Ready-mixed concrete recycling system

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Abstract. This article describes the technological diagram and equipment required for establishing a Ready-Mixed Concrete Recycling System, which allows to divide concrete into separate components, such as cement milk, crushed stone and sand. The waste from demolished concrete structures can be reused to reduce the environmental burden during their life cycle and ensure economic use of the construction resources. The recycled aggregate concrete is a sustainable concrete waste which in the long term can replace the demand for natural aggregate, a process which would, in turn, lead to its preservation. Most concrete industries have been observed to be reluctant in the production of recycled aggregate concrete and utilization in its maximum potential. Industries are yet to embrace it not only due to its uncertain material performance but also due to its unexplored manufacturing plant operations which are yet to be established. The system is using wireless communication technologies and data exchange between sensors and data acquisition devices. The raw materials obtained by the showcased recycling process could be reused in subsequent production cycles of ready-mixed concrete preparation. The following process could help reduce the growing amount of industrial waste generated with constant infrastructure improvements, which could be beneficial both from an environmental and economical standpoint.

1. Introduction
Concrete production, like any other production cycle, is not complete without waste generation. The growing problem of maintaining a clean environment and the reuse of any industrial waste determines the problem of reusing sludge and concrete that remains on the walls and in the cavities of concrete pumps and concrete mixers during their operation. In the intervals between cycles, the structures are washed and the resulting composition is removed. Before the advent of such technologies called recycling, these wastes were usually discharged into the environment. Currently, there is a possibility of their reuse, which positively affects both the state of nature and the consumption of components for the production of concrete.

2. Materials and Methods
Modern engineering technologies completely solve the problem of waste-free production of ready-mixed concrete [1, 2]. Processing complexes allow using the obtained raw materials in subsequent production cycles. The main task of the recycling complex is the separation of the mixture into separate components, such as cement milk, crushed stone and sand (Fig. 1).
The transformation of waste is carried out directly at the factories, the reuse of slag allows you to save on the manufacture of new volumes, and there is no useless mass left.

A complete recycling system consists of the following main processes:
- screening and separating inert materials system;
- recycling waste materials, concrete (actually recycling);
- reuse of water.

Each of these three components can be used autonomously, but in a single complex it is a complete system for thorough transformation and use of recyclable materials.

3. Results and Discussions
The work of the system of units is carried out in three operating modes: two, operating on automation, and manual. The first of the self-acting modes performs the task of flushing waste from a concrete mixer, and the second one - converting large volumes of concrete waste [3, 4]. The essence of the system consists in a kind of splitting of concrete into its components, which are sorted, removed into different containers and sent back for production.

On a significant scale, the percentage of solid residues is greater, therefore, to separate them into sand and crushed stone, a system of sifting and separation of inert materials is used [5, 6]. The plant operates as follows: the raw material is loaded into the receiver, after which the raw material enters the sieve. Then the raw material is sieved and divided into fractions: the sand is taken out to one side, and crushed stone comes out on the other (Fig. 2).
Figure 2. Equipment for the ready-mix concrete recycling system

The beginning of the full cycle of the process - concrete recycling - is the moment when the spray can of a concrete mixer rests on the auto-start lever. At the same time, a sound signal is given, at the same time the operation of the electric motor of the sludge mixer, as well as the pump supplying water to the mixer, is turned on. When the pump is turned off, the water supply stops, and the alarm goes off. The driver can prolong the action of the mixer, and, if necessary, manually continue to supply water using the control panel.

A special filter passes the slurry water to separate the remaining large residues of raw materials, after which the water returns to the storage pool. The so-called garbage is discharged outward, reaching along the screw rod to the unloading passage. Drainage and purity of water is regulated manually or using an electronic panel.

All elements of the system (pump, electric motor) will continue to work for some time to completely recycle the remaining material. Then the agitator passes from the active phase to the stage of periodic stirring. This system provides for the operation of each of the functional units for half an hour.

In the case of the set automatic mode or for a long period of inactivity, prevent the formation of thick in the storage pool. For this purpose, the control system autonomously starts the agitator from time to time. In addition, it itself controls the constant boundary of the water: if it drops to the critical line, the pump starts to supply clean water - this is the ability to maintain a certain density of the sludge water, and its mixing is a suitable state for reuse.

Since the recyclable materials are processed in high quality, there is little waste sludge at the outlet. The proportion of the converted material is small and does not affect the quality factor of the material being produced. Therefore, the processed product is suitable for use in production with small volumes.
4. Conclusion
Recycling technology can significantly reduce the amount of waste generated and makes it possible to create a closed production cycle. Even pure water used to separate fractions is in a state of constant circulation and is used more than once.

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References
[1] Ostroukh A V, Nedoseko I V., Pudovkin A.N., Nuruev Y.E. 2015. Development of the Automated Control System for Concrete Plant with Two Units Concrete Mixing. International Journal of Applied Engineering Research 10(17) 37792-37798
[2] Ostroukh A, Maksimychev O, Nikolaev A, Kolbasin A, Nedoseko I 2016 Development of automation of the drying and milling unit for the mineral powders plant ARPN Journal of Engineering and Applied Sciences 11(9) 5717-5721
[3] Anastasiou E, Papachristoforou M, Anesiadis D, Zafeiridis K, Tsardaka E-C 2018 Investigation of the Use of Recycled Concrete Aggregates Originating from a Single Ready-Mix Concrete Plant Applied Sciences 8(11) 2149 https://doi.org/10.3390/app8112149
[4] Vieira L D B P, de Figueiredo A D, Morriggi T and John V M 2019 Waste generation from the production of ready-mixed concrete Waste Management 94 146-152
[5] Dosho Y 2020 Contributions of Concrete Recycling Technology toward Sustainable Development: Standards and Technologies Related to Recycled Aggregate Concrete in Japan Journal of Materials and Engineering Structures “JMES” 7(4) 525-549
[6] Xuan D, Poon C S and Zheng W 2018 Management and sustainable utilization of processing wastes from ready-mixed concrete plants in construction: A review Resources, Conservation and Recycling 136 238-247