Ecologically pure sorbents for power system of Myanmar

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Abstract. Currently, one of the most important problems of the thermal power plant, and many industrial enterprises in different countries is a wastewater treatment for oil products. When choosing the good sorbents is necessary to consider not only the properties and efficiency of the recommended materials, but also the cost, the possibility of environmentally friendly disposal of used sorbents and the possibility of using secondary resources. The purpose of this paper is to study the possibility of using agricultural waste in Myanmar as the sorbents in wastewater treatment containing oil products. The results of experiments have confirmed that rice hulls, and coconut fiber can be effectively used as the sorbents in wastewater treatment containing oil products at concentrations up to 10 mg/l. According to comparative analysis with the conventional sorbent—activated birch carbon (BAC-A) in the Russian power industry has shown that coconut fiber has very good sorption capacity and it is available to use as the raw materials for industries, which does not require to regenerate after using it and can be directly recycled in the factory.

According to the informational and analysis resource, Asian Vector. Russia and Asian Pacific Region, Myanmar although having substantial natural gas reserves was among the least developed power markets in the region for a long time. The major obstacle to the development of the power market, infrastructure, and capacities for production and processing of the natural resources was the international economic sanctions against Myanmar. In addition, ineffective regulatory policy also adversely affected the power industry. After the reforms were commenced in 2012-2013 and the USA and EC sanctions were banned, an enhanced growth in power production and consumption due to the electrification of the country is predicted thereby forcing the national economy development. The consumption of power resources in 2010-2014 increased, on the average, at a rate of 2% a year. In 2015-2030, the same growth rate will be retained. In this period, the share of oil in the power balance of the country will rise from 18% in 2015 to 24% in 2030, of gas from 13% to 15%, of coal from 2% to 8%. The share of hydraulic power, biomass, and other renewable power sources (RPS) will drop from 67% to 53%. Construction of thermal power stations (TPS) will be enhanced [1].

The objective causes will increase the share of effluents and liquid wastes to be treated. At present, among the critical problems associated with operation of TPSs and many other industrial facilities worldwide is the problem of oily water treatment. For the anticipated intensive development of the power industry in Myanmar, the use of expensive imported sorbents can be awkward.

The results of an investigation into the capabilities to use agricultural wastes for treating effluents and waste water at TPSs are presented. In Myanmar, these sorbents can include natural plant and
mineral materials (e.g., wood chips, straw, rice husk, coconut fiber, etc.). Availability, low price, and effectiveness (see table 1) of these sorbent (i.e., of agricultural wastes) enable us to use them more extensively not only at TPSs, but at any industrial facility as well.

The investigation of agricultural wastes has received much attention in the literature [2-5]. An analysis of the published data (table 1) suggests that these sorbents feature good sorption properties.

| Table 1. Properties of natural materials for treatment of oily water [2-4]. |
|---------------------------------|-------------------|---------------------|------------------|
| Sorbent                          | Oil sorption efficiency, % | Static sorption capacity, g/g | Oil absorption, g/g |
| Rice husk                        | 86 – 99             | 6 – 10              | –                |
| Buckwheat                        | 74 – 85             | 7 – 9               | 3.0 – 3.5        |
| Peat                             | 90 – 99             | 8 – 10              | 17.7             |
| Sawdust                          | 91 – 95             | 4.5 – 8.5           | 1.7              |
| Sunflower husks                  | 96 – 99             | 6 – 8               | –                |

In addition, an analysis of the available publications [3-5] indicates that the investigated sorbents have a low price.

| Table 2. Sorbent properties. |
|-------------------------------|-------------------|-------------------|------------------|
| Sorbent                       | Rice husk | Wheat husk | Coconut fiber from Myanmar | Aqualat®HyperLine activated coco coal | BAC-A                  |
| Parameter                     | Photo of the sorbent | Bulk density, kg/m³ | Particle size, mm | Price, ruble/kg |
| Rice husk                     |          | 341       | 0.3 – 2.0          | 5                  |
| Wheat husk                    |          | 179       | 0.6 – 3.0          | 5                  |
| Coconut fiber from Myanmar    |          | 234       | 1.0 – 8.0          | 10                 |
| Aqualat®HyperLine activated coco coal |         | 527       | 0.4 – 1.7          | 390                |
| BAC-A                         |          | 274       | 3.6 – 1.0          | 130                |

The sorbents, which were agricultural wastes from Myanmar, were tested at the Theoretical Foundations of Thermodynamics Department of the National Research University "Moscow Power Engineering Institute". The investigation of sorption capacity of these materials was carried out in a test facility.

For the sorbents, there were selected:
1. Rice husks (RH);
2. Coconut fiber (CF);
3. Wheat husks (WH);
4. Activated coco coal based on coconut shells grade Aqualat® HyperLine (specially treated material made in India - a coco sorbent) for comparison (CAC);
5. Activated birch coal grade BAC-A as the reference for comparison; it is used as a sorbent in the Russian power industry (BAC-A).

Coconut fiber, rice husks, and wheat husks were reduced in size to obtain 0.5 – 3.0 mm particles since loading long fibers into a filter was impractical, inefficient, and labor consuming. Second,
Comminution of a filtering material is the simplest, cheap, and quite efficient method for increasing the adsorption surface area and, as a result, the absorptivity of a sorbing agent.

It is known [4] that during filtration the surface of material and voids among grains of the filtering medium is a working zone where the geometry of the filtering medium changes continuously as oil particles settle on the surface of grains. The filtration efficiency depends on many properties of the filtering medium including the roughness of its surface. Hence, the investigation involved examination of the surface of sorbents using a KH-8700 3D digital microscope with a magnification of 2500X (made by HIROX Co.) put at our disposal by the OSTEC Company. For the examination results, see figure 1 – figure 4.

The photographs of the absorption surfaces shows that the surface of BAC-A has pores 3 to 25 μm in size and 25 to 80 μm in depth. The coconut fiber surface is rough with a few pores 2 to 35 μm in size. The surface has a fiber-like structure that increases the sorption area and forms. Every filament 10 to 130 μm in size is a sorption center. The rice husk has the surface of cellular ordered structure 5 x 20 μm in size. The wheat surface is practically smooth with very fine cells 1 to 33 μm in size.

The sorption capabilities of the investigated materials were studied under dynamic conditions using a model solution. The sorption columns were loaded with a sorbent to a form a layer 40 cm thick. Then a model solution with an oil content of about 10 mg/l, that is close to the oil content attained in effluent treatment facilities after oil traps and flotators at Russian TPSs, was made to flow through the columns.

**Figure 1.** Photographs (2500X) of the sorption surface of BAC-A under a KH-8700 microscope.
Figure 2. Photographs (2500X) of the sorption surface of Coconut fiber under a KH-8700 microscope.

Figure 3. Photographs (2500X) of the sorption surface of Rice husk under a KH-8700 microscope.
Figure 4. Photographs (2500X) of the sorption surface of Wheat husk under a KH-8700 microscope.

The oil content in the model solution before and after the sorption was determined by the IR-spectrometry technique using a Flyuorat-02 fluid analyzer in accordance the procedure outlined in the Environment Protection Code PND F 14.1:2:4.128-98. The experimental results are plotted in figure 5.

Figure 5. Outlet sorption curves.
An analysis of the curves suggests that all the sorbents feature good sorption properties, but the coconut fiber from Myanmar and the rice husk are the best. The peaks corresponding to oil washing-off from the adsorbent surface are clearly seen in the curves. It should be noted that the peaks in the curves for the activated coco coal, wheat husk, rice husk, and BAC-A have more pronounced amplitudes and the area under these curves is much larger than the area under the coconut fiber. The highest peaks are observed in the curves for the wheat husk and BAC-A with nearly the same volume of water amounting to 6 l which was passed through the either column. For the coconut fiber, the first minor washing-offs occur after 11.2 l of the model solution passed through the column. This means that the coconut fiber surface better retains the oil film as compared with the surface of other investigated sorbents.

These results enabled us to predict the sorbents characteristics presented in table 3.

Table 3. Sorption characteristics of the studied materials

| Sorbent                        | Weight, g | Oil content before treatment, mg/l | Oil content after treatment, mg/l | Dirt-holding capacity, mg/cm³ | Treatment efficiency, % | Dynamic absorption capacity, mg/g |
|--------------------------------|-----------|-----------------------------------|---------------------------------|-------------------------------|--------------------------|-------------------------------|
| BAC-A                          | 97.67     | 10.6                              | 1.496                           | 0.179                         | 85.89                    | 0.708                         |
| Coconut fiber (CF)              | 95.225    | 9.5                               | 1.138                           | 0.281                         | 88.02                    | 1.194                         |
| Activated coco coal (CAC)       | 214.459   | 9.5                               | 1.597                           | 0.277                         | 83.19                    | 0.501                         |
| Wheat husk (WH)                | 64.297    | 8.5                               | 2.668                           | 0.099                         | 68.61                    | 0.617                         |
| Rice husk (RH)                 | 138.768   | 8.61                              | 1.258                           | 0.146                         | 85.39                    | 0.424                         |

The predicted sorption indicators corroborate the conclusion that the coconut fiber has better sorption performance as compared with other investigated materials. All investigated materials remove oil better that the wheat husk does.

Thus, the following conclusion can be made based on the performed experiments and the obtained results:
1. In addition to the porous structure on its surface, the coconut fiber also has fibrous formations promoting better and stronger retention of oil on the fiber surface. Thus, the sorption capacity can be affected not only by the specific and size of pores, but by the structure and type of the adsorption surface as well.
2. All the studied materials except the wheat husk remove oil not poorer than the BAC-A sorbent widely used in the Russian power industry does. The best sorption performance was demonstrated by the coconut fiber from Myanmar.
3. As to the power industry of Myanmar, this sorbent is readily available and cheap.
4. Since sorbents should be selected based on many factors among which is the environmental safety of disposal of waste materials, this problem can solved by using these materials at the power station as supplementary fuel in lighting up or operating a boiler, or delivering them to small-power boiler houses.

References
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