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FOREWORD

The 6th Annual Basic Science International Conference (BaSIC 2016) had been successfully held on 2 – 3 March 2016 at Atria Hotel, in Malang, Indonesia. The conference theme this year is "*Enhancing Innovation in Science for Sustainable Development*". The conference is aimed at promoting scientific research activities by fellow scientists in Indonesia and overseas, in the hope of building and strengthening networks and collaborations. Additionally, the conference is also designed to bring experts as well as students together from different disciplines related to basic sciences, to stimulate the formation of new collaborations. So, it is an event where new generation of scientists will coalesce with the senior and experienced ones.

We do thank all participants for their contributed talks, the keynote speakers, as well as the invited speakers for coming and sharing their knowledge with us. The presenters actively contributed in sending their articles to be published in this proceeding. We also thank Brawijaya University and Faculty of Sciences in particular, the organizing team from the Department of Mathematics, Faculty of Sciences, Brawijaya University, as well as all members of the scientific committee.

We are delighted that the proceeding of the 6th Annual Basic Science International Conference (BaSIC 2016) had been completed. It is a book containing papers that had been presented in the BaSIC conference. Moreover, the articles in this proceeding are divided into a breath of the conference subjects of Material Science and technology, Science and Technology Education, Environmental Science and Technology, Molecular and Health Science, Mathematics, Statistics, and Modeling, Instrumentation and Measurement, as well as Energy. The proceeding is aimed at collecting and sharing any useful information that had been gathered during the BaSIC conference.

The editorial team has made some editing and correction needed in some cases. Most of the editing correction are conducted and concentrated in the organization of the paper based on the guideline and the language. Some figures and tables were corrected, and placed accordingly. In addition, the language is the most time-consuming work; hence on behalf of the committee we apologize for the late publishing of this book and for any inconvenience as a result of the delay.

We give our gratitude to the reviewing and editing team for their hard work and for making the publication of this proceeding happen. We again thank all participants and presenters for the kindness to be part of the BaSIC conference. We hope the readers of this book could gain new knowledge, information, and idea for a research and further research collaboration, particularly in the topics or subjects related to basic sciences.

Best regards,

Achmad Efendi, PhD
Chairman of BaSIC 2016

WELCOME MESSAGE

On behalf of the Dean of Faculty of Mathematics and Natural Sciences, we are very pleased to welcome you in the proceeding of the Sixth Annual Basic Sciences International Conference 2016. This proceeding is one of the continuation for the conference. Based on these papers, hopefully more collaboration can be initiated or should be followed up.

I would like to express my gratitude to all of the contributed papers, also keynote and invited speakers. Many thanks also goes to the reviewers and the editorial team for the big effort in supporting this proceeding.

Last but not least my big appreciation to the steering and organizing committees, in realizing this proceeding.

Faculty of Mathematics and Natural Sciences,

Dean,

Prof. Dr. Marjono, M.Phil.

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Max-Plus Algebra Application of the Production System Model of Crystal Sugar in a Sugar Factory

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Abstract –Max-Plus algebra is the set $\mathbb{R}_{max}$simultaneously with the operation$\oplus$and$\otimes$, denoted by$\mathbb{R}_{\boldsymbol{max}} = (\mathbb{R}_{\boldsymbol{\varepsilon}},\oplus,\otimes,\boldsymbol{\varepsilon},\boldsymbol{e})$.Max-Plus algebra can be applied to the production system model of crystal sugar. In this study, a flow lines modelof the sugar production system will be constructed with reference to the production process in a sugar factory. The production system has a capacity on several processors, so the production system used flow lines with buffer. Furthemore, based on the flow lineswe derive a model of Max-Plus algebra.

1. INTRODUCTION

Sugar is one of the agricultural commodities as defined by the WTO. In addition, sugar is also the basic human needs, a source of energy, and as the main trading commodity. Mostly, sugar traded in the form of solid crystals of sucrose or so-called sugar. Historically, in 1930, Indonesia was once the largest sugar exporter country in the world with production at three million tons [1]. However, at the current domestic sugar production in decline so has not been able to achieve national consumption needs. State government encourages the taking of sugar import to meet public consumption. Such cases a problem for sugar industry, especially the sugar factory in Indonesia to increase the sugar production. Thus, the research is made of a plot or flow lines accompanied buffer for crystal sugar production system in a sugar factory. Further, Max-Plus algebra model that can be developed by applying the length of time in the process model was obtained. In addition, we obtain a production schedule which then used as a reference to estimate total production to be achieved. However, these problems in research limited to obtaining flow lines and model max-plus algebra. Flow lines are made consist of several phases of the process, among others or mills milking station, station purification, evaporation station, station dishes, and station round with raw sugar cane [2].

2. METHODS

2.1 Max-Plus Algebra

Definition 1.[3]
$\mathbb{R}_\varepsilon \overset{\text{def}}{=} \mathbb{R} \cup \{\varepsilon\}$ *are given by* $\mathbb{R}$ *is the set of all real numbers and* $\varepsilon \overset{\text{def}}{=} -\infty$. $\mathbb{R}_\varepsilon$ *defined on the following operations:* $\forall x, y \in \mathbb{R}_\varepsilon$,

$$\boldsymbol{x \oplus y \overset{\text{def}}{=} max\{x, y\}} \textit{ and } \boldsymbol{x \otimes y \overset{\text{def}}{=} x + y}.$$

Further shown$(\mathbb{R}_\varepsilon,\oplus,\otimes)$ is a semiring with neutral element ε and unit element $e = 0$, because for every $x, y, z \in \mathbb{R}_\varepsilon$satisfy:

i. $x \oplus y = \max\{x, y\} = \max\{y, x\} = y \oplus x$,
$(x \oplus y) \oplus z = \max\{\max\{x, y\}, z\} = \max\{x, y, z\} = \max\{x, \max\{y, z\}\} = x \oplus (y \oplus z)$,
$x \oplus \varepsilon = \max\{x, -\infty\} = \max\{-\infty, x\} = \varepsilon \oplus x = x$
ii. $(x \otimes y) \otimes z = (x + y) + z = x + (y + z) = x \otimes (y \otimes z)$,
$x \otimes e = x + 0 = 0 + x = e \otimes x = x$,
iii. $x \otimes \varepsilon = x + (-\infty) = -\infty = -\infty + x = \varepsilon \otimes x$
iv. $(x \oplus y) \otimes z = \max\{x, y\} + z = \max\{x + z, y + z\} = (x \otimes z) \oplus (y \otimes z)$,
$x \otimes (y \oplus z) = x + \max\{y, z\} = \max\{x + y, x + z\} = (x \otimes y) \oplus (x \otimes y)$.

For a further discussion$(\mathbb{R}_{å},\oplus,\otimes)$will be written$\mathbb{R}_{max}$.
Rank in Max-Plus Algebra usual manner introducted using associative nature.For $x \in \mathbb{R}_{max}$and for $n \in \mathbb{N}$, where $\mathbb{N}$is a natural number and $n \neq 0$ is

$$x^{\otimes n} \stackrel{\text{def}}{=} \underbrace{x \otimes x \otimes \ldots \otimes x}_{n}$$

While for $n = 0$ be defined $x^{\otimes n} \stackrel{\text{def}}{=} e$, with$e = 0$and in ordinary algebra can be written as follows[3].

$$x^{\otimes n} \stackrel{\text{def}}{=} \underbrace{x \otimes x \otimes \ldots \otimes x}_{n} = n \times x$$

2.2 Production System Model

The first step to modelling the production system using Max-Plus algebrais to make flow lines or schematic sequence of the production system. In the flow lines, there are inputs, outputs, and some processors arranged series or in parallel. In addition, there are processors in a production system with processing without buffer or with buffer [4].

2.3 Production System of Crystal Sugar

Cane is the raw material used sugar factories in Indonesia to produce sugar. Some processing is done so that the cane into sugar crystal are mill station, purification station, evaporation station, cooking station, and stations round and drying. At each processor there are several machines or processors [4].

Table 1. **Processors List in Flow Lines**

Processors List	Symbols in Flow Lines	Processors List	Symbols in Flow Lines
Mill Station		**Evaporation Station**	
a. Milling machine 1	$M_{1,1}$	a. Evaporator machine 1	$M_{3,1}$
b. Milling machine 2	$M_{1,2}$	b. Evaporator machine 2	$M_{3,2}$
c. Milling machine 3	$M_{1,3}$	c. Evaporator machine 3	$M_{3,3}$
d. Milling machine 4	$M_{1,4}$	d. Evaporator machine 4	$M_{3,4}$
Purification Station		e. Evaporator machine 5	$M_{3,5}$
a. Boulogne	$M_{2,1}$	**Stations Cuisine and Round**	
b. Container chest of mill juice	$M_{2,2}$	a. Vacuum pan A	$M_{4,1}$
c. Pumpof mill juice	$M_{2,3}$	b. Cooler A	$M_{4,2}$
d. Juice heater I	$M_{2,4}$	c. Centrifugals A	$M_{4,3}$
e. Defecator	$M_{2,5}$	d. Mixer A	$M_{4,4}$
f. Sulfitir	$M_{2,6}$	e. Container chest of syrup A	$M_{4,5}$
g. Chest of mill juice after sulfitir	$M_{2,7}$	f. Centrifugals SHS	$M_{4,6}$
h. Pump of mill juice after sulfitir	$M_{2,8}$	g. Vacuum pan C	$M_{4,7}$
i. Juice heater II	$M_{2,9}$	h. Cooler C	$M_{4,8}$
j. Halmagis	$M_{2,10}$	i. Centrifugals C	$M_{4,9}$
k. Container chest of filter juice	$M_{2,11}$	j. Mixer C	$M_{4,10}$
l. Pump of filter juice	$M_{2,12}$	k. Container chest of syrup C	$M_{4,11}$
m. Rotary Facum Filter	$M_{2,13}$	l. Smelting chest	$M_{4,12}$
n. Filter of clear juice	$M_{2,14}$	m. Vacuum pan D	$M_{4,13}$
o. Container chest of clear juice	$M_{2,15}$	n. Cooler D	$M_{4,14}$
p. Pump of clear juice	$M_{2,16}$	o. Centrifugals D_1	$M_{4,15}$
q. Juice heater III	$M_{2,17}$	p. Mixer D_1	$M_{4,16}$
		q. Centrifugals D_2	$M_{4,17}$
		r. Container chest of syrup D	$M_{4,18}$
		s. Mixer D_2	$M_{4,19}$
		t. Smelting chest	$M_{4,20}$

3. RESULTS AND DISCUSSION

In crystal sugar production systemof a sugar factorythere are five processing stations with each station consists of several machines to process or process raw materials, namely sugarcane to be crystal sugar. The production process starts with cane input into the machine one at the first station, the mill station. The output of the engine 1 is input to the engine 2. It thus applies also to the subsequent machines.

The result from this study is accompanied buffer flow lines as shown in Figure 1. From the flow lines it be derived Max-Plus Algebra modelswith letting$\boldsymbol{U_i(k)}$ as a time when the basic material of-$\boldsymbol{i}$ incoming and ready for processing at thestage of-$\boldsymbol{k}$, $\boldsymbol{Y_i(k)}$as the time when the processed of product of-$\boldsymbol{i}$ is finished and leaving the system at thestage of-$\boldsymbol{k}$, $\boldsymbol{X_i(k)}$as a time to begin the process at thestage of-$\boldsymbol{k}$ on processor of-$\boldsymbol{i}$, $\boldsymbol{d}$as the length of the process that occurs in each processor $(\boldsymbol{M})$, $\boldsymbol{t}$ as the length of time it takes a material to move from one processor to another processor, and$\boldsymbol{F}$ as processor capacity or buffer. In terms of determining an algebraic equation of Max-Plus, each processor on the flow lines are defined as $\boldsymbol{X_i(k)}$.

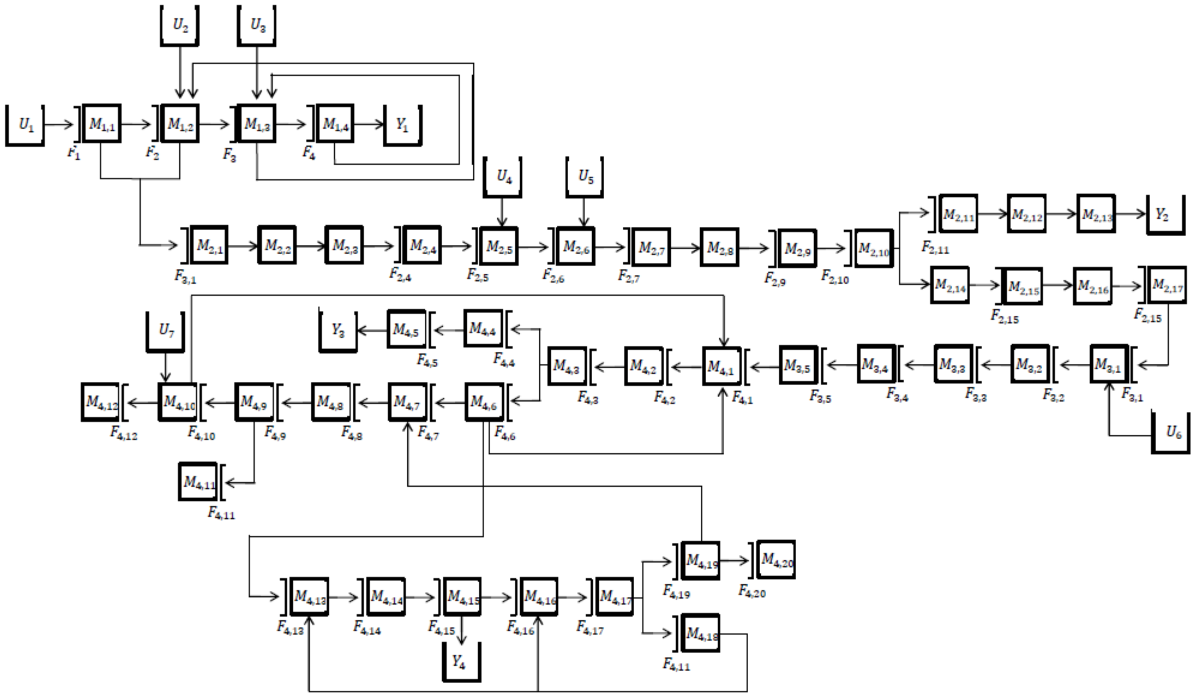

Figure 1. (*Flow Lines* of Crystal Sugar Production System)

__Equations of Max-Plus Algebra__

$$
\begin{aligned}
X_1(k+1) &= d_1 \otimes X_1(k) \oplus -t_{U_1,1} \otimes U_1(k+1-F_1) \oplus -t_{1,2} \otimes X_1(k-F_2) \oplus -t_{1,5} \otimes X_5(k-F_5)\\
X_2(k+1) &= d_2 \otimes X_2(k) \oplus d_1 \otimes t_{1,2} \otimes X_1(k+1) \oplus d_3 \otimes t_{3,2} \otimes X_3(k) \oplus t_{U_2,2} \otimes U_2(k+1) \oplus -t_{2,3}\\
&\quad \otimes X_3(k-F_3) \oplus -t_{2,5} \otimes X_5(k-F_5)\\
X_3(k+1) &= d_3 \otimes X_3(k) \oplus d_2 \otimes t_{2,3} \otimes X_2(k+1) \oplus d_4 \otimes t_{4,3} \otimes X_4(k) \oplus t_{U_3,3} \otimes U_3(k+1) \oplus -t_{3,2}\\
&\quad \otimes X_2(k-F_2) \oplus -t_{3,4} \otimes X_4(k-F_4)\\
X_4(k+1) &= d_4 \otimes X_4(k) \oplus d_3 \otimes t_{3,4} \otimes X_3(k+1) \oplus -t_{4,3} \otimes X_3(k-F_3)\\
X_5(k+1) &= d_5 \otimes X_5(k) \oplus d_1 \otimes t_{1,5} \otimes X_1(k+1) \oplus d_2 \otimes t_{2,5} \otimes X_2(k-F_2)\\
X_6(k+1) &= d_6 \otimes X_6(k) \oplus d_5 \otimes t_{5,6} \otimes X_5(k+1)\\
X_7(k+1) &= d_7 \otimes X_7(k) \oplus d_6 \otimes t_{6,7} \otimes X_6(k+1) \oplus -t_{7,8} \otimes X_8(k-F_8)\\
X_8(k+1) &= d_8 \otimes X_8(k) \oplus d_7 \otimes t_{7,8} \otimes X_7(k+1) \oplus -t_{8,9} \otimes X_9(k-F_9)\\
X_9(k+1) &= d_9 \otimes X_9(k) \oplus d_8 \otimes t_{8,9} \otimes X_8(k+1) \oplus t_{U_4,9} \otimes U_4(k+1) \oplus -t_{9,10} \otimes X_{10}(k-F_{10})\\
X_{10}(k+1) &= d_{10} \otimes X_{10}(k) \oplus d_9 \otimes t_{9,10} \otimes X_9(k+1) \oplus t_{U_5,10} \otimes U_5(k+1) \oplus -t_{10,11} \otimes X_{11}(k-F_{11})\\
X_{11}(k+1) &= d_{11} \otimes X_{11}(k) \oplus d_{10} \otimes t_{10,11} \otimes X_{10}(k+1)\\
X_{12}(k+1) &= d_{12} \otimes X_{12}(k) \oplus d_{11} \otimes t_{11,12} \otimes X_{11}(k+1) \oplus -t_{12,13} \otimes X_{13}(k-F_{13})\\
X_{13}(k+1) &= d_{13} \otimes X_{13}(k) \oplus d_{12} \otimes t_{12,13} \otimes X_{12}(k+1) \oplus -t_{13,14} \otimes X_{14}(k-F_{14})\\
X_{14}(k+1) &= d_{14} \otimes X_{14}(k) \oplus d_{13} \otimes t_{13,14} \otimes X_{13}(k+1) \oplus -t_{14,15} \otimes X_{15}(k-F_{15})\\
X_{15}(k+1) &= d_{15} \otimes X_{15}(k) \oplus d_{14} \otimes t_{14,15} \otimes X_{14}(k+1)\\
X_{16}(k+1) &= d_{16} \otimes X_{16}(k) \oplus d_{15} \otimes t_{15,16} \otimes X_{15}(k+1)\\
X_{17}(k+1) &= d_{17} \otimes X_{11}(k) \oplus d_{16} \otimes t_{16,17} \otimes X_{16}(k+1)\\
X_{18}(k+1) &= d_{18} \otimes X_{18}(k) \oplus d_{14} \otimes t_{14,18} \otimes X_{14}(k+1) \oplus -t_{18,19} \otimes X_{19}(k-F_{19})\\
X_{19}(k+1) &= d_{19} \otimes X_{19}(k) \oplus d_{18} \otimes t_{18,19} \otimes X_{18}(k+1)\\
X_{20}(k+1) &= d_{20} \otimes X_{20}(k) \oplus d_{19} \otimes t_{19,20} \otimes X_{19}(k+1) \oplus -t_{20,21} \otimes X_{21}(k-F_{21})\\
X_{21}(k+1) &= d_{21} \otimes X_{21}(k) \oplus d_{20} \otimes t_{20,21} \otimes X_{20}(k+1) \oplus -t_{21,22} \otimes X_{22}(k-F_{22})\\
X_{22}(k+1) &= d_{22} \otimes X_{22}(k) \oplus d_{21} \otimes t_{21,22} \otimes X_{21}(k+1) \oplus t_{U_6,22} \otimes U_6(k+1) \oplus -t_{22,23} \otimes X_{23}(k-F_{23})\\
X_{23}(k+1) &= d_{23} \otimes X_{23}(k) \oplus d_{22} \otimes t_{22,23} \otimes X_{22}(k+1) \oplus -t_{23,24} \otimes X_{24}(k-F_{24})\\
X_{24}(k+1) &= d_{24} \otimes X_{24}(k) \oplus d_{23} \otimes t_{23,24} \otimes X_{23}(k+1) \oplus -t_{24,25} \otimes X_{25}(k-F_{25})\\
X_{25}(k+1) &= d_{25} \otimes X_{25}(k) \oplus d_{24} \otimes t_{24,25} \otimes X_{24}(k+1) \oplus -t_{25,26} \otimes X_{26}(k-F_{26})
\end{aligned}
$$

$$X_{26}(k+1) = d_{26} \otimes X_{26}(k) \oplus d_{25} \otimes t_{25,26} \otimes X_{25}(k+1) \oplus -t_{26,27} \otimes X_{27}(k-F_{27})$$
$$X_{27}(k+1) = d_{27} \otimes X_{27}(k) \oplus d_{26} \otimes t_{26,27} \otimes X_{26}(k+1) \oplus d_{32} \otimes t_{32,27} \otimes X_{32}(k) \oplus d_{36} \otimes t_{36,27} \otimes X_{36}(k) \oplus -t_{27,28} \otimes X_{28}(k-F_{28})$$
$$X_{28}(k+1) = d_{28} \otimes X_{28}(k) \oplus d_{27} \otimes t_{27,28} \otimes X_{27}(k+1) \oplus -t_{28,29} \otimes X_{29}(k-F_{29})$$
$$X_{29}(k+1) = d_{29} \otimes X_{29}(k) \oplus d_{28} \otimes t_{28,29} \otimes X_{28}(k+1) \oplus -t_{29,30} \otimes X_{30}(k-F_{30}) \oplus -t_{28,29} \otimes X_{29}(k-F_{29})$$
$$X_{30}(k+1) = d_{30} \otimes X_{30}(k) \oplus d_{29} \otimes t_{29,30} \otimes X_{29}(k+1) \oplus -t_{30,31} \otimes X_{31}(k-F_{31})$$
$$X_{31}(k+1) = d_{31} \otimes X_{31}(k) \oplus d_{30} \otimes t_{30,31} \otimes X_{30}(k+1)$$
$$X_{32}(k+1) = d_{32} \otimes X_{32}(k) \oplus d_{29} \otimes t_{29,32} \otimes X_{29}(k+1) \oplus -t_{32,37} \otimes X_{27}(k-F_{27}) \oplus -t_{32,39} \otimes X_{39}(k-F_{39})$$
$$X_{33}(k+1) = d_{33} \otimes X_{33}(k) \oplus d_{32} \otimes t_{32,33} \otimes X_{32}(k+1) \oplus d_{45} \otimes t_{45,33} \otimes X_{45}(k) \oplus -t_{33,34} \otimes X_{34}(k-F_{34})$$
$$X_{34}(k+1) = d_{34} \otimes X_{34}(k) \oplus d_{33} \otimes t_{33,34} \otimes X_{33}(k+1) \oplus -t_{34,35} \otimes X_{35}(k-F_{35})$$
$$X_{35}(k+1) = d_{35} \otimes X_{35}(k) \oplus d_{34} \otimes t_{34,35} \otimes X_{34}(k+1) \oplus -t_{35,36} \otimes X_{36}(k-F_{36}) \oplus -t_{35,37} \otimes X_{37}(k-F_{37})$$
$$X_{36}(k+1) = d_{36} \otimes X_{36}(k) \oplus d_{35} \otimes t_{35,36} \otimes X_{35}(k+1) \oplus t_{U_7,36} \otimes U_7(k+1) \oplus -t_{36,38} \otimes X_{38}(k-F_{38}) \oplus -t_{36,27} \otimes X_{27}(k-F_{27})$$
$$X_{37}(k+1) = d_{37} \otimes X_{37}(k) \oplus d_{36} \otimes t_{36,37} \otimes X_{36}(k+1)$$
$$X_{38}(k+1) = d_{38} \otimes X_{38}(k) \oplus d_{36} \otimes t_{36,38} \otimes X_{36}(k+1)$$
$$X_{39}(k+1) = d_{39} \otimes X_{39}(k) \oplus d_{32} \otimes t_{32,39} \otimes X_{32}(k+1) \oplus d_{44} \otimes t_{44,40} \otimes X_{44}(k) \oplus -t_{39,40} \otimes X_{40}(k-F_{40})$$
$$X_{40}(k+1) = d_{40} \otimes X_{40}(k) \oplus d_{39} \otimes t_{39,40} \otimes X_{39}(k+1) \oplus -t_{40,41} \otimes X_{41}(k-F_{41})$$
$$X_{41}(k+1) = d_{41} \otimes X_{41}(k) \oplus d_{40} \otimes t_{40,41} \otimes X_{40}(k+1) \oplus -t_{41,42} \otimes X_{42}(k-F_{42})$$
$$X_{42}(k+1) = d_{42} \otimes X_{42}(k) \oplus d_{41} \otimes t_{41,42} \otimes X_{41}(k+1) \oplus d_{44} \otimes t_{44,42} \otimes X_{44}(k) \oplus -t_{42,43} \otimes X_{43}(k-F_{43})$$
$$X_{43}(k+1) = d_{43} \otimes X_{43}(k) \oplus d_{42} \otimes t_{42,43} \otimes X_{42}(k+1) \oplus -t_{43,44} \otimes X_{44}(k-F_{44}) \oplus -t_{43,45} \otimes X_{45}(k-F_{45})$$
$$X_{44}(k+1) = d_{44} \otimes X_{44}(k) \oplus d_{43} \otimes t_{43,44} \otimes X_{43}(k+1) \oplus -t_{44,39} \otimes X_{39}(k-F_{39})$$
$$X_{45}(k+1) = d_{45} \otimes X_{45}(k) \oplus d_{43} \otimes t_{43,45} \otimes X_{43}(k+1) \oplus -t_{45,46} \otimes X_{46}(k-F_{46}) \oplus -t_{45,33} \otimes X_{33}(k-F_{33})$$
$$X_{46}(k+1) = d_{46} \otimes X_{46}(k) \oplus d_{45} \otimes t_{45,46} \otimes X_{45}(k+1)$$
$$Y_1(k) = d_4 \otimes t_{4,Y_1} \otimes X_4(k) \quad \Rightarrow \quad baggase\ output$$
$$Y_2(k) = d_{17} \otimes t_{17,Y_1} \otimes X_{17}(k) \quad \Rightarrow \quad blotong\ output$$
$$Y_3(k) = d_{31} \otimes t_{31,Y_1} \otimes X_{31}(k) \quad \Rightarrow \quad sugar\ output$$
$$\boldsymbol{Y_4(k) = d_{41} \otimes t_{41,Y_1} \otimes X_{41}(k) \quad \Rightarrow \quad syrup\ output}$$

4. CONCLUSIONS

In deriving the Max-Plus algebra model that based on flow lines model of sugar production system, it need to consider the time when the basic ingredients go in and ready to be processed,that occurs in each processors, the time when the processed of product is finished and leaving the system, the length of the process that occurs in each processor, the length of time it takes a material to move from one processor to another processor.

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