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KHAIBULLA PROCESSING PLANT: DESIGN SOLUTIONS AND CONSTRUCTION

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In 2011 Khaibulla processing plant phase I has been commissioned for processing copper and copper–zinc ore of Yubileiny deposit in the Republic of Bashkortostan under the project of construction of processing plant with an annual capacity of 3 Mt developed by the general designer — RIVS Science and Production Association, Saint-Petersburg.

The processing plant consists of a coarse-crushing building with a ground-level covered storehouse; the main building with the areas for grinding, flotation and dewatering of concentrates; lime and chemical area; tailings storage with recycling water supply; and engineering and administration buildings. Ore grinding: two SAG mills MPSI-70×23 at stage I and two ball mills MSHCHTS-45×60 at stage II, close-cycled with hydrocyclones; flotation: flotation machines RIF-25 and RIF-8.5; filtration of concentrates: filter presses. The variant with SAG milling has been selected due to reduced cost as against the standard ore pretreatment technology.

At the early operation stage, the processing plant has attained the design performance. Some issues connected with dewatering of concentrates required installation of additional filter press.

Khaibulla processing plant has been constructed in accordance with the modern production standards. The design solutions within the Khaibulla processing plant project enable high performance and further improvement of the plant.

The article gives a review of the design solutions accepted under the project of Khaibulla processing plant for copper–zinc ore flotation under technical regulations prepared by RIVS. The authors compare the flow charts of the standard ore pretreatment and semi-autogenous milling and the design solutions enabling attainment of the design performance data.

Key words: *copper–zinc ore, Khaibulla processing plant, design, construction, ore pretreatment, flotation.*

In June 2011, Khaibulla processing plant (PP) constructed by Bashmed under the technical regulations and project by RIVS was put into service. The project work on the construction and engineering also involved subcontractors: WELD, Universal–Elektrik and Bashpromavtomatika companies.

Thanks to Bashmed and RIVS, Khaibulla PP has reached the design capacity at the earliest possible data and is by now one of the leading and stable-operating plants of the Ural Mining and Metallurgy Holding.

The operational stability of PP in the intervening years has proved the correctness of the key project and process designs.

Khaibulla PP is supplied by copper and Cu–Zn ore from Yubileiny deposit, Republic of Bashkortostan. The deposit is under development by Bashmed company. Mining was launched in 1996. At the present time, the open pit mine extracts upper ore horizons and an underground mine is under construction to cut deeper ore levels.

Processing involves copper ore, and Cu–Zn ores are scheduled to enter the processing in the nearest future.

Engineering design of the processing plant

The decision on PP construction at Yubileiny deposit was made in 2006. The PP construction feasibility study and project planning was accomplished by RIVS-proekt, general design office of RIVS. The project provides for construction of PP with an annual capacity of 3 Mt, with two-phase construction of two sections for parallel intake and processing of copper and Cu–Zn ore.

The design data in accordance with the technical regulations are given in **Table 1**.

Variants of machine flow sheets and design layouts of PP were developed based on equipment manufactured by leading Russian and foreign companies.

The design engineering involved the comparison of:

- ore pretreatment charts based on layout variants and calculations of capital and operating costs;
- dressing process charts based on the analysis of dressability of Cu and Cu–Zn ores.

The project considered two competitive alternatives of ore pretreatment area: conventional, with three-stage milling, and the alternative with semi-autogenous milling (SAG milling).

Subjects in the standard ore pretreatment variant

1. Coarse-crushing building (CCB) to intake Cu and Cu–Zn ore from open pit mine;
2. Ground-level covered storehouse for two stockpiles of copper ore and one stockpile of Cu–Zn ore, with ore unloading by apron feeders on two belt conveyors toward two sections of milling;
3. Medium and fine crushing building with two parallel tandems of medium and fine crushers and coarse-crushed ore washing on screens prior to medium crushing. In order to increase density of undersize of washing screens, there are simplex spiral classifiers.
4. Milling area in CCB with two-stage ball milling.

Table 1. Design process data for start-up and full-capacity PP

Description	Development stages	
	Start-up at 1.5 Mt	Full capacity of 3 Mt
Copper content of copper ore, %	2.56	1.63
Cu–Zn ore content of, %:		
copper	2.25	1.79
zinc	2.31	2.04
Concentrates, %:		
Cu content of Cu concentrate of Cu ore	20	20
Cu content of Cu concentrate of Cu–Zn ore	20	20
Zn content of Zn concentrate of Cu–Zn ore	46	50
Recovery in concentrates, %:		
Cu in Cu concentrate from Cu ore	89.3	90.5
Cu in Cu concentrate from Cu–Zn ore	83.1	83.1
Zn in Zn concentrate from Cu–Zn ore	61.5	61.5

Subjects of SAG milling alternative

1. Coarse-crushing building (as in the standard variant);
2. Ground-level storehouse (as in the standard variant);
3. Ore re-loading unit with re-crushing of critical size grade of SAG mill discharge;
4. Milling area in CCB with SAG milling of coarse-crushed ore with addition of balls up to 8% of SAG mill volume and two-stage closed-cycle ball milling.

The both variants have jaw crusher SHCHDP-12×15 in CCB, loaded from 80 m^3 capacity hopper by heavy-duty horizontal apron feeder 1800 mm wide. In the hopper ore is delivered with open pit mine dump trucks with a capacity of 40 t. The crusher is discharged on a belt conveyor toward the ore storehouse. At PP Phase II, ore will be conveyed from the underground mine ore storage to the coarse-crushed ore storage. The CCB size of the axes is 27.5×30 m. The jaw crusher operation is supported with an overhead crane with a capacity of 32/5 t.

Coarse-crushing building

Coarse-crushing ore storehouse

The coarse-crushed ore storehouse (CCOS) is a ground-level covered deck with a capacity of 13.8 thousand m^3 meant for storing three days ore stock. The storehouse is divided into three sections, one for Cu–Zn ore stockpiling and the other two sections for copper ore stockpiling.

In the standard ore pretreatment variant, the medium and fine crushing building size of the axes is 30×48 m. The height up to the overhead crane base in 28.2 m. The building contains two similar tandems of medium and fine crushers at a ratio of 1:1, with an annular capacity of 1.5 Mt. Each of the two tandems includes crushers KSD-2200T6 and KMD-2200T6, washing screen GRS-2000×5000 before medium crushing, screen GRS-2000×5000 before fine crushing and simplex spiral classifier 1KSP-24.

The main building is a six-passage pavilion-type building with passages 12, 30, 12, 36, 30 and 18 m wide. The milling area is in the passage A–C.

In the A–B passage 12 m wide, there are fine-crushed ore hoppers loaded by means of two belt conveyors with trippers. The hoppers are designed as reinforced concreted boxes with three sections for storage of two grades of ore and both grades can be fed in turns in the first section.

The B–C passage 30 m wide accommodates three-stage grinding and re-grinding mills with hydrocyclones and pumping equipment. The mills are repaired on the site. The operation of the mills is supported with an overhead crane with a capacity of 80/20 t.

The SAG milling variant has the main building as a pavilion with five passages 30, 12, 36, 30 and 18 m wide, respectively.

The project design involves two SAG mills PSI-70×23 at grinding stage I and two ball mills MSHCHTS-4500×6000 at grinding stage II, in closed cycle with cyclones.

The discharge of grinding stage II cyclones goes to flotation in flotation machines RIF 25 with separation of copper "head". The discharge of grinding stage II cyclones is a feed for the rougher copper flotation in copper ore processing and the bulk flotation I in Cu–Zn ore processing.

As for the rest, the SAG milling variant layout is the same as in the standard ore pretreatment variant.

All grinding and re-grinding equipment is placed in the A–B passage.

The B–C passage 12 m wide accommodates lime tanks and reagent batching areas with tanks and systems for chemical dosing.

In the C–D passage with the width of 36 m, there are RIF 25 and RIF 8.5 machines for all flotation circuits, conditioning tanks and other equipment and an operator's room. There is also an overhead crane with a capacity of 10 t.

The D–E passage 30 m wide houses thickeners CETCO with a diameter of 12 m and pressure-type filters MC1-250-S-1250×1250Y for copper and zinc concentrates, with auxiliary equipment. The operation of the machines is supported with an overhead crane with a capacity of 10 t.

In the same passage, there are air blowers and compressors to supply compressed air to sample taking and handling facilities and to control pulp slurry level in flotation machines. The area of air blowers and compressors is maintained with an underslung crane with a capacity of 3 t.

The E–F passage 18 m wide accommodates storehouses for finished products of copper and zinc concentrates. There is a grab crane with a capacity of 10 t.

The area of chemical preparation adjoins the lime milk preparation area, making a unit 42 m long under the same roof for storage and dissolving of reagents, and for placing settlers and pumping equipment. These passages are equipped with underslung cranes 3 t in capacity.

The lime-and-reagent area contains the lime intake and grinding units. The lime intake unit with an area of 156 m^2 includes a hopper with a capacity of 70 m^3, 800 mm wide inclined belt with scales and an underslung crane 1 t in capacity. The lime grinding area (18×42 m) houses mill MSHR-2100×3000 closed-cycled with cyclones GRTS-380 and GRTS-500, two conditioners KCH-40 and pumping equipment. The operation of the equipment is maintained with an overhead crane with a capacity of 10 t.

On the west of the processing plant infrastructure site, there are an administration building (AB) and an engineering building connected with the main building by passageways. In AB the offices of management and chief specialists of the processing plant are arranged, and ablutions. The engineering building houses routine engineering services, research and chemical laboratory and the production control department.

In accordance with the project, Khaibulla PP will be equipped with the process control system, including three analyzers PX-2100, PERI (USA), controllers Simatic S7, SCADA WinCC and fieldbus Profibus. Together with automatic control of the equipment, the process control system allows visualization, inherent regulation and dispatching, emergency protection, data accumulation and reporting.

Heat supply of the processing plant infrastructure is from gas boiler house with a total capacity of 20 MW (including standby boilers).

The tailings pond of Khaibulla PP, with the recycling water supply is situated 900 m southwestward of Yubileiny open pit mine. The tailings storage area project is accomplished by NOVOTEK, Belgorod.

Main building of the processing plant

Lime and chemical area

Administration building

The project involves a “hybrid filling” tailings pond where the downstream tow is generated by inwash and protecting dikes for arrangement of inwash levels are made of local soil.

The tailings storage area is 310 ha. Geomorphologically, the area is divided into two sites: northern site with an area of 190 ha and southern site with an area of 120 ha. It is planned to use the tailings storage sites in turns. First the southern site is to be filled. When the southern site is filled up to the limit mark, the northern site filling begins. The useful capacity of tailings storage stage I (southern site) is about 27 Mm^3, which ensures its operating life of 19 years (from PP commission-

Table 2. Cost/performance ratio of different ore pretreatment variants at annual ore processing capacity of 3 Mt

Expense	Variant I — standard ore pretreatment flow chart		Variant II — SAG milling	
	1 t/RUB	3 Mt/thou RUB	1 t/RUB	3 Mt/thou RUB
Capital investment K, including:	1683.4	5050250	1662	4986128.6
equipment	675.7	2027144	721.7	2164983.2
construction, assembly and other expenditures	1007.7	3023106	940.4	2821145.5
Annual operating cost E	304.45	920418	306.81	913351
Reduced cost	559.3	1677955	553.8	1661271
Current charges (without amortization)	211.75	635263	206.31	618918
Wages fund, thou RUB	18.94	56827	17.54	52607
Manpower	202		187	
Power consumption, BkW·h		119.2		125.5

Table 3. Production data of Yubileiny copper ore processing by the end of 2013 and for 2014 quarter I

PP operation period	Processing, thou t	Cu content of ore, %	Cu content of concentrate, %	Cu recovery, %
Total for 2013	1438.95	2.26	19.54	91.9
January 2014	112.567	2.09	19.4	89
February 2014	102.903	2.18	19.36	89
March 2014	106.427	2.11	19.34	89.3
Total for 2014 quarter I	321.9	2.13	19.37	89.1

ing). The northern site capacity is about 33 Mm^3. The tailings storage will maintain operation of PP for 39–40 years.

The overall project of ore pretreatment has been accepted based on the technical-economic calculation of processing cycle at the full growth by the reduced cost (**Table 2**). The reduced cost is low in the SAG milling variant than in the standard ore pretreatment, first of all, owing to substantially smaller cost of construction–assembly work (nearly by 18%) with higher cost of equipment but lower operating expenditures.

Khaibulla PP has been constructed under the project of SAG ore pretreatment preferred in accordance with the technical-economic calculation data.

In October 2007 Zavodenergostroi company laid foundations of the main building and the coarse-crushing ore storehouse. In May 2007 construction of tailings pond and gathering pond was started. Basic PP equipment was purchased in 2008.

Specific period of Khaibulla PP construction was 2008 crisis, due to which by the moment of erecting of production buildings, the work was suspended almost for a year, till October 2009, and alternatives of temporary abandonment of construction, or reduction in cost as against the previous engineering solutions were considered. Nevertheless, Bashmed company strained every nerve to create conditions for completion of PP construction in less than 3 years. In November 2010 Khaibulla PP was pre-commissioned at an annual capacity of 1.5 Mt.

Development of design capacity and PP operation

Start-up and development of design capacity was implemented by the processing plant personnel in partnership with contract supervision by the equipment manufactures and members of the Engineering Laboratory of RIVS. The equipment start-up was implemented during construction–assembly works, and the final taking-over of the equipment and adjustment of the accepted technology was done in the period of pre-commissioning of the processing plant in quarter IV of 2010.

In June 2011 a symbolic event happened — PP phase I was commissioned in the presence of R. Z. Khamitov, President of the Republic of Bashkortostan, I. K. Makhmudov, President of the Ural Mining and Metallurgy Holding, A. A. Kozitsyn, General Director of the Ural Mining and Metallurgy Holding, as well as executives and specialists of mining, design and construction agencies, financial institutions, and personnel of Bashmed company.

Sustainable operation of the processing plant in the early period confirmed the correctness of RIVS decisions on selection of the technology and equipment for processing of Yubileiny deposit ore (**Table 3**).

In this respect, it has been specified that:

- the project changes in terms of rejecting initial solutions on the coarse-crushing ore building and coarse-crushing ore storehouse being unheated complicate meeting the dust content standard at personnel workplaces, especially in winter time;
- the ore pretreatment package operates sustainably, irrespective of moisture content or clay content of ore; the ground-level storehouse ensures PP operation almost in any weather conditions;
- flotation front is sufficient;
- the concentrate thickening unit operates tensely when concentrate yield grows;
- the press filters show insufficient capacity as against the value declared by the manufacturer, which requires additional equipment installation.

In 2013–2014 the ore processing technology has been improved in view of increased ore supply and changed standards of energy efficiency of the production.

In 2013 the technical regulations have been developed for Dergamysh deposit ore processing and pilot processing of ore has been initiated at Khaibulla PP.

Early in 2014 the automated dispatching of power system has been commissioned at the processing plant (by Bashpromavtomatika company), with the following basic functions:

Automated acquisition, storage and display of PP equipment power supply parameters and condition of commutation elements;

Generation of warning and alarm messages upon overshoot of the processing equipment power supply parameters;

Process recording of power consumption.

Conclusions

1. RIVS Science and Production Association experts have developed the processing technology for copper and Cu–Zn ore of Yubileiny deposit and elaborated the technical regulations and the project for Khaibulla processing plant.

2. Bashmed company has constructed and commissioned at the earliest possible date the Khaibulla PP phase I for copper ore processing with ensured attainment of the design capacity.

3. Khaibulla PP has been constructed in accordance with the contemporary production standards, at high automation level, with the use of high-duty flotation equipment manufactured by RIVS.

4. The engineering solutions within the Khaibulla PP project enable its further development, including processing of ore from other deposits. EM

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