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ENVIRONMENTALLY FRIENDLY DEVELOPMENT OF FERTILIZER PRODUCTION: MODERNIZING TECHNOLOGY AND EQUIPMENT

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ABSTRACT

Main drivers of the industrial growth in the modern society include energy efficiency, compliance with national legislation and international agreements, social and environmental responsibility.

Integration of these factors should be applied to the long-term development plans as the framework of sustainable development, environmental and resource efficiency. Currently, more and more countries are moving towards Best Available Techniques (BAT).

Russia developed 51 Reference Document on BAT (BREF) for main industrial sectors. At the moment, the information collected in BREFs is mainly used for regulation, technology assessment and obtaining integrated environmental permits. However, BREFs provide a wealth of information on Best Available and Emerging Techniques as well as technological and pollution abatement, so they can be used as a source of organizational, technological and technical information for improving existing techniques and developing new more efficient ones.

The paper demonstrates the example of practical application of Russian and European BREFs for the production development measures of mineral fertilizer production resulting in resource, energy and environmental efficiency increase. Therefore, it is advisable to use BREFs for the designing of production development plans.

Keywords: Best Available Techniques, industrial efficiency, fertilizer production

INTRODUCTION

One of the key issues that humankind has to address is a continuous population growth and corresponding increase in resource consummation, agricultural products in particular. An ultimate way to boost land productivity is to use fertilizers.

Planning of efficient production is firmly based on Sustainable Development Goals (SDG); larger industries allot specialized departments that focus on determining criteria, monitoring achievements and reporting on SDG. Fertilizers production sector embraces the following of these Goals: Zero Hunger, Clean Water and Sanitation, Decent Work and Economic Growth, Responsible Consumption and Production, Climate Action. Achievements in this sector show both positive (increase in land productivity) and

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negative sides (emissions of pollutants to air and water, waste generation, greenhouse gases emissions). The main issue for fertilizers industry is to get a balance between ecological, economic, social, and climate factors.

STATE OF BEST AVAILABLE TECHNIQUES IN RUSSIA

Presently, Russia is on its way towards implementation of technological and ecological regulation through an adoption of Best Available Techniques [5 - 11]. BAT as a legal term has been introduced by the Federal Law of 21.07.2014 No. 219-FZ, and this is a concept that upends the system of negative environmental impact regulation. The new regulatory framework suggests that that all installations with negative environmental impact are divided into four categories based on the degree of their effect on the environment, and differential measures of government regulation are applied to each category. Installations with a considerable negative environmental impact (Category I) are required to obtain an Integrated Environmental Permit, or to draft an Environmental Performance Enhancement Programme (EPEP) unless they meet technological requirements and allowable emissions. An EPEP enlists actions on prevention of pollutant emissions to air and water, reduced generation of industrial waste through implementation of BAT.

The present ecological and industrial policy framework in the Russian Federation comprises 51 sectoral and cross-sectoral (so-called 'horizontal') Reference Document on BAT (Russian BREFs), and a number of legal acts and national standards.

The process of issuing IEPs and drafting of EPEPs is currently in full swing. However, the large amount of data on existing technological processes, means and measures for environmental impact reduction, and emerging techniques is used solely as a proof of BAT implementation in an IEP application and a support of an EPEP action plan. Meanwhile, BREFs may serve as a reputable basis for drafting process development and performance enhancement programmes.

USE OF BREFs FOR FERTILIZER PRODUCTION EFFICIENCY INCREASE

Production of complex phosphorous fertilizers presents an interesting case of the BAT use to enhance resource, energy and environmental performance. NP/NPS manufacturing process includes the following stages (Figure 1):

- receiving inspection of raw materials;
- neutralization of phosphoric acid with ammonia;
- granulation;
- cooling and drying of products;
- sieving, crushing and conditioning units.

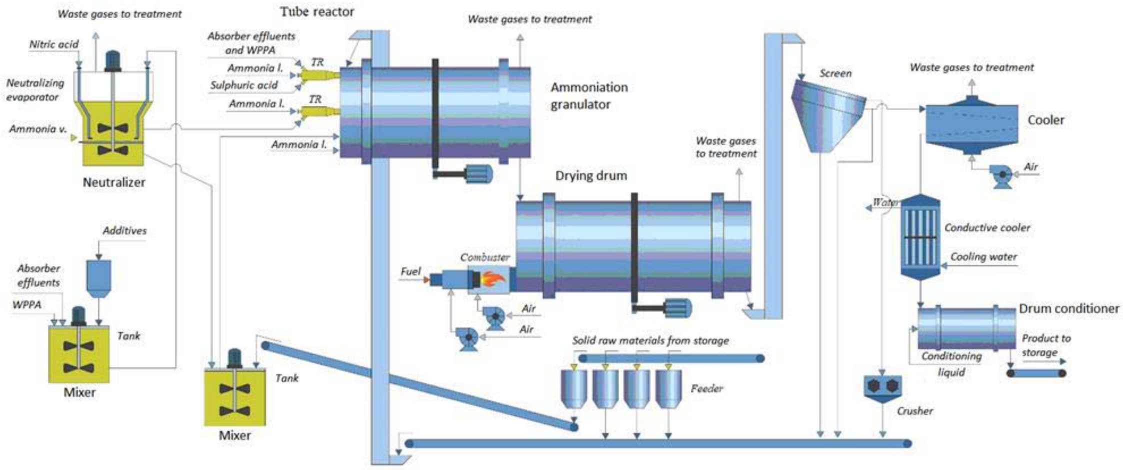

Figure 1. Manufacturing of NP/NPS fertilizers

Production of fertilizers involves a variety of activities, covered by the following Russian BREFs:

- BREF 2-2019. Production of ammonia, fertilizers and inorganic acids;

- BREF 8-2015. Waste water treatment in production, maintenance and servicing at large installations;

- BREF 48-2017. Energy efficiency enhancement in business or other activities;

- BREF 22-2016. Waste gas treatment in production, maintenance and servicing at large installations;

- BREF 47-2017. Waste water and waste gas treatment/management systems in chemical sector;

- BREF 22.1-2016. Common principles and metrology provisions for operational environmental monitoring.

The following EU BREFs also present a valuable source of additional information on the subject:

- EUROPEAN COMMISSION. Reference Document on Best Available Techniques for Energy Efficiency. February 2009;

- EUROPEAN COMMISSION. Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers. August 2007;

as well as domestic legal acts that refer to BAT-associated equipment and enlist entities and technologies with improved energy efficiency [1, 2].

Improvement of efficiency, be it in resource, energy or ecology, is closely related to implementation of relevant institutional, technological and technical actions, and the documents mentioned before contain data on both existing and emerging technologies, approaches and equipment.

Losses may be minimized by:

- The use of waste and secondary products (drip, waste water, granulated slag, phosphogypsum, slurries, etc.);
- Processing of available raw materials, various types of industrial waste and secondary products. The use of waste and secondary products in production of fertilizers enriched in micronutrients;
- Improvement of process and analytical control techniques, i.e. continuous control of ammoniated pulps pH level and flue gases temperature precludes ammonia losses in ammoniating and drying of fertilizers;
- The use of wet-process phosphoric acid (WPPA) from low-grade phosphate rock;
- Production of fertilizers via conversion techniques: conversion of phosphogypsum into ammonium sulphate and calcium carbonate, production of ammonium sulphate through conversion of phosphogypsum, fluorosilicic acid and ammonia, conversion of phosphogypsum and diammonia phosphate into a product containing calcium/ammonium phosphates and ammonium sulphate, conversion techniques for obtaining chlorine-less fertilizers from potassium chloride, etc.
- Production of organomineral fertilizers with the use of peat, animal and bird manure, lignin, organic slime (sapropel), etc. as an organic constituent;
- Production of advanced fertilizer compositions with a controlled nutrient release.

Energy efficiency may be enhanced through:

- The use of more concentrated phosphoric acid;
- The use of secondary heat sources (4 atm steam or hot gases from the neutralization stage) for conditioning of air injected into combustors and used for flue gases dilution;
- Precise control of temperature in neutralization and drying stages;
- Strict regulation of process parameters, and particularly of those affecting minimal process temperature and optimal pressure in the reactor unit, which will improve energy efficiency and minimize pollution;
- Continuous control of the product humidity;
- Continuous control and adjustment of product grain size distribution;
- The use of air cooling systems for a rapid product cooling;
- The use of tubular reactors on the neutralization stage;
- The use of combustors with up-to-date instrumentation and controls that provide constant monitoring of drying temperature, perfect fuel combustion and reduced nitrogen oxides (NOx) emissions;
- The use of conductive heat exchangers for product cooling;
- The use of variable speed controllers for pumps, crushers, mixers, vents, drums, etc.;
- The use of soft starters for drums, ventilation units and pumps;

- The use of endless belt elevators and other units for transportation of loose materials;
- Installation of in-situ compressed air stations;
- Modernization of process stages/equipment: installation of a tank pre-neutralizer with a mixing device, improvement of process efficiency by changing a 'ammoniation granulator – drying drum' combination to a 'ammoniation granulator –drying drum granulator' couple;
- Reducing specific energy consumption via higher production rates;
- Manufacturing of granulated NP/NPK-fertilizers with increased unit output;
- Mapping all possible losses of heat, waste and emissions, with close attention to the source, process and unit parameters, characteristics of and possible ways to re-use/recover losses and wastes;
- Equipment design with decreased amount of main and servicing openings, minimal possible number of process equipment, unit design for continuous operation with lowest possible metal intensity, reduced use of auxiliary chargers and dischargers, optimized heater and exhaust systems, installation of enclosed units;
- Equipment enclosure and the use of channelled gas exhaust systems;
- A close attention to non-process energy consumption and modernization of installations and facilities (i.e. installation of energy efficient lighting, IR heater systems, buildings insulation, etc.);
- Optimized monitoring and control of energy consumption and process parameters with up-to-date automated systems.

Environmental performance may be improved by the following measures:

- Monitoring, adjustment, and robotization in all process stages where pollutants are generated and emitted (reagent ratio, temperature, acidity, etc.). Continuous control of ammoniated pulps pH level, prevention of NH3 emissions through monitoring of absorbing liquor pH level and installation of advanced absorbers;
- Installation of advanced waste gas treatment systems with hygiene gas cleaning;
- The use of cyclones, jet filters (bag filters in raw materials storage area);
- The use of conditioners and conditioning mixtures to suppress dust emissions;
- Installation of in-situ aspirators at overturning and transportation units;
- The use of combustors with up-to-date instrumentation and controls that provide constant monitoring of drying temperature, perfect fuel combustion and reduced NOx emissions;
- Prevention of nitrogen compounds emissions to air: decreasing maximum process temperature and exposure, shortening of high-temperature zone to promote flue gases evacuation;
- Reduction of NOx formation in combustion by the following measures: fuel burning with decreased air ratio, and a two-stage combustion with air injection where

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the first stage operates excessive fuel, and the second provides total combustion with excessive air input;

- The use of hardware with improved reliability (double-sealer valves, pumps/compressors/mixers with end seals instead of gaskets, durable gaskets (spiral wound, sleeve-type)), and corrosion-resistant units in critical positions;
- Implementation of water recirculation systems with effluent neutralization and re-use;
- Reduction of water consumption and waste water generation: prevention of virtually clean water contamination by process waste water; recirculation of treated effluents; minimal possible processing of deep-well water via waste water recirculation; re-use of cooling water and vacuum-pump drip;
- Underground disposal of wastewater;
- Implementation of emissions control system for variable process conditions with process parameters correction;
- Continuous pH control at effluent discharge outlet to rainwater sewers.

These measures may be filled up with solutions from the EU BREFs [3, 4]:

- Disuse of vehicles, which may help reduce emissions to air and cut down risks of workplace accidents;
- Regular energy audits for the whole production site, efficient production and use of resources, constant monitoring of key performance parameters that may significantly affect energy efficiency;
- Increased process integration, optimized energy use on-site or off-site;
- Use of reaction heat for water evaporation;
- Optimized fuel combustion efficiency by advanced computerised control of combustion conditions for emission reduction and boiler performance, use of the heat content of the flue-gas for district heating, low excess air, lowering exhaust gases temperature, decrease of CO concentration in flue gases, preheating of fuel/combustion air with waste heat, use of recuperative and regenerative combustors, combustor regulation and control, reducing heat losses by insulation, reducing losses through furnace openings;
- Optimisation/maintenance of air compressors, pumps, heating, ventilation and air conditioning systems, lighting, drying, concentrating and separation processes. Proper choice of equipment and drive performance, energy efficient design and installation of steam distribution pipework, use of variable speed drives, optimising steam distribution systems to ensure adequate operation and maintenance, installation of high efficiency transmission/reducers, use of direct coupling where technically feasible, use of synchronous belts or cogged V-belts in place of conventional V-belts, and helical gears in place of worm gears;
- Establishing energy efficiency criteria;
- Energy efficient design of a new plant or installation;

• Reduction of energy losses: insulation on steam pipes and condensate return pipes, and other heat equipment.

Existing lists of BAT-related equipment and of entities and technologies with improved energy efficiency [1, 2] are applicable in process design and engineering and may be addressed as supplementary materials when claiming a governmental support for retrofitting and upgrading: the use of conductive heat exchangers, absorbers, scrubbers, cyclones and cloth filters, variable speed controllers, soft starters, up-to-date combustors, gas analyzers, fiberglass and polymer pipelines, heat sinks, radial-flow, piston and rotor pumps (50 to 72 % efficiency), axial-flow fans (up to 85 % efficiency), electric motors (above 91,6 % efficiency, dependent on power output), air compressors (above 87 % efficiency), etc.

CONCLUSION

BREFs represent a wide collection of consolidated data. Industrial Reference Documents on BAT such as BREF 2-2019 Production of ammonia, fertilizers and inorganic acids contain data on both existing and emerging technologies, approaches and BAT-associated equipment. Cross-sectoral, so-called 'horizontal' Reference Documents on BAT (BREF 8-2015. Waste water treatment in production, maintenance and servicing at large installations; BREF 48-2017. Energy efficiency enhancement in business or other activities; BREF 22-2016. Waste gas treatment in production, maintenance and servicing at large installations; BREF 47-2017. Waste water and waste gas treatment/management systems in chemical sector; BREF 22.1-2016. Common principles and metrology provisions for operational environmental monitoring.) may be put to good use for minimizing losses of raw materials, water and energy consumption.

BREFs have extensive practical application for designing new and modernization of existing installations, for technical, ecology, and energy audits, for drafting and assessment of feasibility studies and investment plans.

Implementation of BATs and emerging technical, technological and institutional actions allows to achieve much of Sustainable Development Goals, enhance resource, energy or environmental performance of fertilizer industries.

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