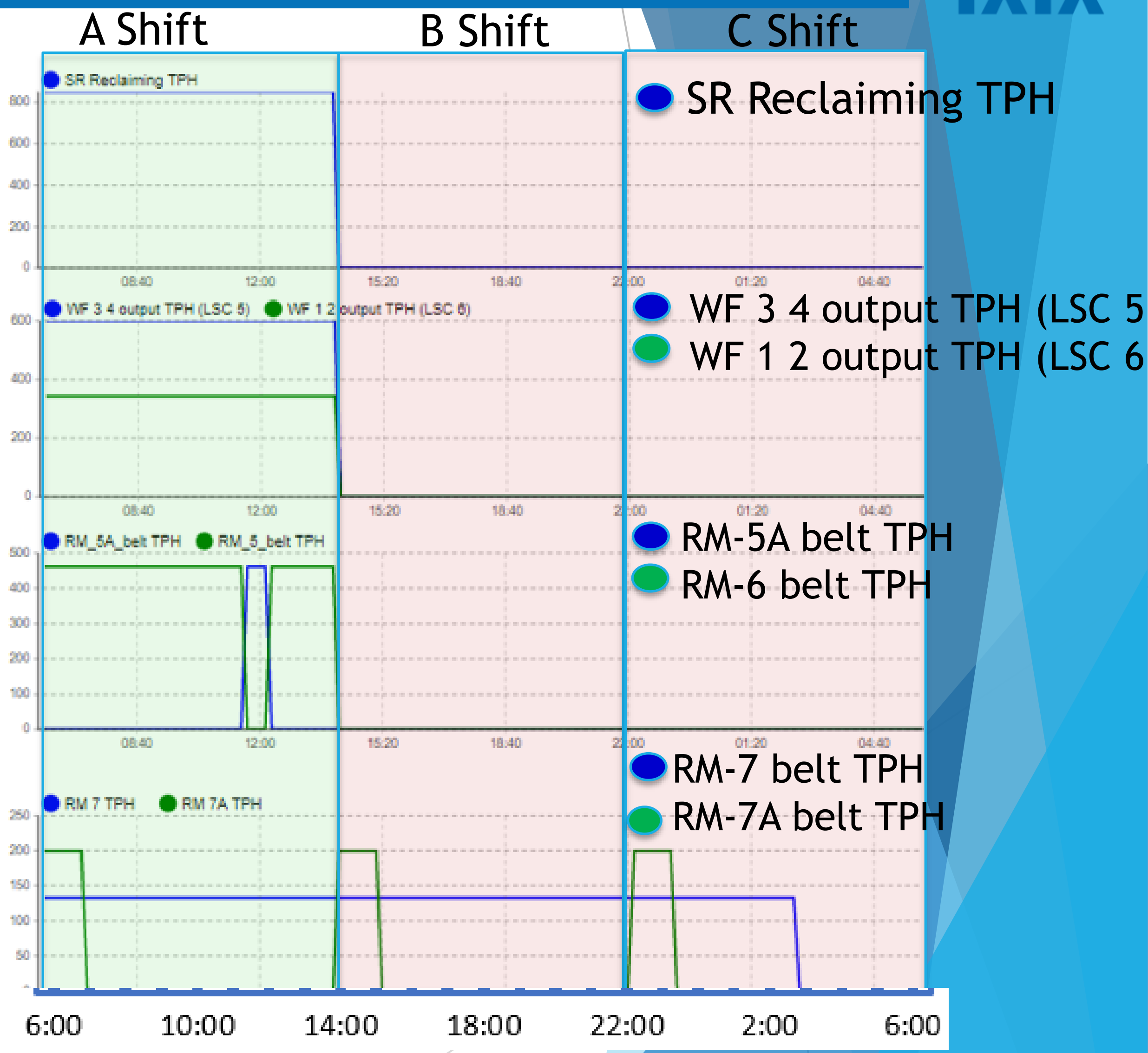
Case4: Scenario: Buffer Stock Analysis

Case 4 : With avoiding Bin 2 constraint and taking more Production from Kiln 1-6 with Surge Bin utilization

- Obtain the Minimum stock which can be maintained in Bin2, Bin3 and Bin4

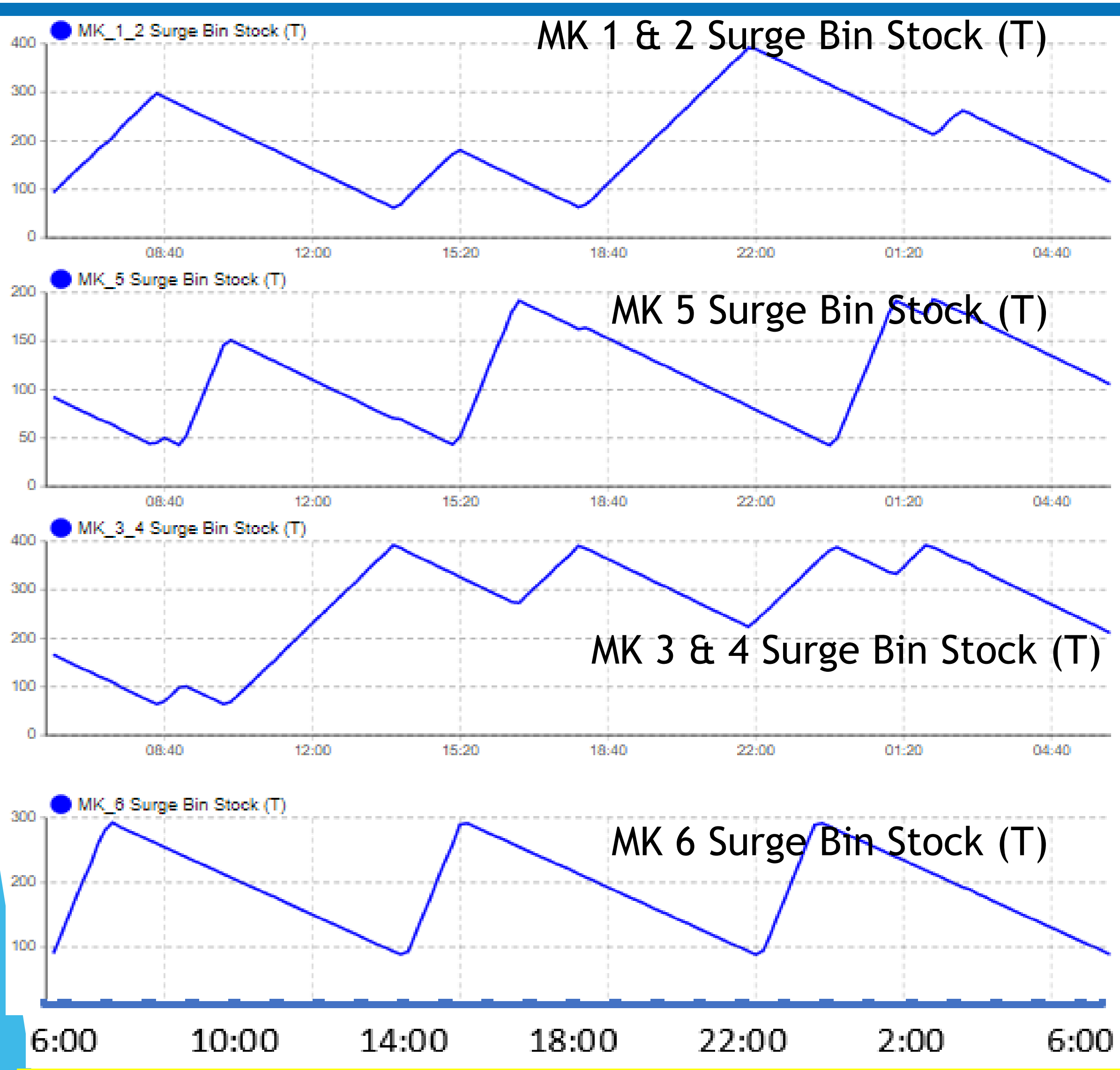
Case4: Simulation Result (1/3)





- Minimum stock which can be maintained in Bin2, Bin3, Bin4 are obtained from Model

Case4: Simulation Result (2/3)



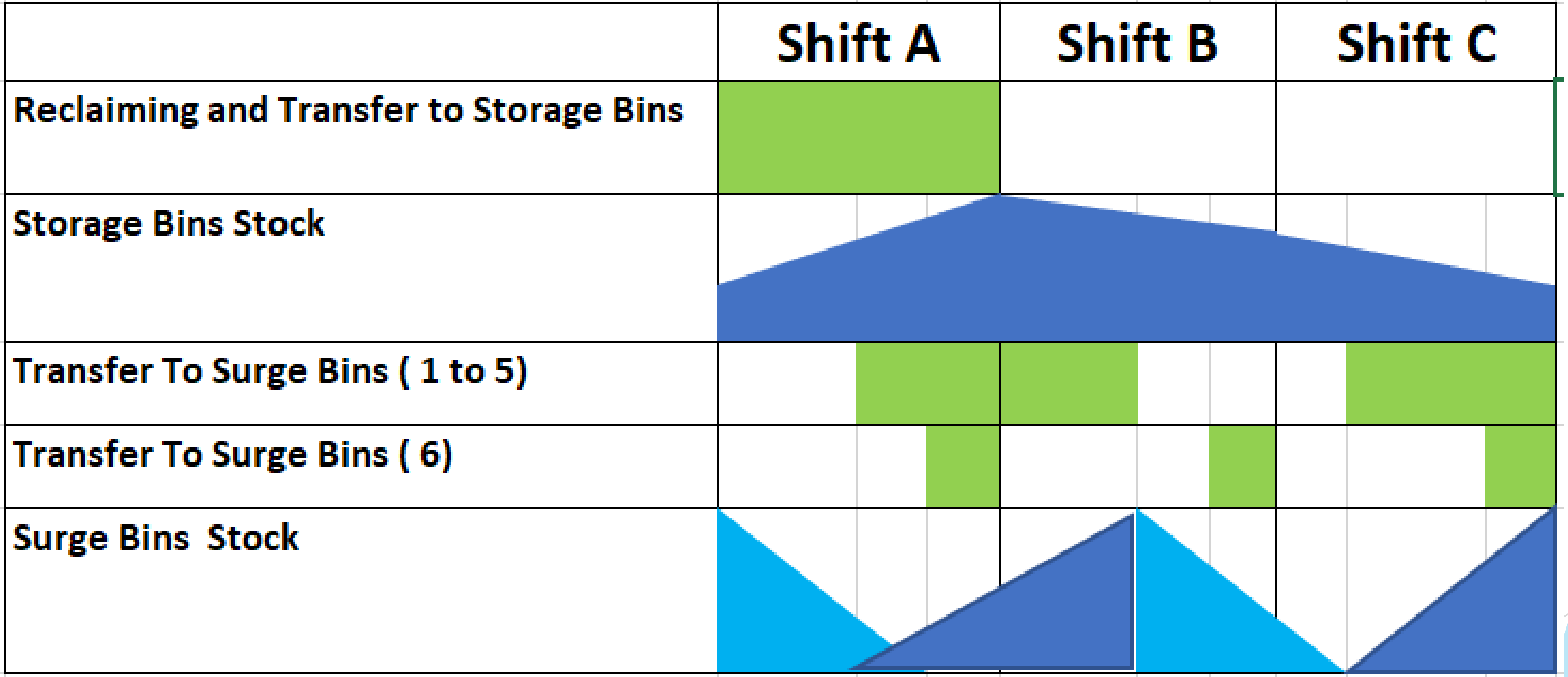
- Bin 2 constraint no more applicable for Kiln # 1-6 if we utilize Surge Bin with minimum 400 T space for stock initially

It is feasible to take full capacity production from Kiln # 1-6

Case4: Observations and analysis (3/3)

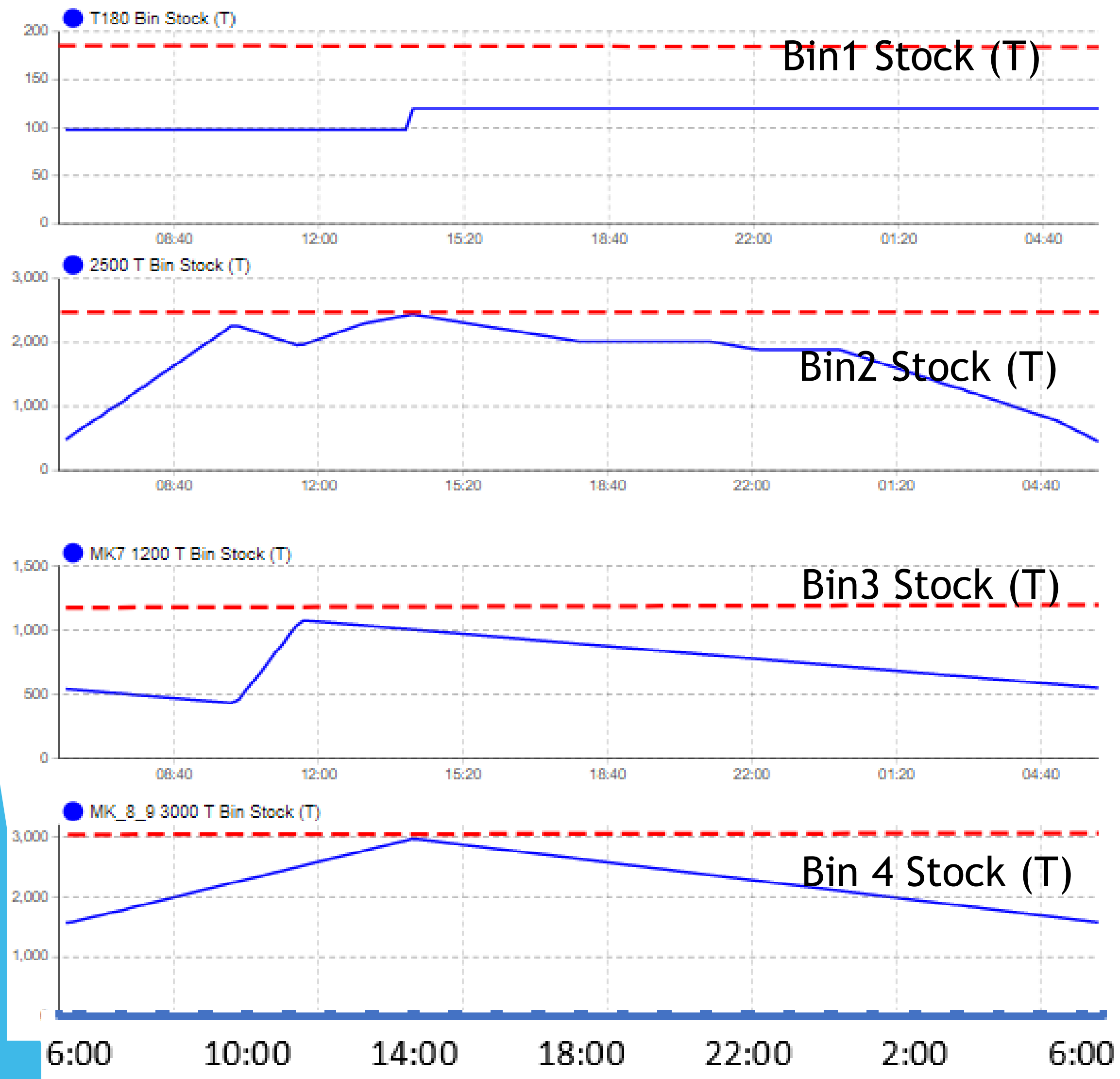
- Bin2 constraint is no more applicable for Kiln # 1-6 if we utilize Surge Bin with minimum 400 T empty space initially
- Belt Snap(tear), Chute or structure issue takes up to 12 - 14 hours to repair, for that time to running the production continuously buffer stock is needed
- Minimum stock in storage Bins and Surge Bins which can be maintained is obtained from Simulation
- Total Minimum stock available in Bins is as below
  - Enough buffer stock can be maintained for Production from Kiln # 8 & 9 for 2 shift
  - Enough buffer stock can be maintained for Production from Kiln # 7 for 2 shift
  - Minimum available stock in Bins are not sufficient for 2 shift production from Kiln # 1 to 6 in case of any breakdown

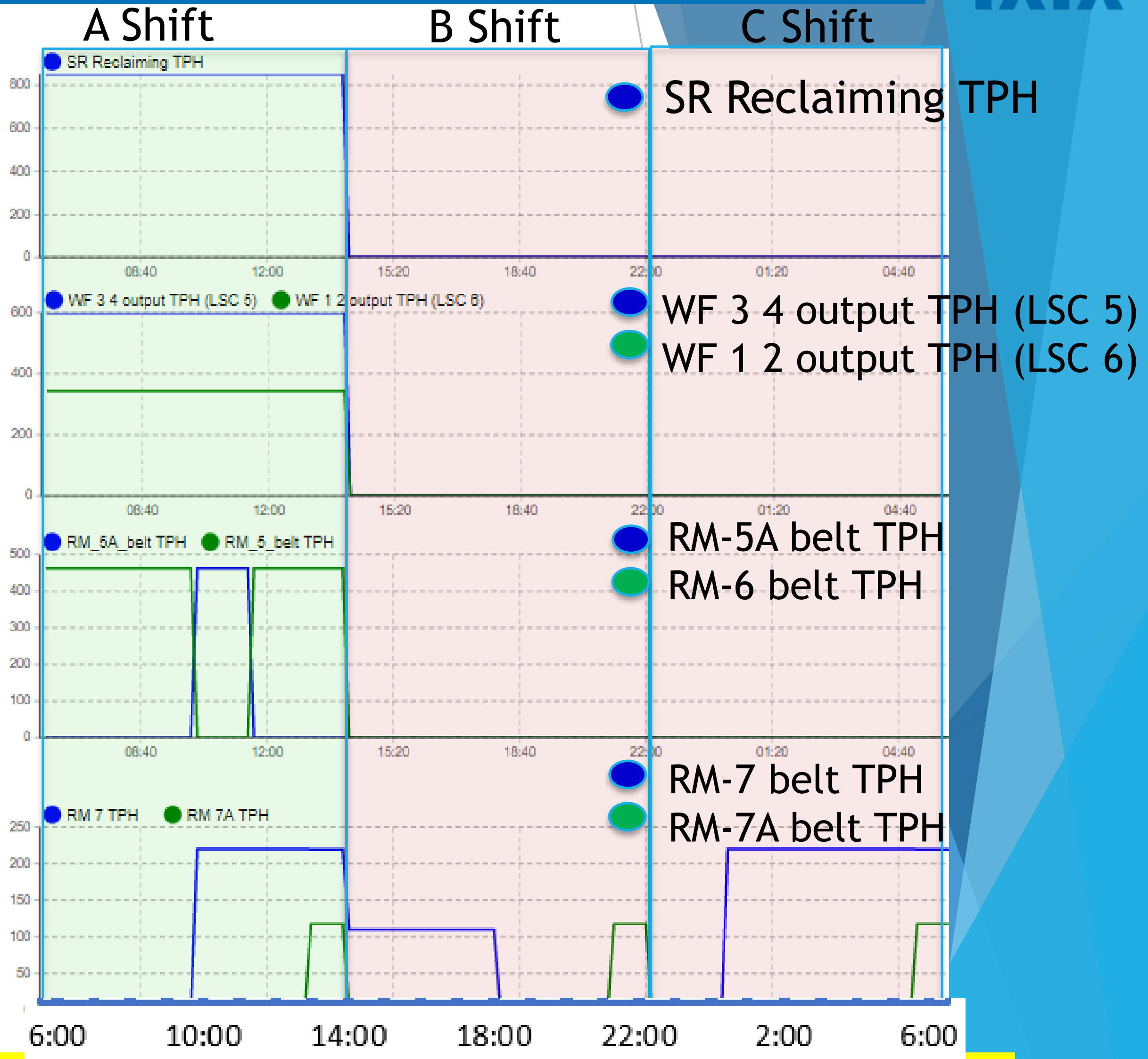
Case 5 : optimistic schedule as below to maintain sufficient buffer stock in circuit



Later, it is also observed that transfer to surge bin is enough to take 4 hrs in A Shift and 2-2 hours in B & C Shift

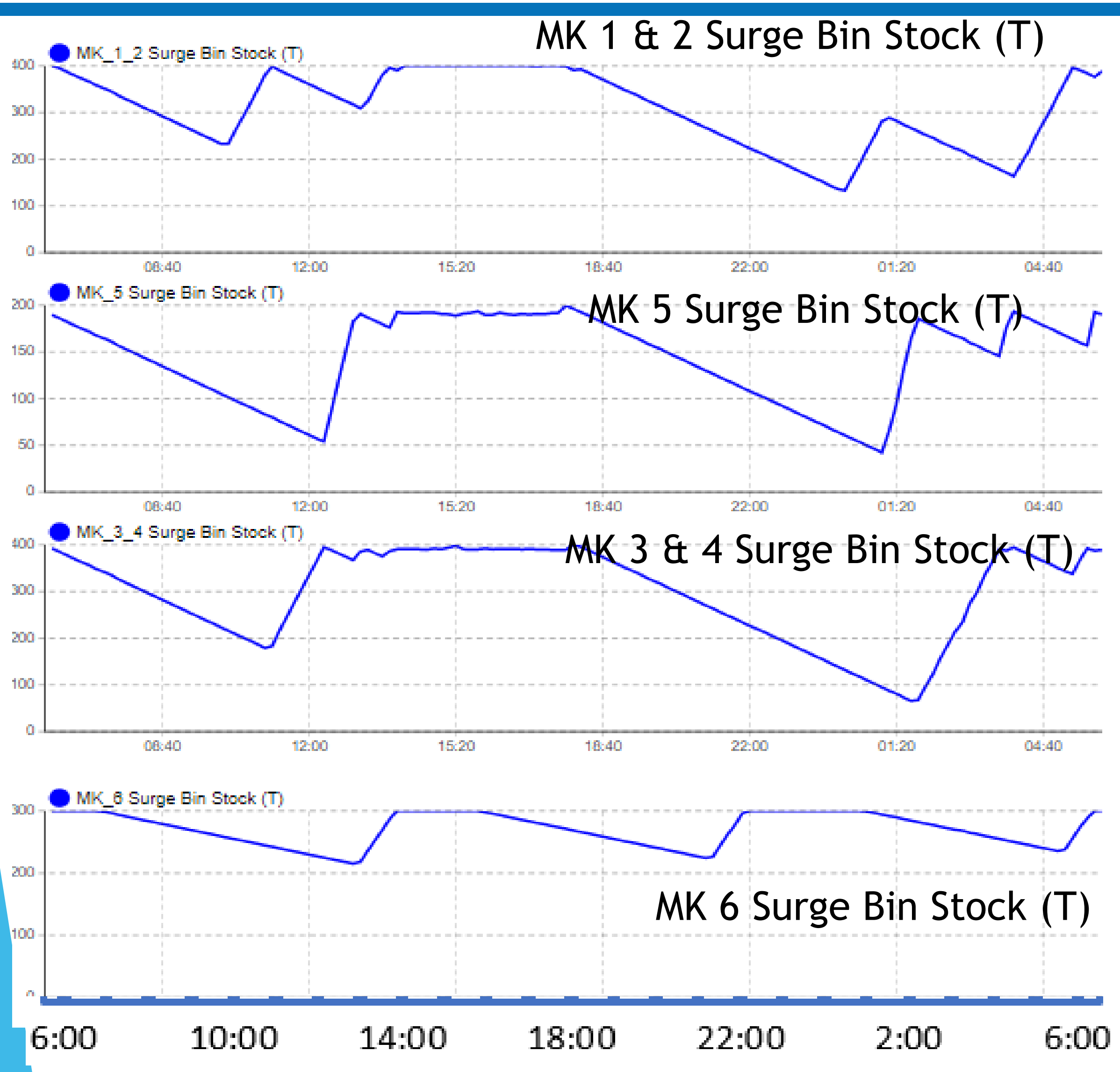
Case5: Simulation Result (1/4)

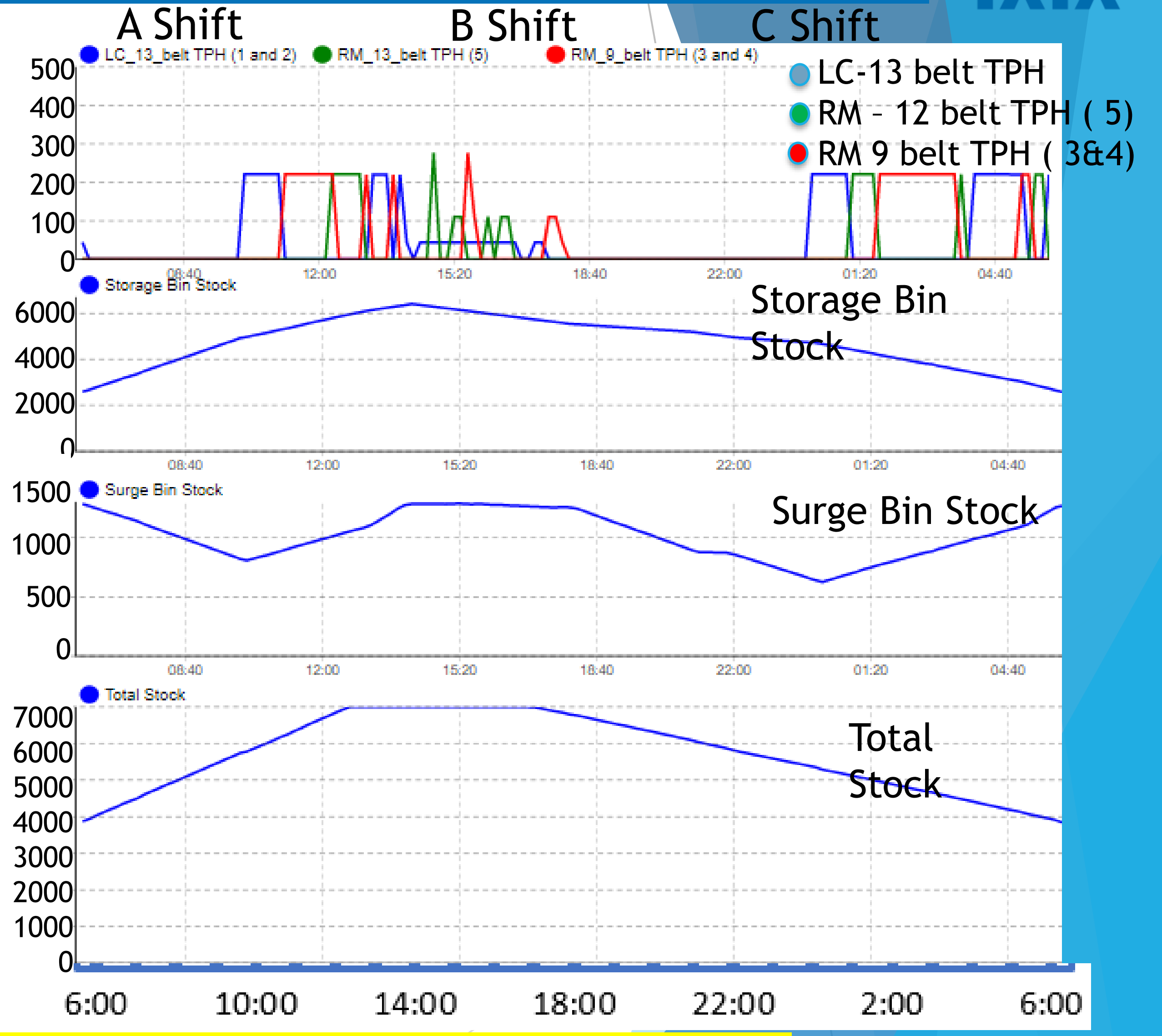




- Bin 2 constraint is again needed for Kiln # 1-6 if we utilize Surge Bin with full stock initially, This is same as case 2, where no space is available for reclaiming stock in Surge Bin

Case5: Simulation Result (2/4)

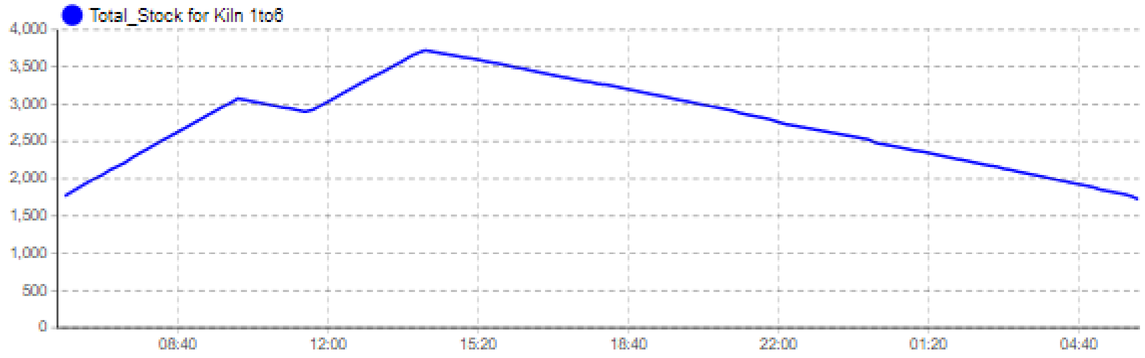




- Buffer Stock Which can be maintained in Storage Bin and Surge Bin are obtained from the Model

Case5: Observations and analysis (3/4)

- Storage Bin to Surge Bin transfer can be taken in two spell of 8 and 6 Hours, then this circuit can be turn off for 10 hours in a day and can save power.
- At the end of C shift when stock is at minimum level in Storage Bins then Surge Bin stock are full to its capacity
- With this strategy, the maximum production which can be taken from Kiln 1-6 is reduced by 225 T (compare to Case 4) which can be managed by Kiln #7, but buffer stock will be increased by 750 T
- Buffer stock is enough to take 2 shift production from all Kiln in case of any breakdown in Logistic circuit



Case5: Final running hours of conveyer belts(4/4)

	Route	Conveyer Belts	Running Hour
Reclaiming	Bin1 to DD Screen 1	LSC-5, RM-1C	8
	Bin1 to DD Screen 2	LSC-6	8
	DD Screen 1 to Bin2	RM-5, RM-6	6.5
	DD Screen 1 to Bin3	RM-5A, RM-5B, RSC-1	1.5
	DD Screen 2 to Bin4	LSC-7, LSRSC-1	8
Storage Bins to Surge Bins	Bin2 to RM#8	RM#7, RM#8	6
	RM#8 to Surge Bin 1,2	LC#13	2.7
	RM#8 to Surge Bin 3,4	RM#9	2.7
	RM#8 to Surge Bin 5	RM#13	2.7
	Bin2 to Surge Bin 6	RM#7A, RM#8A, RM#15	3
Surge Bins to Kiln	Surge Bins to Kilns	LC#14, RM#10,RM#11, RM#12 RM#14, RM#16, RM#5C, RM#5D, LSC#8 or LSC#9, LSRC#1 or LSRC#2	24

Results

- Maximum production is obtained from model which can be taken with **one shift reclaiming** only, for remaining 2 shift reclaiming can be turn off and still production can continue with same rate
- Maximum production from Kiln # 1 to 7 with one shift reclaiming is obtained as WF# 3 & 4 feeding TPH become constraint for more production
- Surge Bin (1-5) is only sufficient to take 6-hour production, after that they again must refill
- The below strategy is **optimum** to take production for a day
  - A shift (6 am to 2 pm) reclaiming
  - Take Storage bin to surge bin (Kiln # 1 to 5) transfer from 10 am to 6 pm and then 12 am to 6 am (Two spell of 8 hours and 6 hours in a day) (later on it is derived that it is enough to run for 8 hr only in a day
  - Take Storage bin to surge bin Kiln # 6 transfer in last 1-2 hour of every shift
- With the above strategy , enough buffer stock can be maintained to take 2 shift production in case of breakdown

Recommendation

- WF 3 & 4 feeding rate is bottleneck for the system, it is proposed to increase it capacity up to *** TPH
- Bin 2 is constraint for the circuit, It is proposed to increase its capacity up to *** T
- It is preferred to take production from Kiln # 1 to 6 only up to *** and deviate remaining production to other kilns, If possible

Saving Potential: Power Consumption Saving

Equipment	Voltage	Current	Currently Running Hr	Proposed Running Hr	Saving (Hr)	Saving (Unit)
LSC-5	415	37.22	16	8	8	86.499
LSC-6	415	28.54	16	8	8	66.327
LSC-7	415	98.49	16	8	8	228.891
LSRSC-1	415	8.78	16	8	8	20.405
RM-1C	415	18	16	8	8	41.832
RM-5	415	67.69	16	8	8	157.312
RM-5A	415	36	16	8	8	83.664
RM-5B	415	35.8	16	8	8	83.199
RM-6	415	11.53	16	8	8	26.796
RSC-1	415	17.44	16	8	8	40.531
Double Deck Screening1	415	36.79	16	8	8	85.500
Double Deck Screening 2	415	36.79	16	8	8	85.500
Screen#1(LSVS#1)(45kW)	415	23.37	16	8	8	54.312
Screen#2(LSVS#2)(45kW)	415	23.37	16	8	8	54.312
Magnetic Separator LSC#6	415	10	16	8	8	23.240
Belt Weigh Feeder(LSBWF#1)	415	8	16	8	8	18.592
Belt Weigh Feeder(LSBWF#2)	415	8	16	8	8	18.592
RM-7A, RM-8A and RM 15	415	73.64	11	3	8	171.139
			Total Unit saving per day			1346.6
			Total savings per annum (INR Lakh)~			**19.66**

Thanks