Ninth Int. Workshop on GNs, Sofia, 4 July 2008, 35-40

GENERALIZED NET MODEL OF PRECIPITATE PRODUCTION

Lubka Atanasova[1], Evdokia Sotirova[1,2]

[1]Prof. Asen Zlatarov" University, Bourgas-8000, Bulgaria,
e-mails: lgatanasova@btu.bg, esotirova@btu.bg
[2]CLBME - Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 105, Sofia-1113

Abstract

Generalized Nets (GN) have been used for the construction of a model, describing the process of precipitate production.

1. Introduction

Calcium hydrogen phosphate dihydrate, known also as precipitate, is prepared by neutralization of phosphoric acid with calcium hydroxide and the process is called precipitation. As a fertilizer, calcium hydrogen phosphate (precipitate) with chemical formula $CaHPO_4.2H_2O$ has high agricultural effectiveness, close to that of the superphosphate. It is known also as a good regulator of plants growth. It contains two nutritive elements (phosphorus and calcium) in favourable ratio which allows its usage as an additive to livestock forage [1, 2]. Generalized Nets [3, 4, 6] are used for modelling of production of precipitate [5]. The goal of the article is the construction of a model of production of precipitate. GNs suggest a powerful tool base for modelling of parallel, real-time flowing processes. They allow their simulation and the following of their behavior in the future, their management and optimization.

2. Description of the process

The principal technological scheme of the precipitate production lime is presented in Figure 1.

The precipitate is produced basically from purified wet process phosphoric acid and calcium hydroxide. The purified wet process phosphoric acid containing 26-35 % P_2O_5 is supplied by "Purification" section of the sodium tripolyphosphate production facility and is diluted to 9-11 % P_2O_5 content. The diluted acid is then fed into "Reaction" section together with calcium hydroxide containing 98-106 g/l CaO. For the precipitation of calcium hydrogen phosphate, the stoichiometric ratio between both initial agents is strictly kept constant. Solution P_H is maintained within the range from 5.0 to 5.2.

$$\mathbf{H_3PO_4 + Ca(OH)_2 = CaHPO_4.2H_2O}$$

The reaction is exothermic and takes place in the temperature interval 36-45 °C. The temperature of the suspension obtained should not be higher than 45-50 °C to prevent the formation of the unstable calcium hydrogen phosphate called monetite. The suspension is then centrifuged to obtain a product with 13 % moisture content. It is further dried in an airfountain tube with heated air at a pressure of 200-400 Pa. From the airfountain, the product together with the drying air is supplied into a cyclone separator where 90 % of the solid phase is separated into a local hopper and then transferred to the storage hopper. The air used is contaminated with fine precipitate particles and is further purified in a duster system and released in the atmosphere.

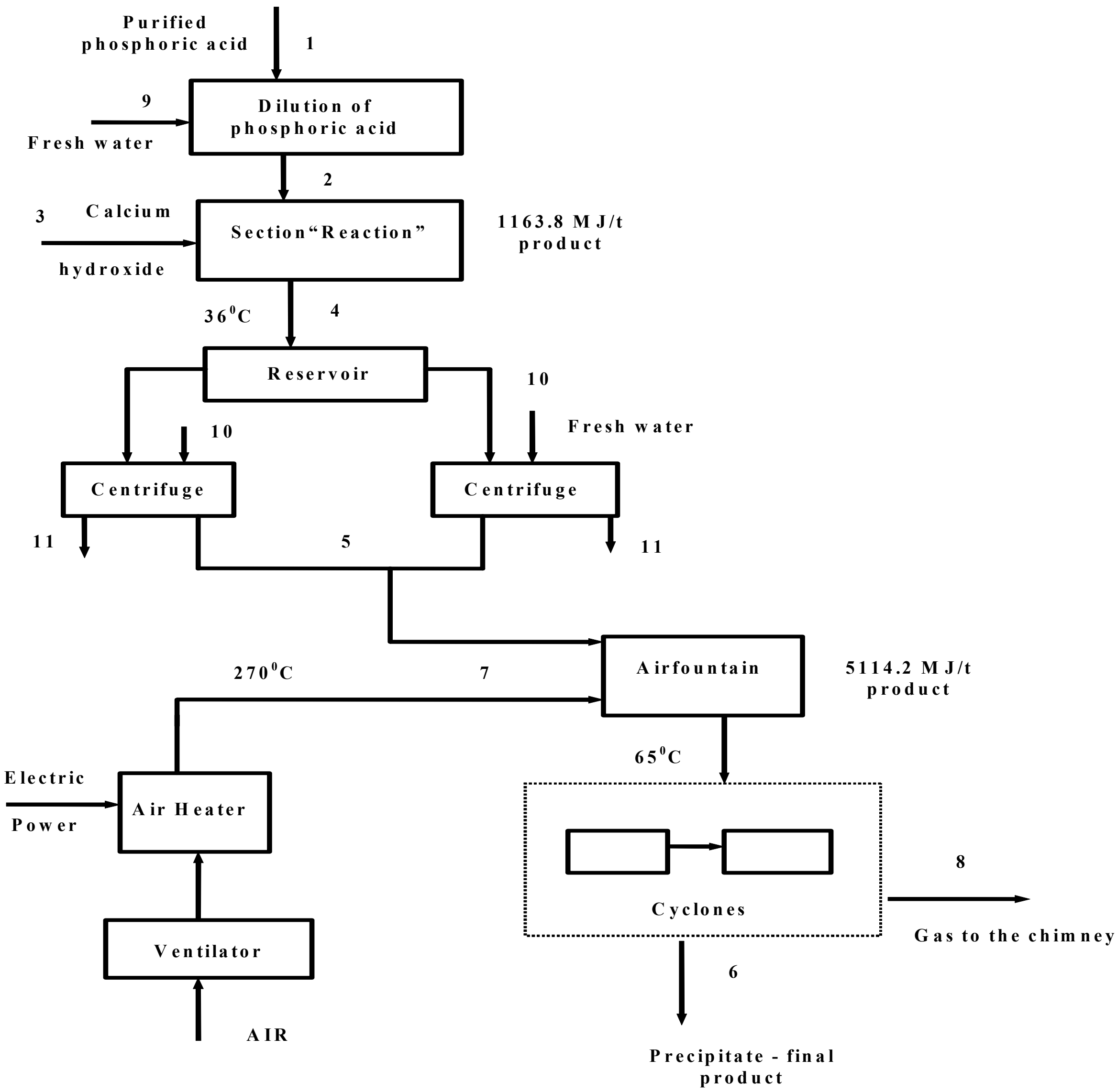

Figure 1. Components and flows for the precipitate production

3. A GN-model

Figure 2 shows the generalized net model describing the process of production of precipitate (calcium hydrogen phosphate dihydrate).

The generalized net contains the following set of transitions:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7, Z_8, Z_9\},$$

where the transitions describe:

- The process of splitting the fresh water – transition Z_1;
- The functions of the Dilution of the phosphoric acid – transition Z_2;
- The functions of the Section "Reaction" – transition Z_3;
- The functions of the Reservoir – transition Z_4;
- The functions of the Centrifuge – transition Z_5;

- The functions of the Airfountain – tranzition Z_6;
- The functions of the Ventilator – transition Z_7;
- The functions of the Air heater – transition Z_8;
- The functions of the Cyclones – transition Z_9.

Initially the GN contains the following tokens:

- β_6 – token in place l_6 with characteristic "Dilution of phosphoric acid",
- β_9 – token in place l_9 with characteristic "Reaction",
- β_{11} – token in place l_{11} with characteristic "Reservoir",
- β_{14} – token in place l_{14} with characteristic "Centrifuge",
- β_{16} – token in place l_{16} with characteristic "Airfountain",
- β_{19} – token in place l_{19} with characteristic "Ventilator",
- β_{22} – token in place l_{22} with characteristic "Air Heater",
- β_{26} – token in place l_{26} with characteristic "Cyclones".

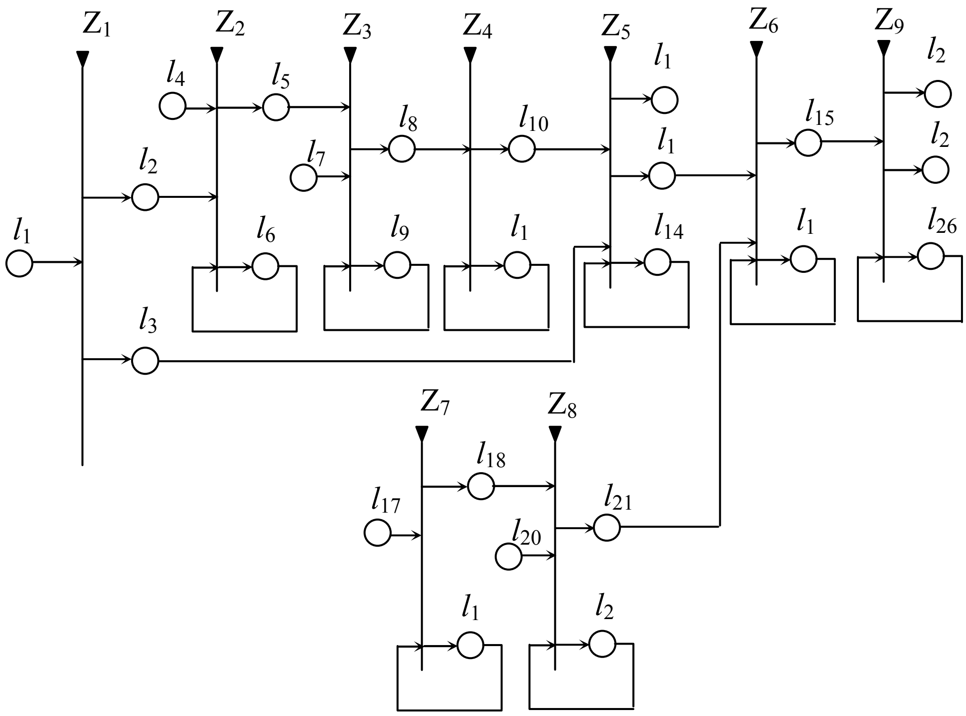

Figure 2. The GN model of the process of production of precipitate

This β-tokens will be in their own places during the whole time during which the GN functions.

From place l_1 comes α_1-token with characteristic "Fresh water, temperature 25 ^{0}C, amount 9970.70 kg/t precipitate". On the first activation of the transition Z_1 it splits into two tokens (α_1' and α_1") that enter places l_2 and l_3.

$$Z_1 = \langle \{ l_1 \}, \{ l_2, l_3 \}, R_1, \vee(l_1) \rangle,$$

where

$$R_1 = \begin{array}{c|cc} & l_2 & l_3 \\ \hline l_1 & true & true \end{array}.$$

Token α_2 enters place l_2 with a characteristic:

"Fresh water, temperature 25 ^{0}C, amount 3345.45 kg/t precipitate", and token α_3 enters place l_3 with a characteristic:

"Fresh water, temperature 25 ^{0}C, amount 6625.25 kg/t precipitate".

From place l_4 comes α_4-token with characteristic "Purified phosphoric acid, temperature 25^{0}C, amount 1454.55 kg/t precipitate".

$$Z_2 = \langle \{ l_2, l_4, l_6 \}, \{ l_5, l_6 \}, R_2, \vee(\wedge(l_2, l_4), l_6) \rangle,$$

where

$R_2 =$

	l_5	l_6
l_2	*false*	*true*
l_4	*false*	*true*
l_6	$W_{6,5}$	*true*

,

where,

$W_{6,5}$ = "A phosphoric acid is deluted".

Token α_5 enters place l_5 with a characteristic:

"Deluted phosphoric acid, contain 10 % P_2O_5, temperature 25 ^{0}C, amount 4800.00 kg/t precipitate".

From place l_7 comes α_7-token with characteristic "Calcium hydroxide, temperature 25 ^{0}C, amount 3770.20 kg/t precipitate".

$$Z_3 = \langle \{ l_5, l_7, l_9 \}, \{ l_8, l_9 \}, R_3, \vee(\wedge(l_5, l_7), l_9) \rangle,$$

where

$R_3 =$

	l_8	l_9
l_5	*false*	*true*
l_7	*false*	*true*
l_9	$W_{9,8}$	*true*

,

where,

$W_{9,8}$ = "A pulp is produced".

Token α_8 enters place l_8 with a characteristic:

"Pulp (solid phase and filtrate), temperature 36 ^{0}C, amount 8570.20 kg/t precipitate".

$$Z_4 = \langle \{ l_8, l_{11} \}, \{ l_{10}, l_{11} \}, R_4, \vee(l_8, l_{11}) \rangle,$$

where

$R_4 =$

	l_{10}	l_{11}
l_8	*false*	*true*
l_{11}	*true*	*true*

.

The α_{10}-token that enters place l_{10} do not obtain new characteristic.

$$Z_5 = \langle \{ l_3, l_{10}, l_{14} \}, \{ l_{12}, l_{13}, l_{14} \}, R_5, \vee(\wedge(l_3, l_{10}), l_{14}) \rangle,$$

where

$R_5 =$

	l_{12}	l_{13}	l_{14}
l_3	*false*	*false*	*true*
l_{10}	*false*	*false*	*true*
l_{14}	$W_{14,12}$	$W_{14,13}$	*true*

,

where,
$W_{14,12}$ = “A filtrate is got”.
$W_{14,13}$ = “A precipitate is got”.

Token α_{12} enters place l_{12} with a characteristic:

“Filtrate, temperature 30 ^{0}C, amount 14039.05 kg/t precipitate”,

and token α_{13} enters place l_{13} with a characteristic:

“Precipitate, temperature 30 ^{0}C, amount 1156.40 kg/t precipitate”.

$$Z_6 = \langle \{ l_{13}, l_{16}, l_{21}\}, \{ l_{15}, l_{16} \}, R_6, \vee(\wedge(l_{13}, l_{21}), l_{16}) \rangle,$$

where

$$R_6 = \begin{array}{c|cc} & l_{15} & l_{16} \\ \hline l_{13} & false & true \\ l_{16} & W_{16,15} & true \\ l_{21} & false & true \end{array},$$

where,
$W_{16,15}$ = “A precipitate is dried”.

Token α_{15} enters place l_{15} with a characteristic:

“Precipitate, temperature 65 ^{0}C, amount 1000.00 kg”.

From place l_{17} comes α_{17}-token with characteristic “Air, temperature 25 ^{0}C, amount 89.22 kg/t precipitate”.

$$Z_7 = \langle \{ l_{17}, l_{19} \}, \{ l_{18}, l_{19} \}, R_7, \vee(l_{17}, l_{19}) \rangle,$$

where

$$R_7 = \begin{array}{c|cc} & l_{18} & l_{19} \\ \hline l_{17} & false & true \\ l_{19} & W_{19,18} & true \end{array},$$

where,
$W_{19,18}$ = “There is an air”.

Token α_{18} enters place l_{18} with a characteristic:

“Air, temperature 25 ^{0}C, amount 89.22 kg/t precipitate”.

From place l_{20} comes α_{20}-token with characteristic “Electric power”.

$$Z_8 = \langle \{ l_{18}, l_{20}, l_{22} \}, \{ l_{21}, l_{22} \}, R_8, \vee(\wedge(l_{18}, l_{20}), l_{22}) \rangle,$$

where

$$R_8 = \begin{array}{c|cc} & l_{21} & l_{22} \\ \hline l_{18} & false & true \\ l_{20} & false & true \\ l_{22} & W_{22,21} & true \end{array},$$

where,
$W_{22,21}$ = “The air is heated”.

Token α_{21} enters place l_{21} with a characteristic:

“Air, temperature 270 ^{0}C, amount 89.22 kg/t precipitate”.

$$Z_9 = \langle \{ l_{15}, l_{26} \}, \{ l_{24}, l_{25}, l_{26} \}, R_9, \vee(l_{15}, l_{26}) \rangle,$$

where

$$R_9 = \begin{array}{c|ccc} & l_{24} & l_{25} & l_{26} \\ \hline l_{15} & false & false & true \\ l_{26} & W_{26,24} & W_{26,25} & true \end{array},$$

where,

$W_{26,24}$ = "There is a precipitate - product".

$W_{26,25}$ = "There is a gas to the chimney".

Token α_{24} enters place l_{24} with a characteristic:

"Precipitate - product, temperature 65 ^{0}C, contain moisture 3 %, amount 1000.00 kg",

and token α_{25} enters place l_{25} with a characteristic:

"Gas to the chimney, temperature 65 ^{0}C, amount 245.62 kg".

4. Conclusion

The process of production of precipitate production was described by generalized nets. The use of hierarchical operators, which could model the same transition at each place in more detail, would make the model more concrete. Most of the model parameters can also be regarded as characteristics of tokens from an additional contour, thus achieving optimization with respect to our given aim. Statistical information would need to be collected in order to monitor the development of the process.

References

[1] Karshev I., Gruncharov I., Tudgarova F., Bozadgiev P, Production of phosphorous fertilizers, Sofia, Inteltech-3, 1992.

[2] Pozin M, Technology of the mineral salts, Leningrad, Chemistry, 1989.

[3] Atanassov, K., Generalized Nets, World Scientific: Singapore, New Jersey, London, 1991.

[4] Atanassov, K., Generalized Nets and Systems Theory, Publ. House of Bulgarian Academy of Sciences, Sofia, 1997.

[5] Atanasova L., Rasheva D., Exergy analysis of precipitate production, Proceedings of The 16th International Conference ECOS' 2003 "Efficiency, Cost, Optimization, Simulation, and Environmental Impact of Energy Systems", June 30- July 2, 2003, Technical University of *Denmark,* Editors Niels Houbak, Brian Elmegaard, Bjorn Qvale, Michael J. Moran, Vol. II, 705-710.

[6] Atanassov, K. On Generalized Nets Theory. Sofia: Prof. M. Drinov Academic Publishing House, 2007.