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R&D Park: towards global leadership in precious metals.

Plenary session 1:

Cities, STPs and other areas of innovation: challenges and strategies

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R&D Park: towards global leadership in precious metals.

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Executive summary.

R&D Park is an infrastructure for technologies development and its transfer in the field of precious metals.

The Park was launched in March 2016 by Krastsvetmet, the Russia's biggest precious metals refinery in order to establish an open innovations platform allowing to foster technologies and new products developments.

Since its launch R&D Park has already done 4 acceleration programs (two programs were done in collaboration with Russian Venture Company, one - with regional business incubator and another one was run by ourselves), 7 projects reside in the Park and a lot of partnerships with universities, industrial companies, investors and startups were established. R&D Park has also developed several technologies for partnering precious metals companies enhancing the efficiency of their processes.

R&D Park is a good example of how a corporation can boost innovation activities in a particular city and region. We are very welcome startups, universities and industrial companies to collaborate.

Region Krasnoyarsk krai: from natural resources to high-end products.

Krasnoyarsk krai is the second largest federal territory in Russia with the area of 2.3 million sq.km. (approx. ¼ size of Canada and 13% of Russia's total area). However, the population of the region is only 2.8 million inhabitants representing 2% of Russia's total population.

Krasnoyarsk krai is very reach in natural resources. The region concentrates 80% of Russia's nickel, 75% of cobalt, 70% of copper, 16% of coal, 25% of gold, 20% of timber, 95% of platinum and platinum group metals.

Precious metals industry is one of the core industries of the region.

Strategy of scientific and technological development of Russia and strategy of Krasnoyarsk krai define transformation from resource economy to the economy of knowledge.

Krastsvetmet: from the leadership in refining to the leading diversified precious metals company.

Krastsvetmet strategy is perfectly aligned with Russia's and Krasnoyarsk krai's strategy, which implies diversification of its product line and new highly-marginal products development.

Krastsvetmet is one of the largest companies in Krasnoyarsk krai, the largest manufacturer of precious metals in Russia. It refines 97% of platinum group metals produced in Russia, 75% of gold and 60% of silver. The company is oriented towards new product development. The major objective of the company is launch of new highly marginal products.

To fulfil this objective the company started R&D Park, Russia's first infrastructure for technologies development and their transfer in the field of precious metals.

R&D Park – center for technology development and transfer in the field of precious metals in Krasnoyarsk krai and in Russia.

Physically R&D Park is a 6-floors building with 13 000 sq. of laboratories with access to the precious metals and more than 500 items of high-tech analytical and experimental equipment. Access to the precious metals means that a researcher may come to R&D Park and make experiments with precious metals. After the experiments, all the materials and waste produced may be send to the refinery. Thus, a researcher does not need to spend money for purchasing precious metals.

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Practically R&D Park is also an ecosystem for growing new products and technologies in the precious metals business. It does not mean that R&D Park focuses only on refining but it implies a wide range of industries including catalysis, medicine, powders, etc. R&D Park is also focused on ecological aspects of refining business.

It was founded in March 2016 and until now, it is developing rapidly. Its strategy implies that it will become a major technology development center specialised in the field of precious metals. It thus perfectly fulfils the strategical objectives of Krastsvetmet, region and country.

R&D Park's concept implies that there are four key types of partners: universities, industrial companies, startups and investors. Up to this moment partner relations were established with Moscow Institute of Steel and Alloys, Tomsk Polytechnic University, Siberian Federal University, Warsaw University, Moscow State University and etc. The ecosystem has also an access to funding provided by Russian Venture Company, federal and regional funds, as well as private investors. Currently there are around 300 projects developing precious metals based technologies in the pipeline. During the last two years, around 13 projects were funded and 7 projects are physically hosted in R&D Park. R&D Park also ran a startup development program in 2017. We got 72 applications and selected 6 projects for further development.

Practical case 1: participation in an accelerator organized by a third party.

In 2016-2017 we participated as an industrial partner in the federal accelerator called GenerationS. It is the largest start-up accelerator in Russia. It has been launched by Russian Venture Company since 2013. The accelerator includes several tracks, such as Metals&Mining, TechNet, FinTech, etc.

During the accelerator we collected 251 applications from start-ups and researchers.

As a result of our first year of participation we selected 11 projects and invited them to our site. We developed with them plans for collaboration and we were implementing these plans during 2017. However, by the end of the year we continued collaboration with only 3 companies due to the fact that the other projects did not pass practical product-market fit.

Key lessons that we learnt during this experience are the following:

1. Very few startups have really deep understanding of the markets they are working on. Most of startups are technology-driven, they have very deep experience in the technological part but do not deeply understand the marketing part.
2. It is extremely important to use reliable external experts for the new projects. We were looking for new products and thus for the markets that we do not really have experience on. Unfortunately for some of the projects we were not able to find suitable experts quickly and this resulted in not sufficiently efficient collaboration.
3. It is very important to understand the match of startup and corporate needs from both sides. We realized that the most important part of the program was the part when startups spend several days on our site. They examined the production process, talked to our experts and this experience was very useful in two ways. Firstly, this helped them to formulate an adequate and relevant proposition. Secondly, this motivated our employees and widened their experience.

Practical case 2: own startup development program.

In 2017 we ran our own startup development program. We were looking for startups developing their products in the fields related to precious metals. The program was structured in the following way:

- We gathered applications till October, 2017;
- We then analysed the applications based on technological and market criteria till November 2017;
- Based on the internal analysis we selected 6 startups and we invited them to our site and 20 startups we would like to continue further collaboration with;

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- In December 2017 we welcomed 6 startups at our site for a three-day visit. The first day we made a detailed excursion at the production site which gave them understanding of how everything operates in real life;
- We then appointed one technical expert and one economist to every startup in order to help them to formulate their proposal in more relevant way and to make financial calculations for the project.
- On the third day all six projects made their presentations to top-management of Krastsvetmet.

We also ran the GenerationS acceleration program for the second time in partnership with Russian Venture Company. This time we did not run the acceleration part of the program but rather used it as an additional source for new applications.

We compared the performance of our own program to Generation S program.

Program	Registrations	Applications	Applications passed screening	Selected applications
Startup development program	150	74	29	6
Generation S	222	165	25	n/a

We have not yet had data for the number of selected application in the Generation S program as we are still reviewing 25 projects passed screening stage.

But based on the data at the screening stage we may see that the conversion rate (number of applications successfully passed all the screenings divided by the total number of applications) of the Startup development program was 19%, while in the Generation S case the conversion rate was 11%. Thus, we may conclude that the relevance and quality of the projects was higher in the case of Startup development program.

Main lessons learnt:

- It looks like the fact that an industrial company runs a startup competition increases the quality of projects as we certainly had less marketing and projects sourcing capabilities than Russian Venture Company has.
- Visiting production site and having profound discussion with technical experts is very important for startups to tailor their proposition.
- Very serious devotion and motivation are needed from the company to run a short on-site program (to assure availability of experts and top-management).

Practical case 3: technology engineering as a part of R&D Park's activity

Besides running startup development programs and bringing innovative projects into life, a significant part of R&D Park's activity belongs to technology engineering. This is about servicing global precious metals industry with a technology expertise that comes from 75 years of Krastsvetmet operations. Engineering is an opportunity, granting an access to new overseas market that have not been reached yet by Krastsvetmet's products. Typically, these type of markets are closed or not viable for products due to country's legislation that favors and supports local manufacturing companies. A legislations boundary creates a pass forward for technology cooperation between such countries. This is a cooperation where companies do not have product competition on each other's markets and may engage into technology exchange effortlessly and beneficially.

Business model for technology engineering

Engineering work-frame involves three consequent steps where it is to identify common or specific issues within a certain technology's lifecycle, then find an appropriate solution and deliver it to the customer in a sound manner.

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At the first step, issues are spotted through networking events within industry's community or elaborated with an individual company, partnering with Krastsvetmet, at personalized approach. Networking events open possibilities for collaborative R&D studies. When a study is requested under a common issue by a group of companies, its results and intellectual property will be shared among group on a participation basis. Individual cooperation is born to create a joint close loop of technologies. Some parts of technology value chain are transferred to a partnering company in the other country to service industry on the joint markets with a distributed approach. This type of cooperation is only possible with companies who gained great confidence in Krastsvetmet's market and technology profile. It starts with technology audit of partnering company' facilities.

Therefore, the second step of frame-work can be distinguished in two general ways. The one is where technological solution is already at R&D Park's possession and can be transferred. The other incepts a R&D study to deliver new findings to a customer.

In the end, the closing step should accommodate a smooth technology transfer, adoption and integration of expertise to customer's brownfield or greenfield production. A set of instruments that come at hand here is building information modeling (BIM). BIM is an innovative way to management of facility's full lifecycle from its designing to maintenance.

First markets to target with engineering

The most demanding markets for a technology supply in precious metals industry come from countries with the most precious metals demand. Historically and traditionally, these are two country, China and India that a number one and two precious metals consuming countries, respectively. Moreover, China is the world's largest gold producing country with a booming economy for new precious metals applications. With regard to Indian, it corresponds for a notorious gold investment demand. The country accounts for more than 22 000 tons of gold above ground stocks that are jewelry and religion's articles. This is a significant amount of gold when comparing to a global annual gold production of 4 500 tons.

A technology engineering activity has resulting in a several customers successful stories that are listed below briefly.

Customers' successful stories

Story #1, effective solutions for rebellious material

Gold and silver refiner wanted to get new material in its pipeline, but traditional analytics and refining techniques failed to deliver expected results. Refiner struggled with new rebellious material, mostly gold Doré "contaminated" with iridium and osmium, suffering analytical failures and ineffective processing. New material samples were lab tested at R&D Park and solution for new analytical approach was elaborated and enhancement for processing techniques were proposed. Recommendations were adopted well at the refiner's site, giving a new business opportunity to process new material stream efficiently and be competitive on the market.

Story #2, process optimizer for spent industrial catalyst processing

Customer had 3 own parallel technologies for spent industrial catalyst processing with individual constrains and benefits and 2 complement sub-contractors for spent industrial catalyst (material) pretreatment. Allocation of incoming material streams were executed manually when considering following parameters: operational costs, lead-time and yields, equipment specifications, financing costs and even sub-contractor logistics. This way of decision making for every certain batch of material involved manual estimations with low precision level. R&D Park analyzed available technologies, digitizing its parameters (process chemistry, equipment specifications, operational parameter) into the automated application. Mathematical modeling tools were used as a core basis for application development. As a result effective feedstock allocation was carried out unmanned and effortlessly. Applications recorded production log, ran history analysis, generated production scenarios.

Story #3, localized organometallic catalyst production

Procuring from overseas catalyst manufacturers involved high shipping cost, customs duties and time delay. Also it gives no possibility to customize catalyst's properties freely. A customer inquired a

technology transfer to set up domestic organometallic catalyst production. R&D Park analyzed the catalytic process that was accommodated by existing imported catalyst and developed new organometallic catalyst with improved characteristics. As the result R&D Park transferred the technology to the local company. Local greenfield production was incepted and luckily the business was expanded with savings on shipping and customs duties. New catalyst with affordable price and increased efficiency was offered to market by our customer.

Story #4, substitution with alternative resources for competitive processing

R&D Park got a request from a customer to process spent industrial catalysts on-site. Commercially available smelting technology had on-site constrains: unstable electricity sources and its high cost. R&D Park conducted a study to develop a substitution for smelting – a hydrometallurgical technology which exploits site's available resources only. The developed technology was transferred to the local company successfully. Custom approach worked well within resources scarcity and limitations.

Lessons learnt:

- Technology engineering broadens company's range of services and grants an access to new global markets that have never been within a company's attainment beforehand. It brings companies to a next level of cooperation where collaborating parties gain competitive advantages against other market players, having a faster and robust technological development.

Practical case 4: successful development of new technologies.

In collaboration with a startup new equipment was developed in R&D Park. Starting from 2016 we ran a project on the development and manufacturing of a reaction apparatus for the process of liquid phase chlorination of materials and industrial products. The process of liquid phase chlorination is the first stage of refining of precious metals, which involves the introduction of gaseous chlorine into a hydrochloric acid solution with the material, in order to convert the platinum group metals and non-noble elements into a solution in the form of chloride complex compounds.

In 2014 as a result of a technological audit a task of optimization of the chlorination reactor appeared.

In 2015 in Krastsvetmet a model of the reactor for studying the hydrodynamics processes was created.

Based on the model created we understood that we have quite limited experience in the reactor equipment thus we started to search for external competences. As a result, in the first half of 2016 a new project on the development of a new layout of the reactor was initiated in the R&D Park. The scope of the project was very broad and included optimization of heating, cooling, reagent injection parts of the reactor. This is the moment when we started interacting with the start-up.

By the end of 2018 we concluded a contract with the start-up for the services of designing the layout scheme. The goal was to reduce the duration time of the process and increase of 1.5 times the lifetime of the mixing device. In 2017 – beginning 2018 a new reactor was designed and made. Pilot industrial tests were ran successfully. In 2018 we plan to ran the industrial implementation of the reactor.

This project is one of the examples of successful collaboration between an industrial company and a startup. This is also a good example when the R&D Park helped to find a startup and led all the collaboration. There is also possibility for external commercialization of the IP developed in the project. The commercialization phase will also be led by R&D Park.

Main lessons learnt:

- For an industrial company it is very important to use external resources and competences in order to broaden the scope of expertise;
- Industrial company may be a co-developer and a test facility for a new technology, which may be commercialized externally. We used this model for collaboration with startups several times and it proved its viability and efficiency.

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Practical case 5: influence on the region's innovation ecosystem.

R&D Park influences the regional ecosystem in several ways:

1. It is a customer for startups and researchers.
2. It is a provider of technological and marketing expertise.
3. Industrial partner of other institutions like universities, incubators, etc.
4. Provider of new startups.

As the former two bullet points were covered previously quite deeply we will focus here on the latter two points.

R&D Park established collaboration with many research institutes in Siberia (like Institute of solid state chemistry and mechanochemistry of the Russian academy of science with which we have a joint mechanochemical laboratory at R&D Park, Catalysis institute of the Russian academy of science, Siberian Federal University, etc). R&D Park participates as a partner at major innovations events in the region (like Innovative breakthrough, Startup tour, etc.).

The active searching position for innovative projects from R&D Park side forms strong demand for innovations in the region. This stimulates incubators and universities focus on the topics of our interest.

R&D Park also promotes intrapreneurship in Krastsvetmet. During the last year two projects were initiated as a result of this work. It is also a very important and useful job as it motivates employees for creativity and intrapreneurship. One of these projects was initiated by a researcher from our corporate R&D center, another one was initiated by a worker from the refinery division. It is although too early to talk about success of these projects but it is a work that need to be continued.

Lesson learnt:

- It is very important to build a system for growing new projects internally and externally. In most of cases we cannot find ready-to-invest projects on the market thus by constructing collaborations with universities and incubators, as well as other technology and science parks, it is possible to grow such projects on demand. Incubators may also be of very good help to incubate projects which were initiated internally in the company.

Why a technology park must be specialised in the field of precious metals?

Precious metals are widely used in large range of industries including catalysts, electronics, glass production, aerospace, energy, medicine, etc. They also have very specific techniques for extraction and refining. In the past decades we saw that the complexity of chemical compounds and applications involving precious metals increased dramatically. This requires new techniques for their treatments and new techniques for refining precious metals from new compounds.

Knowing global trends for precious metals applications and carrying out research and development according to them we make contribution to global development of precious metals based technologies.

Main results of two years of operation.

During the past two years R&D Park was equipped with more than 500 items of laboratory installations allowing to make different kinds of experiments and analysis.

We also launched 3 acceleration programs for the startups in the field of precious metals gathering from 70 to 220 applications from startups and universities. A pipeline of more than 300 projects was formed. Among these projects, we funded more than 10. We have 7 projects in different directions (ecology, powder metallurgy, mathematical modeling, hydrometallurgy, pyrometallurgy), which reside in R&D Park. We have developed two refinery technologies completely new for Krastsvetmet.

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Strong collaborations with universities were established. We launched a precious metals program in Siberian Federal University and more than 100 students visited R&D Park during this year. A joint program with Quantorium (science park for children) was also launched in 2017 and we are receiving around 30 children every month showing them laboratories and giving lectures on precious metals, thus popularising the industry.

Several partnerships with large industrial companies were established. According to them we developed several technologies increasing the processes efficiency in the partnering companies.

Conclusion: looking for new partners in precious metals based technologies.

Taking into account that substantial progress was done during the past two years there is still a lot to do. We are very welcome startups, universities and industrial companies to collaborate. We tend to be a global leader in precious metals based technologies and would like to establish strong partnerships internationally. If you have any ideas for collaboration we would be happy to discuss them.