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MODULARIZATION OF WASTE WATER PURIFICATION DEVICE

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Abstract: *Lots of housings (dwellings) are situated on the landscape where sewerage is often missing. An automatic water-cleaning device is needed for collecting and cleaning wastewater of one or group of houses. The productivity of the device has to be adjustable in quite large range. Simple assemble and easy maintenance of the device is needed. Development of biorotor type wastewater purification device for housings is considered in this work. The device design was modularized for it to be better adapted to the changing market needs. The development of modular structure for wastewater purification device product family is discussed in this paper. The device was divided into functional units; modules were created according to the Wilson methodic. To change the productivity the suitable number of modules has to be used or switched on.*
Key words: Product Platform, Product Family, Modularity, Product Structure

1. INTRODUCTION

The type of the wastewater purification device is mechanical-biological. By its working principles and size it belongs to the group of small purification devices. The purification takes place inside one body (look figure 1), which has been divided into four parts:

1. primary sedimentation A
2. biological purification B, C
3. final sedimentation D
4. mud chamber E

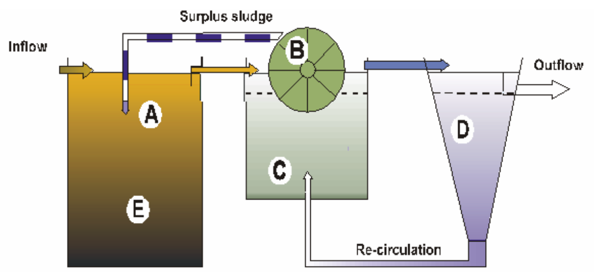

Fig. 1. Principle scheme of mechanical-biological type of purification device

To make the outflow rate more even the basin is equipped with bearing walls to prevent escaping of equipped with a measuring overflow.

2. MODULAR STRUCTURE

One of the main reasons to create module system is the opportunity to make wider range of products from essentially smaller number of different modules and components. Compared to the traditional process of product development, where components are developed in series, in the case of the module system the whole system of information movement is created. [Huang, 1999] The system embraces the specification of connections of the components based on the architecture of a product, that determinates the outcome of the development process before it has begun and a detailed project has been worked out.

Modularization is not only good for producing complicated details, but also as a principle structure of the products. In the case of module system the simplification of production and the abbreviation of the time of product development are not the only important factors but also the opportunity to create an individual solution according to the needs of a client.

As the wastewater purification device is a device, which market demands are very general and connections and joints of a module are simple the best design methodic to use is the Wilson methodic. Wilson methodic is intended for improvement and advance development of the products already created, so there is no need for market analysis.

According to the Wilson methodic the creation of the system has been divided into three parts:

1. Partial allocation of functional elements.
2. Definition of main subassemblies and modules.
3. Creation and development of some schemes of joints.

Determinative factors are types of joints between different parts.

2.1 Creation of functional elements

The purification device has been divided into functional elements and main subassemblies and modules are defined as follows.

	Name of function	Description
1	Inflow	Polluted water inflow
2	Sedimentation	Mechanical pre-treatment
3	Sludge storage	Anaerobic stabilisation of the sludge
4	Flow to biozone	The pre-treated water flows into the space of biological purification
5	Binding water and oxygen	Oxygen is led into the water
6	Water mixing	Keeping water in movement to avoid deposition
7	Growing of biological film	Production of the biological film on the surface of the water
8	Flow to sedimentation basin	Activated mixture from the biozone flows to the vertical settling basin
9	Settling	Settling of the prepared mud
10	Overflow	The discharge trough of pure water
11	Sludge return flow	Fluent sludge flows to biozone
12	Excessive activated sludge to pre-treatment	Excessive activated sludge flows back to settling tank

Table 1. The functions of elements of the device

2.2 Definition of subassemblies and modules

According to the Table 4, it can be seen that the functions are combined into four sub-processes as described earlier. There are only few other functions that are needed between these four sub-processes.

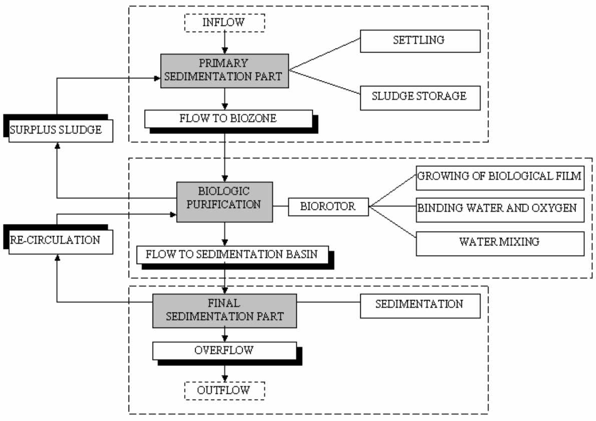

Fig. 2. Division of the purification process into three sub processes.

Figure 2 shows that the purification process has been segmented into three sub-processes.

3. CONSTRUCTION OF THE PURIFICATION DEVICE

3.1 Localization of biorotors

It is necessary to offer purification devices with different productivity depending on the solution of the device. Productivity can be changed by placing biorotors in sequence or parallel. So it is possible to form a gradually changing line. [Blackenfelt, Stake, 1998]

3.2 Localization of primary and final sedimentation

Primary and final sedimentation must be placed directly next to the complex of the biorotor to guarantee its self-circulation. The best solution is to place all components into a single frame. In any other case the pumps must be used. This kind of solution is conceivable with big purification devices or when renovating the old devices if the biorotor purification device is placed directly next to the old purification device and it is used as one step in purification process. In this case the biorotor complex has been used as a module.

3.3 General construction

Working out a general construction of the device following aspects must be taken into consideration: compact building of the device and localization of motors and gears to assure the access to these points. The limits to proportions are set by transport and by building conditions. In the following section different solutions for building a module of a purification device are generated. Attention is on attaching different modules to each other.

3.4 Possible variants of building a module with low productivity

Purification device with low productivity is meant to serve up to 20 people and is able to clean daily 3000 l wastewater. As the rotors are small it is reasonable to use one drive to run several rotors and place rotors in parallel. Compared to the solution, where every rotor has its own drive, the use of the single drive guarantees higher reliability of the operation and easier maintenance. Observing the technology of cleaning process it is possible to create the module considering the following conditions:

1. common primary sedimentation,
2. zones of biocleaning are separated from each other,
3. final sedimentation modules are separated from each other and outflow directed together.

Taking into consideration the conditions presented above, it is possible to create a parallel module, whose function does not differ from the function of assembly. Partition walls that in the case of the parallel placing separate primary sedimentation of the module have been removed. Example of this kind of module has been shown on the figure 3.

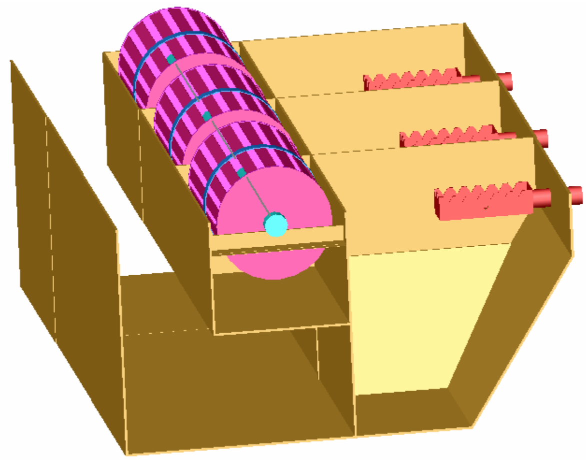

Fig. 3. Low productivity purification device with 3 modules placed in parallel.

3.5 Possible variants of building a module with high productivity

In the case of the purification device with higher productivity (for 20 people and more) the gradual line of productivity may have a bigger step than the device with lower productivity. This gives an opportunity to create frame module of purification device instead of the purification device module and because of that it is possible to change the proportions of the device.
The body of the purification module is a U-shaped element with certain width. Many elements placed side-by-side form the body of the purification device. It is possible to vary the proportions of the purification device depending on the number of modules. It is especially important in the case of primary and final sedimentation, where it is necessary to smoothly regulate capacity of the space.

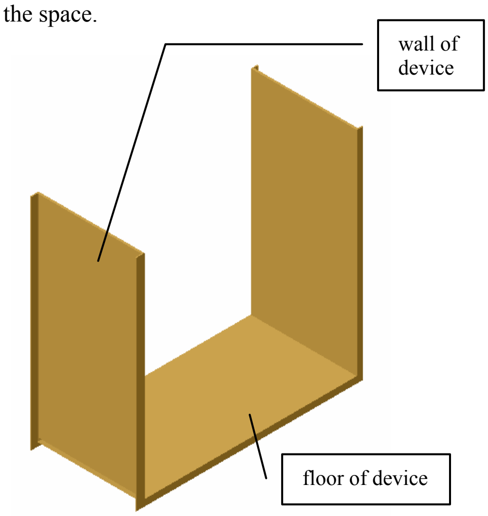

Fig. 4. U-shaped body module

Body details must be maid in two sizes. The purification device must be maid with two different widths, depending on the location of rotors as described in chapter 3.1. It is quite easy to vary measures of the details in this way.
This module system gives 3 opportunities in the future:

1. easy repairment,
2. possibility to make the devices wider,

3. modify the device according to the needs.
[Gershenson, Prasad, 1997]

3.6 The use of the module in the product family
The term “modularity” indicates a high degree of independence among individual elements, excellent general usability, and seamless interfacing between elements. [Bi and Zhang, 2001]
It has been emphasized in chapter 3.6 that the module of the frame of a purification device has been created. This gives an opportunity to use this frame also for other solutions. [Heikkilä, Karjalainen, Martio Niininen, 2002] For instance to create an independent biological zone primary or final sedimentation part or just a tank.

4. THE FRAME OF PURIFICATION DEVICE

4.1 Joining of the frame elements
U-shaped body modules have been chosen, which are placed side-by-side to form square frame with straight and even surface. For the joining of the body modules the following problems must be solved:

1. positioning on instalment;
2. waterproof joining;
3. stiff joining.

To join the modules together the simple joining of the elements is not enough, because a frame made from modules in this way is neither stiff enough nor durable. A secondary element (a supporting construction) must be created to join the modules. It does not have any functions in purification process, but is needed to guarantee the durability of the device. [Bi and Zhang, 2001]

4.2 Supporting construction
An example of a supporting frame can be seen on the figure 5. There you can see connection plates that join supporting frames to each other.

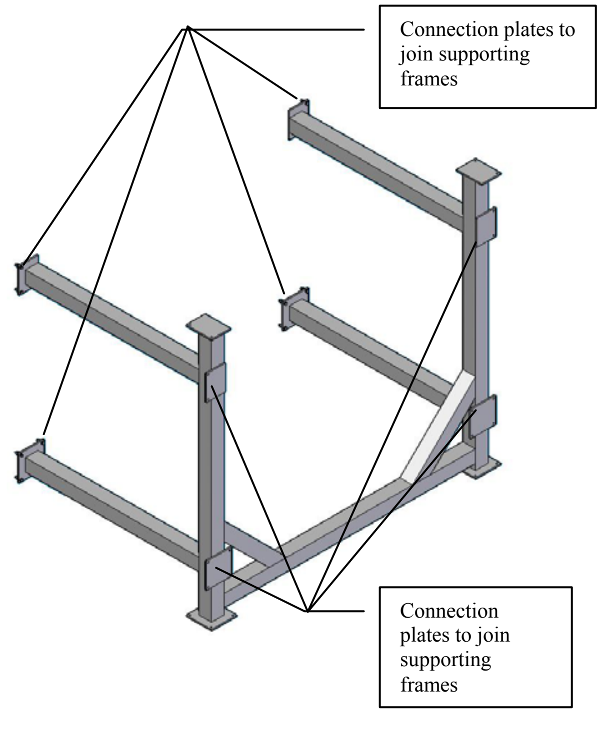

Fig. 5. Module of supporting construction – supporting frame

As a result of joining the modules, as shown on figure 5, the framework is created. The framework, shown in figure 6, is needed to support the walls of the purification device. Firstly the framework is constructed and later the purification device is built inside of it.

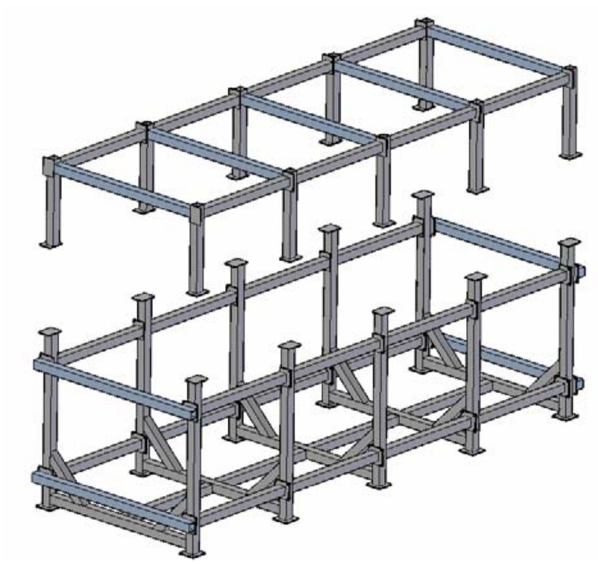

Fig. 6. Supporting construction assembly made from modules

4.3 Formation of the supporting construction
It is necessary to consider the physical parameters of the body elements to determine the measurements of the modules of the supporting construction. Body elements are plates that are made from PEH (polyethylene) plastic that has following physical parameters:
$E=1000\ N/mm^2=1\ GPa$,
$\sigma_t=25\ MPa$.
The deflection and tensile stress of plates with different measurements are calculated with consideration that the maximum height of the water column in the purification device is 2 m. As a result of that the optimal size of the plate is 1.5 m x 1.5 m with thickness being 25 mm. The maximum deflection of the plate is 56 mm.
The measurements of the module are determined accordingly. The width is fixed according to the transport conditions and this is 2.2 m. The height of the module has been determined to be 2 m and to that an upper frame is added with the height of 1 m. Extra horizontal beams must be used to guarantee the calculated measurements 1.5 m x 1.5 m of an unsupported part of a plate.

4.4 Example of a purification device
In figure 5 there is an example of purification device, where four supporting frame modules of a supporting construction are joined and the end-element added. The walls of the purification device can be joined direct to framework. Framework fulfils two functions:

1. integrates body details to one-piece housing,
2. gives stiffness to construction,

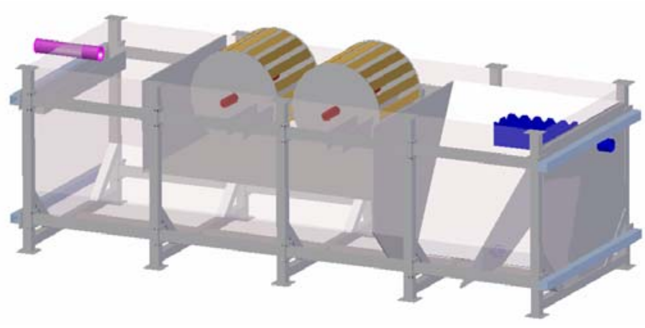

Fig. 5. Assembly of a purification device.

The created supporting frame module can be used in product families. In figure 5 we see that inside the purification device there is possibility for free positioning of partition walls. This gives us a chance to make changes to product. Thanks to modules we can divide the process to stand alone units. This gives us the possibility to integrate new cleaning units to already working treatment plants. As example we add biological pre-cleaning to chemical treatment. In figure 6 there is an example of biorotor complex.

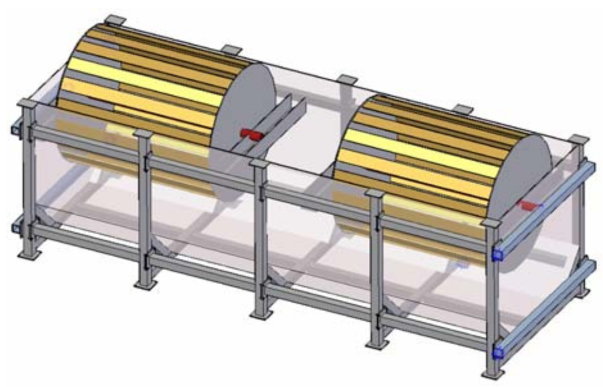

Fig. 6. Biorotor complex

5. CONCLUSION

Through analysis of theories of different authors a modular construction of biological wastewater purification device is created. The purpose of modularization is to distinguish between the independent, standardized and internally changeable units. This solution reduces the risks of market changes. Also this gives a chance to divide production between sub-contractors in a simple and accurate way. [Hildebrand 2002].

The created supporting frame module, allows us to produce purification devices with various architecture and productivity. Transport factors, technologies and process of assembling are all taken into account in the development process of modules and in determination of their size. The created supporting frame module can be used in product families. This way we separate the process of the treatment plant into stand alone units and integrate them into other processes.

7. ACKNOWLEDGEMENT

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