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GRAPH THEORY IN REASERCHING INERTIAL PROPERTIES OF WATER SLURRY SCHEMES OF COAL PREPARATION PLANTS

The problem and its connection with scientific and practical tasks. Clarification system of circulating water coal preparation plants is a large and complex technological system. With its design and development problems associated with choosing the best topology (structure) and the optimal organization of the interaction elements. For such systems characterized by a large number of interconnected and interoperable nodes, changes in the operation of one of the nodes are reflected on the recognized results of the other units and of the whole system. Despite the diversity in the system components, their interaction occurs via exchange of materials (pulp flows). You can change the topology of the system. There is a need to develop methods which enable the play work as VSS branched objects connected by traffic. Particular attention should be paid to the same time for processing and transporting the slurry flows that determine the time of the unsteady mode.

It should be noted that existing methods of calculation are used to study the analysis of simple, low operating systems clarification. But in the closed cycles accumulation of sludge always occurs, which complicates the analysis of VSS, since it is difficult to trace the kinetics of the process and to detect changes of the equilibrium concentration in the process. Sludge stabilization process content in circulating water is very long, so you need to keep trace of all the change indicators from the beginning of the scheme before entering the stationary mode. To perform such an analysis by calculation is not possible.

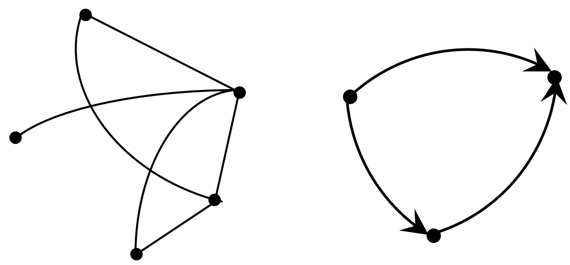
Scope graph theory involves modeling a variety of branched circuits. Versatility graph theory allows to use it when considering discrete systems, manufacturing operations occurring in sequence, one-way interaction and frequency [1].

Analysis of studies and publications. Existing methods of researching of water-slurry systems (VSS) differ from each other in methods of description of the sludge accumulation in closed systems, adopted mathematical models of systems clarification, assessment criteria and final conclusions. With that the distribution of the slurry on the system nodes, connecting them in flows is taken into account as well as the time sludge remains in the nodes, vessels and VSS pipelines, which makes it impossible to analyze the inertial properties of the system [2-3].

It should be noted that the analysis of the content VSS position with the incoming and outgoing content sludge is not exhaustive, as the same factor circulating slurry may have a completely different complexity, staging, number of nodes and flows of the system. At this duration is of great importance to stabilize the concentration of sludge in the circulating water, as the accumulation of sludge adversely affects the efficiency of the main and auxiliary equipment. From this position, the analysis of complex subdivided schemes should be carried out taking into account the distribution of the slurry flows in all technological routes, hubs and devices of the system. The complexity of the test circuitry topology affects the accumulation of sludge and duration reaches an equilibrium mode.

Statement of the problem. Problem analysis confirmed the necessity to develop methods of research work VSS allowing to take into account the performance of each unit and the unit scheme, regardless of its complexity. The problem is solved in the work using iterative substitution schemes of studied VSS that are based on directed graphs. The calculation of iterative schemes is performed using a computer program that takes into account all the technological features of the schemes under study.

Presentation of the material and the results. Concept of the graph is important in terms of programming and network management, because it is associated with a variety of modeling processes. Count is best represented as a set of interconnected lines and points in the plane (Fig. 1).



a) *b)*

Figure 1. Sample image of the graph:
a – undirected, b – oriented

The points shown in the image plane, are called the vertices of V (vertex), and the lines connecting them together - arcs or edges. There are undirected graphs, where the of direction arcs connecting vertices is not set. In these graphs joining order of vertices is not important. In line directed graphs are presented in the form of arrows, and the move from the top to the top of the route is built or the so-called path. With the help of graphs we can determine roads communication system, power lines, computer networks, etc. [4].

Operation of closed water-slurry cycle can be interpreted from the perspective of graph theory, because between nodes in the system there is a connection, and the impact of the transmission portion of sludge from the start node to the output circuit is included. In addition, all threads in the system have a specific destination. Therefore, to reproduce the data patterns is possible using directed graphs. At the same nodes and VSS devices serve as vertices of the graph, and piping and gutters - as connecting arcs.

Analyzing the basic definitions of graph theory we can confirm-that the system of water circulating clarification is incomplete, being a antisymmetric oriented multigraph. Vertices of the graph correspond to the individual nodes of the system. The pipelines and draughts, sifting slurry flows in one direction serve as connecting arcs. All nodes in the system regardless of technological applications, in fact, share a portion of the original slurry flow separation products and through connecting streams transmitted to other sites where the same thing happens. It should also be noted that the separation process occurs in devices with different inertia. In high-speed devices with pressure feed separation is carried out in seconds, and in the apparatus, receiving and processing large volumes of sludge water separation can be tens of minutes.

To meet the industrial conditions it is necessary to make the length of the directed edges of the graph correspond to the actual delays in transport streams, which are dependent on the amount of pulp in the flow and the geometric characteristics of communications. To do this, we consider a directed multigraph with given lengths of directed edges. This approach allows us to take into account the inertial properties of the circuit components and estimate the duration of the sludge accumulation process.

The number *L(u)>0*, called arc length is assigned a directed edge of u in compliance. Depending on imposition, this number can be a measure of physical distance, time or other important parameter [4].

Although some of the operations may be independent from each other, in the general case there is a time dependence, a_i operation should end, to initiate the operation a_j. Such dependencies are represented as directed graph as shown in fig. 2.

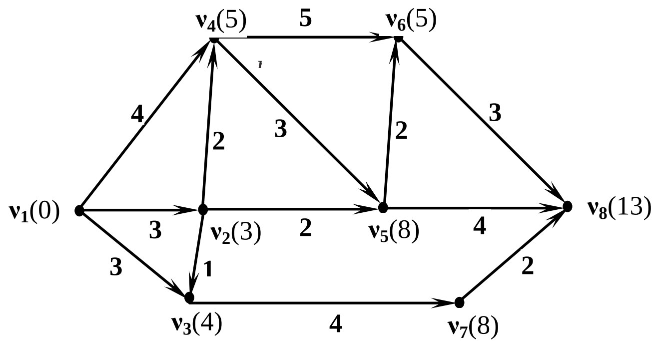


Figure 2. The graph of performing separations with the specified lengths of arcs

The operation a_j takes the time, which is reflected $t(a_j)$ in numbers on the directed edges. Length (that is the amount of time slots) of any path v_1 to v_i in the lower end of time, measured from the start of operation of the system before the event v_i, after which the operation can be started with v_i as the initial vertex.

When calculating each vertex a number (time) is assigned:

$$T(v_1) = 0, T(v_j) = \max \{t(\mu)\}, \quad (1)$$

where:

$t(\mu)$ is the path length and the maximum is determined by all the paths of v_1 to v_i.

The way length μ is the sum of the lengths of arcs included in μ:

$$L(\mu) = \sum_{v \in \mu}^{n} L(v) \quad (2)$$

The longest time path from the initial to the final event ν1 ν is a critical event in a way that the system can not be the only one. For example, for the graph in figure 2, there are two critical paths (on vertices of the graph): $\mu_1 = (v_1, v_2, v_4, v_5, v_6, v_8)$, $L(\mu_1) = 13$, and a path $\mu_2 = (v_1, v_2, v_4, v_6, v_8)$, $L(\mu_2) = 13$.

Critical-path length corresponds to the shortest time in which all operations in the system are performed [4].

In real existing schemes all slurry water is collected in a particular node and sent to the pre-and post-operation recovery, further distributing all nodes of the system. The distribution takes place by connecting threads with transport delays in strict technological sequence. In other words, in the operations occurring in the clarification system we can see a time dependence. This means that the separation of the final regeneration cannot start working or responding earlier to any changes in process parameters, than the pre- separation regeneration. Everything will happen in sequence with the total transport delay streams connecting the nodes.

The total transport delay means here the total time of transport and processing portions of sludge in all streams and devices included in the reporting process route system. For digraph VSS this would be equivalent path length $L(\mu)$, which is defined as the sum of the lengths of directed edges included in μ (2).

For VSS, depending on the quantity of sludge output nodes, is determined a number of process routes along which the moving and handling of the slurry flow. These routes have identical paths in the digraph describing the operation of the scheme, and are incorporated into the set of nodes, devices and connecting communications. The total lengths of the arcs (the inertia of vessels and pipelines) within the processing routes, determine the critical path output sludge.

Let's consider a hypothetical VSS to create the equivalent circuit using directed graphs with a given length and weight values arcs (Fig. 3).

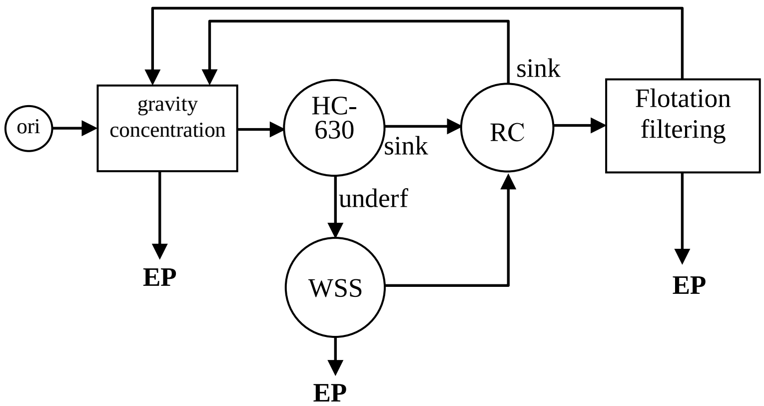


Figure 3. Hypothetical water-sludge system in the block image

With the VSS substitution with an accurate model - a directed graph – it is necessary to consider all the nodes and their connecting streams. To set the graph and its subsequent perception of computers is the most convenient way to define a plurality of adjacencies in which each vertex, a list of incoming and outgoing vertices. Since all VSS occur in sequence, and each subsequent operation occurs after a certain time, taking into account traffic delays and time slime threads. That is a graph that replaces real VSS has certain directed edges lengths for the objective evaluation of the system with regard to its inertial properties. For all flow traffic delays are calculated by geometric lines and largest volume of pulp feeding. Inertial properties of devices depend mainly on the volume of capacity, sludge separation process flows and determined on the basis of practice. After analyzing all the parameters affecting the efficiency of VSS, a block diagram is replaced by a directed graph with a given value of the lengths of directed edges and directed edges with weight values equal partition coefficients sludge.

Next, the computer program reproduces the real system topology and simulates the separation of sludge feed stream water over the nodes and devices in the specified routes. With this we not only observe the given sequence, but also the corresponding delay of all operations included in the production chain (Fig. 4).

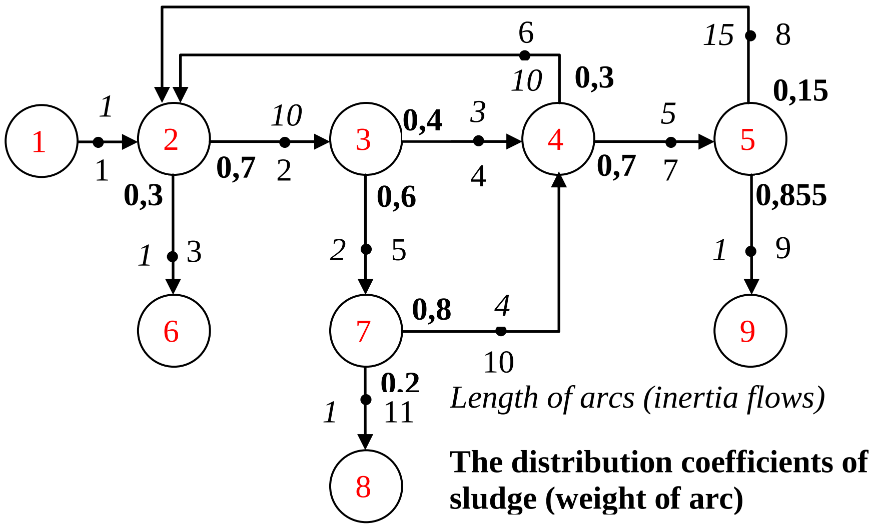


Figure 4. Iterative equivalent circuit of hypothetical VSS - a directed graph with the specified arcs (transport delays slurry flows)

The results of the program are a large amount of data for office application Excel. For fine and granular sludge individual files are archived. For each node is assigned the value of the slurry contents during the period of time from the start of work to the stationary mode. Further, the results are processed and presented in the form of diagrams or accumulation of fine granular sludge. Based on these charts, a detailed analysis of the accumulation of sludge in the complex closed technological cycle is made, taking into account the inertial properties of nodes, devices and slurry flows.

Conclusions and directions for further research. Thus, the VSS work may be reproduced using digraphs with lengths directed edges equal transport delays slurry flows. This takes into account the separation of sludge on all possible routes with all the technological separation operations included in this circuit. VSS performance evaluation on graphs with known lengths of the directed edges is more complete and objective, since in real practical terms, each unit and connecting communications are characterized by certain transport delay. Regeneration schemes in the presence of high inertial devices causes the appearance of critical paths - technological routes with maximum traffic delays slurry flows that hinder the achievement of the equilibrium concentration. Operation of such routes can be assessed only in accordance with the substitution with a graph where connecting arcs have appropriate length. One area of future research can be the substitution of gravitational separation schemes with graphs, as nodes and flows therein also influence the inertia of the water circuit.

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