Generalized Net Model of Mechanical Wastewater Pre-treatment

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Abstract: *In the current paper, a Generalized Net (GN) model of mechanical treatment of wastewater in a wastewater plant is presented. The technological scheme comprises the main processes in this first stage of wastewater treatment. The proposed GN-model allows for more complex monitoring and managing the individual steps in the mechanical stage of the treatment process. Moreover, it can be helpful in tracing, analyzing and setting of some parameters related to the operation of the equipment.*

Keywords: *Wastewater treatment, Mechanical purification, Generalized Net, Modelling.*

Introduction

In the process of industrial usage, water is usually polluted with different types of dispersions and impurities. As a result, these have to be removed from the production process and discharged into the environment. Discharge of wastewater into the environment without pre-treatment or purification causes pollution of natural water and could become a real threat for environmental disaster in entire regions. Due to this fact, it is obligatory to perform purification of the contaminated water before discharging it into the receiving water [3].

The first confirmed records related to the wastewater treatment (WWT) plant date back to 2500-3000 years BC during the Mesopotamian Empire [13]. Nowadays, the application of EU Directive 91/271/EEC requires purification of the wastewater up to a degree that would allow discharging the water in water intake bodies in a manner consistent with the permission of water usage or the individual emission norms of the complex industrial enterprises. All these facts put an emphasis on the maintenance of WWT plants as a whole, but also turn the focus to the technology, equipment, and last but not least – effective control of the processes execution at the separate stages of the wastewater treatment process [4, 29].

The diversity of pollutants contained in wastewater determines the different methods used in their processing in the course of their treatment. Mechanical purification technology is a mandatory first step for treatment of municipal and industrial wastewater [13, 28]. This step includes removing the coarse particles to prevent the next technological steps from damage or contamination and to facilitate their work.

There are some approaches successfully applied to the WWT modeling processes, e.g. neural networks [10]. Among them the theory of Generalized Nets (GNs) [1] is an effective approach for modeling, analysis and decision making in different areas of application – expert systems [2, 17, 24], optimization [5, 23], biology [11], neural networks [12, 26], genetic algorithms [15, 21, 22], medicine [18-20], e-learning [25], intercriteria analysis [27]. There have been already a variety of applications of GN apparatus for modelling of WWT processes, i.e. modeling of the processes in the"bioreservoir – sedimentor" system [6], WWT processes of methane fermentation [14] and in fixed-bed bioreactors [16], simulation of a WWT [8], etc. Considering the modelling of the main stages in a WWT plant, there have been developed GN-models of physico-chemical [9] and of biological treatment of wastewater [7]. So, the next logical step in the application of GNs to modelling of WWT plants is the development of a GN-model of mechanical wastewater pre-treatment, which represents the first purification step of a WWT plant. Since its reliability is thus the prerequisite for all subsequent treatment steps, in this paper a detailed GN-model, describing the main processes in this step, is proposed.

Technological scheme of mechanical wastewater treatment

Mechanical treatment involves several steps: percolation through grates and screens, averaging, sedimentation and filtration. A typical scheme of mechanical treatment stage is presented in Fig. 1.

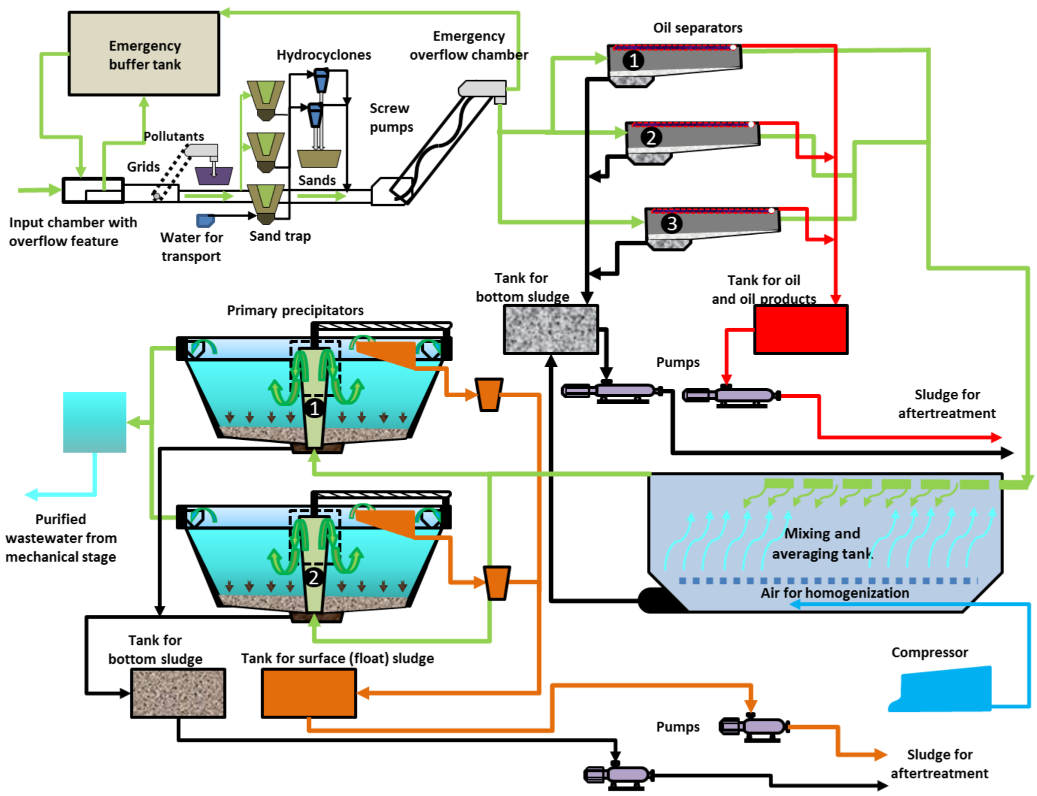

Fig. 1 Technological scheme of mechanical wastewater treatment

Strain is typically used to remove larger floating and insoluble fibrous substances with the help of grids and screens. The grids are used to retain the coarsest materials found in the water, and the screens are designed to keep relatively rough-dispersion impurities. A process of averaging follows, which is used for averaging the composition of the effluent containing more than 500 mg/l suspended solids. The process is carried out in the so-called mixing and averaging tank (mixing of water streams and averaging their parameters at the exit). After this process, wastewater falls in the so-called precipitators, where precipitation process is carried out to separate sedimenting in water free mechanical pulp by precipitation, precipitation unfree or slurry precipitation. The sand and other particulate matter of mineral origin, which show free sedimentation, can be removed prior to the precipitation of the other substances suspended in the so-called sand traps. Also, by precipitation (emerge) as the most common method, removal of oil and petroleum products from water is performed. The process is carried out in the so-called oil separators. The final stage in mechanical WWT is the filtration process. The wastewater leaving the mechanical stage for further processing is with a 60% reduced content of suspended solids and contaminants from the organic matter is reduced by 15 to 35%.

Generalized net model of mechanical wastewater treatment

Based on the discussed scheme of mechanical wastewater treatment a GN-model is developed. The presented in Fig. 2 GN-model contains 18 transitions and 52 places and has the following description:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7, Z_8, Z_9, Z_{10}, Z_{11}, Z_{12}, Z_{13}, Z_{14}, Z_{15}, Z_{16}, Z_{17}, Z_{18}\}.$$

The transitions represent the following processes:

- Polluted wastewater obtaining – transition Z_1;
- Emergency buffer tank functions – transition Z_2;
- Grids functions – transition Z_3;
- Sand trap functions – transition Z_4;
- Hydrocyclones functions – transition Z_5;
- Screw pumps functions – transition Z_6;
- Emergency overflow chamber functions – transition Z_7;
- Oil separators functions – transition Z_8;
- Functions of the tank for oil and oil products from oil separators – transition Z_9;
- Functions of the pumps for oil and oil products from oil separators – transition Z_{10};
- Functions of the tank for bottom sludge from oil separators – transition Z_{11};
- Functions of the pumps for bottom sludge from oil separators – transition Z_{12};
- Mixing and averaging tank functions – transition Z_{13};
- Primary precipitators functions – transition Z_{14};
- Functions of the tank for surface (float) sludge from primary precipitators – transition Z_{15};
- Functions of the pumps for surface (float) sludge from primary precipitators – transition Z_{16};
- Functions of the tank for bottom sludge from primary precipitators – transition Z_{17};
- Functions of the pumps for bottom sludge from primary precipitators – transition Z_{18}.

Initially, tokens α, β, γ, χ, δ, ε, ϕ, $\theta_{1,1}$, $\theta_{1,2}$, $\theta_{1,3}$, φ, μ, τ, λ, σ, $\psi_{1,1}$, $\psi_{1,2}$, ρ, υ, η and κ occupy places l_3, l_5, l_8, l_{12}, l_{15}, l_{17}, l_{20}, l_{24}, l_{25}, l_{26}, l_{28}, l_{30}, l_{33}, l_{35}, l_{39}, l_{43}, l_{44}, l_{46}, l_{48}, l_{50} and l_{52}. They remain in these places throughout the whole time of the generalized net functioning with the following initial and present characteristics:

- α-token in place l_3 with a characteristic "*Flowing amount polluted wastewater*";
- β-token in place l_5 – "*Emergency buffer tank*";
- γ-token in place l_8 – "*Grids*";
- χ-token in place l_{12} – "*Sand trap*";
- δ-token in place l_{15} – "*Hydrocyclones*";
- ε-token in place l_{17} – "*Screw pumps*";

- ϕ-token in place l_{20} – "*Emergency overflow chamber*";

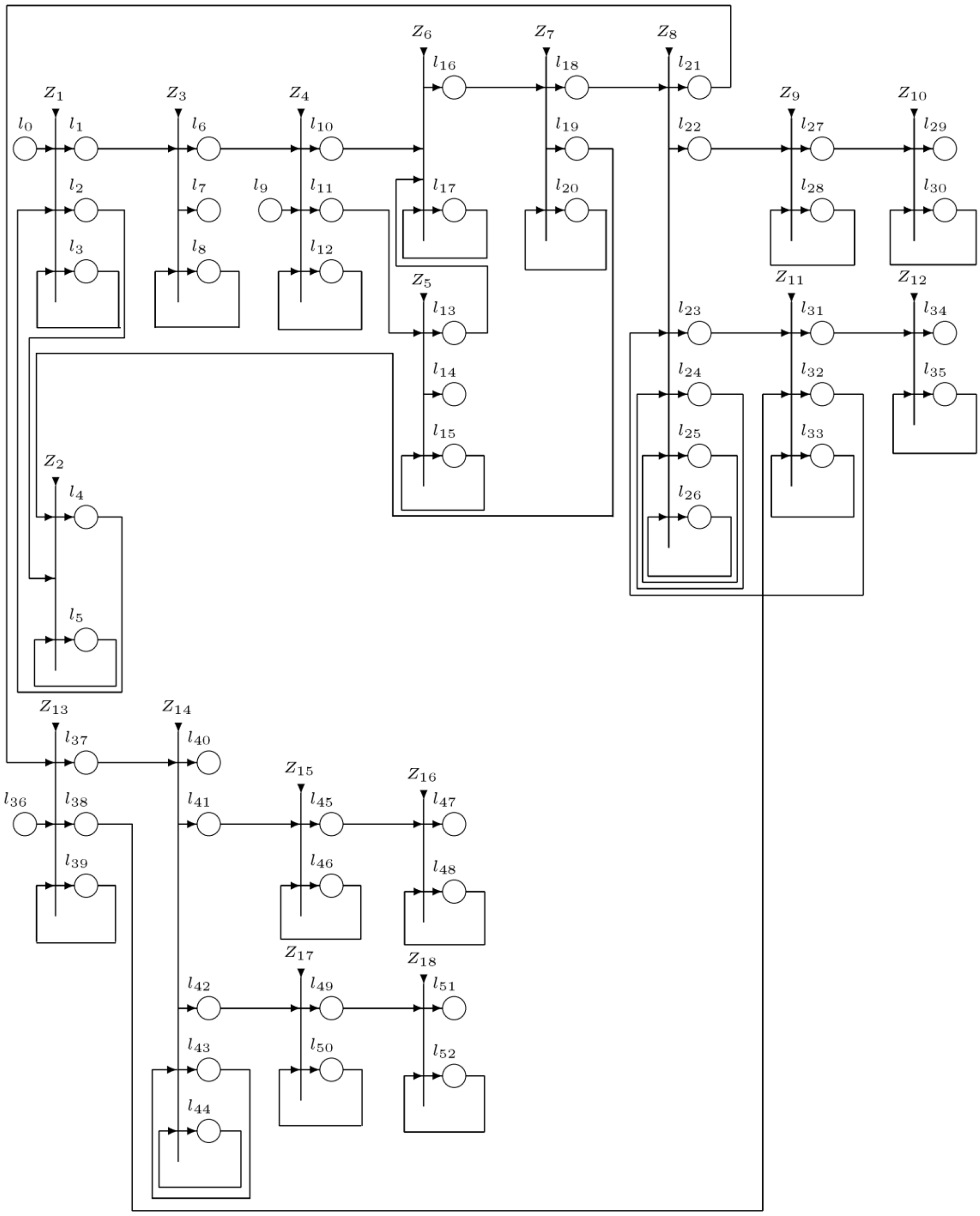

Fig. 2 GN-model of mechanical stage in WWT plant

- $\theta_{1,1}$, $\theta_{1,2}$, $\theta_{1,3}$-tokens in places l_{24}, l_{25}, l_{26} – "*Oil separator 1*", "*Oil separator 2*" and "*Oil separator 3*", respectivelly;
- φ-token in place l_{28} – "*Tank for oil and oil products from oil separators*";
- μ-token in place l_{30} – "*Pumps for oil and oil products from oil separators*";
- τ-token in place l_{33} – "*Tank for bottom sludge from oil separators*";
- λ-token in place l_{35} – "*Pumps for bottom sludge from oil separators*";
- σ-token in place l_{39} – "*Mixing and averaging tank*";
- $\psi_{1,1}$, $\psi_{1,2}$-tokens in places l_{43}, l_{44} – "*Primary precipitator1*" and "*Primary precipitator2*", respectivelly;

- ρ-token in place l_{46} – "*Tank for surface (float) sludge from primary precipitators*";
- υ-token in place l_{48} – "*Pumps for surface (float) sludge from primary precipitators*";
- η-token in place l_{50} – "*Tank for bottom sludge from primary precipitators*";
- κ-token in place l_{52} – "*Pumps for bottom sludge from primary precipitators*".

The token α_0, with a characteristic "*Polluted wastewater*", enters the GN in place l_0. The form of the first transition of the GN-model is as follows:

$$Z_1 = \langle \{l_0, l_3, l_4\}, \{l_1, l_2, l_3\}, r_1, \vee(l_0, l_3, l_4)\rangle,$$

$$r_1 = \begin{array}{c|ccc} & l_1 & l_2 & l_3 \\ \hline l_0 & false & false & true \\ l_3 & W_{3,1} & W_{3,2} & true \\ l_4 & false & false & W_{4,3} \end{array},$$

where
$W_{3,1} = W_{4,3}$ = "There are polluted wastewater for mechanical treatment";
$W_{3,2}$ = "There are wastewater for emergency buffer tank".

α_0-token, entering in place l_3 (through place l_0), keeps its characteristic "*Polluted wastewater*". α_1-token, entering in place l_1, obtains a characteristic "*Wastewater for mechanical treatment*". α_2-token, entering in place l_2, obtains a new characteristic "*Wastewater for emergency buffer tank*".

The form of the second GN-model transition is as follows:

$$Z_2 = \langle \{l_2, l_5, l_{19}\}, \{l_4, l_5\}, r_2, \vee(l_2, l_5, l_{19})\rangle,$$

$$r_2 = \begin{array}{c|cc} & l_4 & l_5 \\ \hline l_2 & false & true \\ l_5 & W_{5,4} & true \\ l_{19} & false & true \end{array},$$

where $W_{5,4}$ = "There are wastewater from emergency buffer tank for mechanical treatment".

α_2 and ϕ_2-tokens, entering in place l_5 (through places l_2 and l_{19} from transition Z_7), keep their characteristics. β_1-token, entering in place l_4, obtains a characteristic "*Wastewater from emergency buffer tank for mechanical treatment*".

The form of the third GN-model transition is as follows:

$$Z_3 = \langle \{l_1, l_8\}, \{l_6, l_7, l_8\}, r_3, \vee(l_1, l_8)\rangle,$$

$$r_3 = \begin{array}{c|ccc} & l_6 & l_7 & l_8 \\ \hline l_1 & false & false & true \\ l_8 & W_{8,6} & W_{8,7} & true \end{array},$$

where
$W_{8,6}$ = "There are wastewater purified from rough admixtures";
$W_{8,7}$ = "There are rough admixtures for disposal".

α_1-token, entering in place l_8 (through place l_1), keeps its characteristic. γ_1 and γ_2-tokens entering in places l_6 and l_7 when the value of predicates $W_{8,6}$ and $W_{8,7}$ is "true". γ_1 and γ_2-tokens obtain the following characteristics: "*Purified wastewater from rough admixtures*" in place l_6 and "*Rough admixtures*" in place l_7.

The form of the fourth GN-model transition is as follows:

$$Z_4 = \langle \{l_6, l_9, l_{12}\}, \{l_{10}, l_{11}, l_{12}\}, r_4, \vee(\wedge(l_6, l_9), l_{12})\rangle,$$

$$r_4 = \begin{array}{c|ccc} & l_{10} & l_{11} & l_{12} \\ \hline l_6 & false & false & true \\ l_9 & false & false & true \\ l_{12} & W_{12,10} & W_{12,11} & true \end{array},$$

where
$W_{12,10}$ = "There are wastewater purified from sands";
$W_{12,11}$ = "There are sands for the hydrocyclones".

γ_1 and χ_0-tokens, entering in place l_{12} (through places l_6 and l_9), keep their characteristics. χ_1 and χ_2-tokens entering in places l_{10} and l_{11} when the value of predicates $W_{12,10}$ and $W_{12,11}$ is "true". χ_1 and χ_2-tokens obtain the following characteristics: "*Purified wastewater from sands*" in place l_{10} and "*Sands with transport water*" in place l_{11}.

The form of the fifth GN-model transition is as follows:

$$Z_5 = \langle \{l_{11}, l_{15}\}, \{l_{13}, l_{14}, l_{15}\}, r_5, \vee(l_{11}, l_{15})\rangle,$$

$$r_5 = \begin{array}{c|ccc} & l_{13} & l_{14} & l_{15} \\ \hline l_{11} & false & false & true \\ l_{15} & W_{15,13} & W_{15,14} & true \end{array},$$

where
$W_{15,13}$ = "There are wastewater purified in hydrocyclones";
$W_{15,14}$ = "There are sands for disposal".

χ_2-token, entering in place l_{15} (through place l_{11}), keeps its characteristic. δ_1 and δ_2-tokens entering in places l_{13} and l_{14} when the value of predicates $W_{15,13}$ and $W_{15,14}$ is "true". δ_1 and δ_2-tokens obtain the following characteristics: "*Purified wastewater in hydrocyclones*" in place l_{13} and "*Sands*" in place l_{14}.

The form of the sixth GN-model transition is as follows:

$$Z_6 = \langle \{l_{10}, l_{13}, l_{17}\}, \{l_{16}, l_{17}\}, r_6, \vee(\wedge(l_{10}, l_{13}), l_{17})\rangle,$$

$$r_6 = \begin{array}{c|cc} & l_{16} & l_{17} \\ \hline l_{10} & false & true \\ l_{13} & false & true \\ l_{17} & W_{17,16} & true \end{array},$$

where $W_{17,16}$ = "There are wastewater for emergency overflow chamber".

χ_1 and δ_1-tokens, entering in place l_{17} (through places l_{10} and l_{13}), keep their characteristics. ε_1-token, entering in place l_{16}, obtains a characteristic "*Wastewater for emergency overflow chamber*".

The form of the seventh GN-model transition is as follows:

$$Z_7 = \langle \{l_{16}, l_{20}\}, \{l_{18}, l_{19}, l_{20}\}, r_7, \vee(l_{16}, l_{20})\rangle,$$

$$r_7 = \begin{array}{c|ccc} & l_{18} & l_{19} & l_{20} \\ \hline l_{16} & false & false & true \\ l_{20} & W_{20,18} & W_{20,19} & true \end{array},$$

where

$W_{20,18}$ = "There are wastewater from emergency overflow chamber for the oil separators";

$W_{20,19}$ = "There are wastewater from emergency overflow chamber for emergency buffer tank".

ε_1-token, entering in place l_{20} through place l_{16}, keeps its characteristic. ϕ_1 and ϕ_2-tokens entering in places l_{18} and l_{19} when the value of predicates $W_{20,18}$ and $W_{20,19}$ is "true". ϕ_1 and ϕ_2-tokens obtain the following characteristics: "*Wastewater from emergency overflow chamber for the oil separators*" in place l_{18} and "*Wastewater from emergency overflow chamber for emergency buffer tank*" in place l_{19}.

The form of the eighth GN-model transition is as follows:

$$Z_8 = \langle \{l_{18}, l_{24}, l_{25}, l_{26}, l_{32}\}, \{l_{21}, l_{22}, l_{23}, l_{24}, l_{25}, l_{26}\}, r_8, \vee(l_{18}, l_{24}, l_{25}, l_{26}, l_{32})\rangle,$$

$$r_8 = \begin{array}{c|cccccc} & l_{21} & l_{22} & l_{23} & l_{24} & l_{25} & l_{26} \\ \hline l_{18} & false & false & false & true & true & true \\ l_{24} & W_{24,21} & W_{24,22} & W_{24,23} & true & false & false \\ l_{25} & W_{25,21} & W_{25,22} & W_{25,23} & false & true & false \\ l_{26} & W_{26,21} & W_{26,22} & W_{26,23} & false & false & true \\ l_{32} & false & false & false & true & true & true \end{array},$$

where

$W_{24,21} = W_{25,21} = W_{26,21}$ = "There are wastewater purified after the oil separators";

$W_{24,22} = W_{25,22} = W_{26,22}$ = "There are oil and oil products from the oil separators";

$W_{24,23} = W_{25,23} = W_{26,23}$ = "There are bottom sludge from the oil separators".

$\theta_{1,1}$, $\theta_{1,2}$, $\theta_{1,3}$-tokens, in places l_{24}, l_{25} and l_{26}, have initial characteristics "*Oil separator 1 – parameters*", "*Oil separator 2 – parameters*", "*Oil separator 3 – parameters*", respectively. They entering in place l_{23} when the value of predicates $W_{24,23}$, $W_{25,23}$ and $W_{26,23}$ is "true". θ_2-token, in place l_{23}, obtains a characteristic "*Bottom sludge from the oil separators*". θ_3-token, in place l_{22}, obtains a characteristic "*Oil and oil products from the oil separators*" when the value of predicates $W_{24,22}$, $W_{25,22}$ and $W_{26,22}$ is "true". Token θ_4, in place l_{21}, obtains a characteristic "*Wastewater purified after the oil separators*" when the value of predicates $W_{24,21}$, $W_{25,21}$ and $W_{26,21}$ is "true".

The form of the ninth GN-model transition is as follows:

$$Z_9 = \langle \{l_{22}, l_{28}\}, \{l_{27}, l_{28}\}, r_9, \vee(l_{22}, l_{28})\rangle,$$

$$r_9 = \begin{array}{c|cc} & l_{27} & l_{28} \\ \hline l_{22} & false & true \\ l_{28} & W_{28,27} & true \end{array},$$

where $W_{28,27}$ = "There are oil and oil products for emptying from tank of oil and oil products". θ_3-token, entering in place l_{28} (through place l_{22}), does not obtain a new characteristic. φ_1-token, entering in place l_{27}, obtains a characteristic "*Oil and oil products from the tank for oil and oil products*".

The form of the tenth transition is as follows:

$$Z_{10} = \langle\{l_{27}, l_{30}\}, \{l_{29}, l_{30}\}, r_{10}, \vee(l_{27}, l_{30})\rangle,$$

$$r_{10} = \begin{array}{c|cc} & l_{29} & l_{30} \\ \hline l_{27} & false & true \\ l_{30} & W_{30,29} & true \end{array},$$

where $W_{30,29}$ = "There are oil and oil products depleted from pumps".

φ_1-token, entering in place l_{30} (through place l_{27}), keeps its characteristic. μ_1-token, in place l_{29}, obtains a characteristic "*Oil and oil products*".

The form of the eleventh GN-model transition is as follows:

$$Z_{11} = \langle\{l_{23}, l_{33}, l_{38}\}, \{l_{31}, l_{32}, l_{33}\}, r_{11}, \vee(l_{23}, l_{33}, l_{38})\rangle,$$

$$r_{11} = \begin{array}{c|ccc} & l_{31} & l_{32} & l_{33} \\ \hline l_{23} & false & false & true \\ l_{33} & W_{33,31} & W_{33,32} & true \\ l_{38} & false & false & true \end{array},$$

where
$W_{33,31}$ = "There are bottom sludge for emptying from tank for bottom sludge from oil separators";
$W_{33,32}$ = "There are oil separators cleaned from bottom sludge".

θ_2 and σ_2-tokens, entering in place l_{33} through l_{23} and l_{38}, keep their characteristics. τ_1 and τ_2-tokens entering in places l_{31} and l_{32} when the value of predicates $W_{33,31}$ and $W_{33,32}$ is "true". τ_1 and τ_2-tokens obtain the following characteristics: "*Bottom sludge from tank for bottom sludge from oil separators*" in place l_{31} and "*Oil separators cleaned from bottom sludge*" in place l_{32}.

The form of the twelfth GN-model transition is as follows:

$$Z_{12} = \langle\{l_{31}, l_{35}\}, \{l_{34}, l_{35}\}, r_{12}, \vee(l_{31}, l_{35})\rangle,$$

$$r_{12} = \begin{array}{c|cc} & l_{34} & l_{35} \\ \hline l_{31} & false & true \\ l_{35} & W_{35,34} & true \end{array},$$

where $W_{35,34}$ = "There are bottom sludge from tank depleted from pumps".

τ_1-token, entering in place l_{35} (through place l_{31}), keeps its characteristic. λ_1-token, in place l_{34}, obtains a characteristic "*Bottom sludge for after treatment*".

The form of the thirteenth GN-model transition is as follows:

$$Z_{13} = \langle \{l_{21}, l_{36}, l_{39}\}, \{l_{37}, l_{38}, l_{39}\}, r_{13}, \vee(\wedge(l_{21}, l_{36}), l_{39})\rangle,$$

$$r_{13} = \begin{array}{c|ccc} & l_{37} & l_{38} & l_{39} \\ \hline l_{21} & false & false & true \\ l_{36} & false & false & true \\ l_{39} & W_{39,37} & W_{39,38} & true \end{array},$$

where

$W_{39,37}$ = "There are wastewater from mixing and averaging tank for the primary precipitators";

$W_{39,38}$ = "There are sludge from mixing and averaging tank for the tank for bottom sludge from oil separators".

σ_0 and θ_4-token, entering in place l_{39} (through place l_{36} and l_{21}), keep their characteristics. Tokens σ_1 and σ_2 entering in places l_{37} and l_{38} when the value of predicates $W_{39,37}$ and $W_{39,38}$ is "true". Tokens σ_1 and σ_2 obtain the following characteristics: "*Wastewater from mixing and averaging tank for the primary precipitators*" in place l_{37} and "*Sludge for the tank for bottom sludge from the oil separators*" in place l_{38}.

The form of the fourteenth GN-model transition is as follows:

$$Z_{14} = \langle \{l_{37}, l_{43}, l_{44}\}, \{l_{40}, l_{41}, l_{42}, l_{43}, l_{44}\}, r_{14}, \vee(l_{37}, l_{43}, l_{44})\rangle,$$

$$r_{14} = \begin{array}{c|ccccc} & l_{40} & l_{41} & l_{42} & l_{43} & l_{44} \\ \hline l_{37} & false & false & false & W_{37,43} & W_{37,44} \\ l_{43} & W_{43,40} & W_{43,41} & W_{43,42} & true & false \\ l_{44} & W_{44,40} & W_{44,41} & W_{44,42} & false & true \end{array},$$

where

$W_{37,43} = W_{37,44}$ = "There are wastewater from mixing and averaging tank for the primary precipitators";

$W_{43,40} = W_{44,40}$ = "There are purified wastewater after the primary precipitators";

$W_{43,41} = W_{44,41}$ = "There are surface sludge from the primary precipitators";

$W_{43,42} = W_{44,42}$ = "There are bottom sludge from the primary precipitators".

$\psi_{1,1}$ and $\psi_{1,2}$-tokens, in places l_{43} and l_{44}, have initial characteristics "*Primary precipitator 1 – parameters*" and "*Primary precipitator 2 – parameters*", respectively. They entering in place l_{42} when the value of predicates $W_{43,42}$ and $W_{43,44}$ is "true". In place l_{42} ψ_2-token obtains a characteristic "*Bottom sludge from the primary precipitators*". In place l_{41} ψ_3-token obtains a characteristic "*Surface sludge from the primary precipitators*" when the value of predicates $W_{43,41}$ and $W_{44,41}$ is "true". Token ψ_4 leaves the net through place l_{40} with a characteristic "*Purified wastewater from mechanical stage*".

The form of the fifteenth GN-model transition is as follows:

$$Z_{15} = \langle \{l_{41}, l_{46}\}, \{l_{45}, l_{46}\}, r_{15}, \vee(l_{41}, l_{46})\rangle,$$

$$r_{15} = \begin{array}{c|cc} & l_{45} & l_{46} \\ \hline l_{41} & false & true \\ l_{46} & W_{46,45} & true \end{array},$$

where $W_{46,45}$ = "There are surface sludge for emptying from the tank".

ρ_1-token, entering in place l_{45}, obtains a characteristic "*Surface sludge for emptying from the tank*".

The form of the sixteenth GN-model transition is as follows:

$$Z_{16} = \langle\{l_{45}, l_{48}\}, \{l_{47}, l_{48}\}, r_{16}, \vee(l_{45}, l_{48})\rangle,$$

$$r_{16} = \begin{array}{c|cc} & l_{47} & l_{48} \\ \hline l_{45} & false & true \\ l_{48} & W_{48,47} & true \end{array},$$

where $W_{48,47}$ = "There are surface sludge from tank depleted from pumps".

ρ_1-token, entering in place l_{48} (through place l_{45}), keeps its characteristic. υ_1-token leaves the net through place l_{47} with a characteristic "*Surface sludge for after treatment*".

The form of the seventeenth GN-model transition is as follows:

$$Z_{17} = \langle\{l_{42}, l_{50}\}, \{l_{49}, l_{50}\}, r_{17}, \vee(l_{42}, l_{50})\rangle,$$

$$r_{17} = \begin{array}{c|cc} & l_{49} & l_{50} \\ \hline l_{42} & false & true \\ l_{50} & W_{50,49} & true \end{array},$$

where $W_{50,49}$ = "There are bottom sludge for emptying from the tank for bottom sludge from primary precipitators".

ψ_2-token, entering in place l_{50} (through place l_{42}), keeps its characteristic. η_1-token, entering in place l_{49}, obtains a characteristic "*Bottom sludge for emptying from the tank for bottom sludge*".

The form of the eighteenth GN-model transition is as follows:

$$Z_{18} = \langle\{l_{49}, l_{52}\}, \{l_{51}, l_{52}\}, r_{18}, \vee(l_{49}, l_{52})\rangle,$$

$$r_{18} = \begin{array}{c|cc} & l_{51} & l_{52} \\ \hline l_{49} & false & true \\ l_{52} & W_{52,51} & true \end{array},$$

where $W_{52,51}$ = "There are bottom sludge from the tank depleted from pumps".

η_1-token, entering in place l_{52} (through place l_{49}), keeps its characteristic. κ_1-token leaves the net through place l_{51} with a characteristic "*Bottom sludge for after treatment*".

Conclusion

Following the technological scheme presented in Fig. 1, a GN-model is developed, describing in details the significant processes in the mechanical wastewater pre-treatment. Being the first step in the whole WWT process, the mechanical stage is essential as it ensures the effective start of the treatment processes in all further station's facilities. The proposed GN-model makes it possible to track changes with sufficient accuracy in individual qualitative and quantitative characteristics of the treated water before and after going through specific facilities to ensure optimal conditions for conducting the treatment processes. Moreover, the

GN-model would also contribute to the more effective operation of the subsequent purification steps in the process of the WWT plant's functioning.

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