Technology Upgrade for Russian Aluminum Plants: Our Experience at IRKAZ

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Abstract
North American Technical Services, Ltd. (NATS) is the engineering subsidiary of Access Industries. NATS specializes in the technology upgrade of metal production facilities in Russia.

NATS has been working with the Irkutsk Aluminum Smelter (IRKAZ) and SibVAMI for three years; together, these companies formed a project team which is fulfilling a $38 million contract to upgrade IRKAZ. They have established project goals to improve metal quality, increase production, improve safety conditions, reduce polluting effluent, and reduce input consumption. (Input consumption includes raw materials, electricity, labor and capital used in the reduction process; the NATS team considers this on a per-ton-of-aluminum-produced basis).

The project is unique in approach and implementation. Based on initial experience, project team members determined that realization of the above goals depends on both the establishment of new work practices / pot room management procedures and the installation of capital equipment. Accomplishments of the project are described along with details of project goals and steps taken to achieve the goals.

Introduction
The Russian primary aluminum industry was largely isolated from the world market until the fall of the Berlin Wall in October 1989. Over 85% of Russia's primary production is based on Soderberg technology implemented with Russian pot designs, equipment and materials. The Russian technology and equipment has proven reliable and capable of producing over 3 million tons of primary aluminum a year; however, little attention has been paid to metal quality and operational efficiency.

IRKAZ management sensed that there was an opportunity to improve its process by combining Western know-how and Russian technology. Discussions between IRKAZ management and Renova (an investment company which owns equity in IRKAZ) led to several trips to IRKAZ by foreign specialists. A project team evolved consisting of IRKAZ senior pot room personnel together with specialists from NATS and SibVAMI. The first step was to establish plant performance; from there, project priorities were developed and project execution begun.

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IRKAZ is located in the city of Shelekhov, about 20 kilometers outside Irkutsk. Irkutsk is a city of 650,000 people in southern Siberia, about 250 kilometers north of Mongolia. The plant is located in an area with abundant hydraulic resources, with Lake Baikal, the world's largest fresh water lake, about 80 kilometers to the east.

The smelter began operation in 1962 and has an annual capacity of 250,000 metric tons of aluminum which is produced in four pot lines. The oldest pot line operates at about 130,000 amperes; the other three pot lines operate at about 160,000 amperes.

During 1991, Russian aluminum smelters faced shortages of alumina, coke and pitch. IRKAZ was forced to take about 25% of its pots out of operation and operate with reduced anode material in the remaining pots. There were times during this period when alumina shortages threatened to curtail production. With the help of Renova, the plant was able to stabilize its process and begin bringing pots back into operation.

The first visit to IRKAZ by NATS specialists was in February 1992. At the time, several Western aluminum producers had visited the plant and were conducting feasibility studies for plant improvements. The results of these studies were typically elaborate and costly plans to retrofit the plant with pre-baked technology and / or plans to construct entirely new pot lines based on pre-baked technology. These proposals were not feasible due to high capital costs; they also ignored the value of the existing facilities. Based on this conclusion, the team focused on bringing the existing Soderberg operation up to the level of the best Soderberg plants in the world.

Data Collection - Operational Parameters

Solid data on the IRKAZ plant were not available during the early stages of the project. The NATS members of the project team suggested a methodology be adopted which started with data collection / analysis; from the data analysis, the team would develop project priorities. From the priorities, the team would then develop plans for project execution. Along the way, team members would work on standards and objectives of quality and efficiency. Development of standards has proved important because traditionally in Russia, definitions of quality and efficiency were handed down from a central authority. As a result, traditional definitions of quality and standards in Russia have little bearing on market realities. This methodology was adopted and the data collection process begun.

It was assumed the team would collect its own data where possible, and when not possible, audit data collected from other sources. There were some problems collecting this data including lack of standards and modern equipment at the plant. The team overcame these problems by importing equipment and experts and developing standards when necessary; the goal was not to find absolute numbers, but rather to establish a working approximation of the state of the plant.

The following table summarizes the data collected:

IRKAZ Baseline Data

Gas collection efficiency	50%	
Scrubber efficiency [4]	89-95%	
Average pot life	13,000	days
Anode paste production	130,000	tons per year
Paste factor	0.59	
Percentage of A7 metal [5]	45%	of production
DC kWh	16,800	per ton
Current efficiency	82%	
Bath Ratio	1.45	

The data indicated the plant had many opportunities for improvement; the following is a summary of the team's analysis:

- The gas collection / scrubbing problem had two elements:

    1. A worker hygiene component; better safety equipment was needed.
    2. A gas collection efficiency problem; this was a result of pot line instability and pot room practices.

The average pot life was shorter than it should be; examining the evidence, the two primary causes of short life were determined to be:

1. Pot startup procedures.
2. Sick pots resulting from pot line instability.

- The anode paste factor was higher than it should be; it was determined that there were three factors which contributed to this:

[4] There are two types of gas cleaning systems employed at IRKAZ; the range indicates the different performance characteristics between these systems.

[5] Metal which is 99.7% aluminum or better.

- Inconsistent raw material supply.

- Poor quality anode paste.

- Pot line instability.

- Anode paste production was less than required. The plant produces 250,000 tons of primary aluminum per year; with the high paste factor, the plant consumes about 160,000 tons of anode paste.

- The metal quality was lower than it should be; further analysis indicated that the reason for this was poor housekeeping, pot line instability and contaminates in the raw materials.

- The input consumption was higher than it should be (raw materials, electricity, labor and capital); the data indicated the primary reasons for this were pot line instability, high bath ratio and poor anodes.

From the data and analysis, the team concluded that the following areas were the critical factors to focus on to improve reduction performance:

1. Pot line stability.
2. Anode quality / quantity.
3. Bath chemistry.
4. Cathode life improvement.

These four elements became the **Areas of Focus.** The balance of the project has become focused on identifying enablers and implementing change to make improvements in these areas.

Execution of Process Changes / Technology Upgrade

The team decided to focus on one (1) pot line at a time during the execution stage; the team started with the oldest pot line (130 kA) in need of the most repairs. The team concluded that improvements would be dependent on implementation of both ***hardware upgrade*** (capital equipment) and ***software upgrade*** (work practices, pot room management procedures, etc.). While it was true that the plant needed investment in capital equipment, the team felt that the most pressing requirements fell into the category of software upgrade. A simple capital expenditure program without attention to the software issues would not yield positive results.

The following are examples of how the team approached two of the areas of focus (Low Bath ratio and Cathode Life improvement), integrating hardware upgrade and software upgrade:

Low Bath Ratio Area of Focus

Goal: Lower Bath Ratio from 1.45 to 1.12

Hardware

- X-ray diffractometer plus sample preparation equipment.
- Bath temperature measuring equipment.

Software

- Standards for x-ray diffractometer.
- Instruction / supervision on how to manage low ratio pots. Procedures developed by IRKAZ / NATS / SibVAMI team.
- Location of x-ray diffractometer and support equipment.
- Training in how to use x-ray diffractometer and sample preparation equipment.

Cathode Life Improvement Area of Focus

Goal: Increase cathode life from 1,300 days to 1,800 days

Hardware

- Cathode gas baking system.
- Collector bar pre-heating system.
- Introduction of alternate materials in cathode construction (silicon carbide bricks and cements).

Software

- New start-up and cut-in procedures developed by IRKAZ and NATS personnel.
- Visit to Western Soderberg plant by IRKAZ personnel to observe start-up procedures.
- New cathode construction procedures and quality assurance process developed by IRKAZ and NATS.

The team developed a series of similar plans to address each of the other areas of focus. The plans were not fixed, but were written in a series of protocols; adjustments to the plans were made as the team learned and gained experience during the implementation steps.

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Results

Progress has been slow compared to what would have been achieved in a Western aluminum plant; this is largely because the changes are major in scope and much of the new equipment must be brought from the West, not to mention language barriers and telecommunications problems. As in Western plants, time is required to gain buy-in of the changes; also, as in Western plants, experiments must be run to determine the best procedures given the local culture and traditional practices. Having said this, tangible results are being achieved.

To illustrate the progress, consider the low bath ratio area of focus. As mentioned above, an x-ray diffractometer with calcium fluorescence channel was installed along with support equipment including sample preparation equipment and modern thermocouples / thermometers for measuring bath temperature. New x-ray diffraction standards had to be developed for the IRKAZ electrolyte. (IRKAZ, like other Russian smelters, includes MgF in their bath). In addition, other software issues had to be addressed including pot room training and training to run the new equipment. Even the location of the diffractometer was considered critical. The team decided that the new analysis equipment should be placed in a laboratory closer to the pot rooms to enable better communication between operators and laboratory technicians; as a result, a new laboratory was built in a vacant space adjacent to the pot rooms.

In order to effectively reduce the bath ratio and make other changes in bath composition, procedures were developed to make the changes while maintaining control over the pot line. Steps taken included the following:

- Reduce the bath ratio on four (4) test pots from 1.45 to 1.25 over a two to four week period.
- Check the bath temperature daily on the four test pots.
- Sample the bath and test the bath ratio on the test pots every second day and make additions of AlF as required.
- Check frozen ledge and sludge on the test pots at least twice a week during the tests.
- Gradually reduce the MgF from 3.0% to 0% while gradually increasing the CaF from 3% to 5 - 6%.

After the initial four test pots, the number of test pots was increased to eight and later to 20 pots. The test was then rolled-out in one pot room and later yet to one potline. Today, one potline is operating at about 1.20 bath ratio.

The results from this test and the addition of the diffraction equipment have been positive. Bath ratio test frequency has been increased by a factor of six while the time required to test samples and give feedback to pot operators has been cut to less than 5% of what it was. Bath ratio test repeatability has increased and, as a result, the operators have been able to lower the bath ratio without losing control of the pot line. The results are summarized in the following table:

IRKAZ Bath Ratio Progress

	1992	1994	Goal
Bath ratio test frequency	2x/month	3x/week	> 3x/week
Feedback time	1 week	6 hours	3 hours
Test repeatability accuracy	+/- 20%	+/- 5%	+/- 1%
Bath ratio	1.45	1.20	1.12

The equipment and software have increased the frequency and quality of bath testing and shortened the feedback time to the pot operators, thus allowing the reduction of bath ratio on the pot line.

As mentioned above, the NATS program includes work on cathode life, paste quality and quantity and pot line stability / gas collection. Tests have been started with new equipment and procedures for pre-heating new cathodes and early pot operations. Tests are also being conducted and changes implemented to paste materials (coke and pitch). Work has begun to identify the changes which must be made to improve the anode paste quality through upgrade of equipment, raw materials and process procedures. New amperage metering equipment is also being installed along with pot room computer process control equipment to improve pot line stability. New safety equipment has been issued to pot operators, crane personnel and maintenance crews. While the results of some of this work will not be known for years (e.g. changes made toward improving cathode life), measurable improvements are being made. The current efficiency has increased by 4 percent, metal quality has improved and the paste factor has been reduced. The initial progress from these programs is summarized in the table below:

IRKAZ Operating Metrics Progress

	1992	1994	Goal
Current efficiency	79%	83%	89%
Metal quality [6]	45%	62%	90%
Paste Factor	0.60	0.58	0.54

[6] Percentage of total production that is 99.7% pure or better.

The numbers show both that improvement has been made and that there are substantial opportunities for further progress. More significantly, however, is that a process has been established which is focusing the organization's capabilities on continual improvement.

The long-term objective of the IRKAZ technology upgrade is an increase in production along with improved safety conditions, improved metal quality, lower emissions and lower input consumption. The potential for increased production brought about by the changes covered in this report along with increased current is over 50,000 metric tons of production annually, i.e., a 20% boost to capacity. The team thinks this objective is realistic and can be accomplished through the upgrade process.