

This issue of CRYOSTAR Magazine marks five years since I took on the role of President. It has been an exciting period of extraordinary growth for our company, and of course not without its challenges.

In this time period we have seen a significant decline in the market for LNG carriers, and CRYOSTAR has reacted by broadening its offering and changing the product mix — for example by extending our presence in the hydrocarbon market. At the same time we have taken on innovation challenges, such as the introduction of 6-stage compressors.

Our facilities have grown and adapted with our needs, and those of our customers. Our new world-class testing facilities are in constant use; there's more on p.10 about our tests on hydrocarbon turbines destined for Russia's great Amur Gas Processing Plant. Meanwhile our next investment is a €1.4m warehouse extension and upgrade to incorporate complete automation. As well as improved organization, this also has major health and safety benefits (for more details see p.8).

Of course it isn't just our buildings that have adapted. The past five years have also seen changes in terms of more recruitment, and a reorganization of our business unit struc-

The leadership challeng

ture to better reflect where we are today, and where we see ourselves in the future. Our implementation of the CRYOSTAR Academy builds on our existing thorough training practices to ensure that our staff are well versed in the soft skills necessary to succeed, as well as in their technical or specialist roles. Turn to p.9 for our article on the Academy.

Our Service offering has a major role to play as we go forward, supporting and complementing our position as a technology leader. Digitisation is another challenge, which we embrace.

I am extremely proud of our progress, and would like to thank all our employees for their talents and commitment. We have built something exceptional, together.

## Samuel Zouaghi **PRESIDENT**

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Samuel Zouaghi took on the role of President in 2013, and since then the pace of change in technology, markets and personnel, has been considerable. Here he reflects on leading CRYOSTAR through an exceptional period of growth, and on what the future may hold.

# In terms of leading CRYOSTAR, what went as planned and what came as a surprise during your first five years?

What met my expectations was the pleasure of leading a growing company with excellent prospects in expanding markets, that performs and engages the necessary resources. The pleasure of being surrounded by competent personnel, who are motivated and committed to the company: A company with the resources, latitude, and autonomy to be able to afford what we want to undertake.

I mentioned growth as an expectation, but the steep rate of growth came as a surprise. It was not easy, even as a 'good' problem, to manage the magnitude of growth we experienced in 2013 and 2014.

Next come all the technical challenges related to ongoing innovations, the 4-stage compressors, and then the 6-stage. In five years, we have launched two generations of LNG compressors. These ongoing innovations lead, from time to time, to technical issues. This is typical in highly innovative companies. Our customers judge a good partner to some extent by its ability to solve problems.

The market for LNG carriers declined by around 75%, leading us to compensate – particularly in terms of service, but also with new growth drivers in diversified markets. These include LNG as a fuel, LNG stations, and hydrocarbon turbines (a real challenge). These significantly change the CRYOSTAR "product mix". Notably, we have made a strategic move to established CRYOSTAR in the hydrocarbon market, offering CRYOSTAR the means to become a major player.

In the business and wider community, CRYOSTAR is a respected company which makes its voice heard and garners a lot of attention. I had not anticipated the scale of our reputation, which extends far beyond the three borders region where CRYOSTAR is based.

Despite several years of extensive preparation, the magnitude of personnel management was still higher than anticipated. It is time-consuming, but also brings great personal rewards.

#### What were the major challenges?

Growth has been a big challenge, as has the decline of LNG. Growing the business while also satisfying our shareholder can be tough, even though in our case, we have a good relationship.

The implementation of business unit (BU) organisation was a challenge that was already under way. We however had to take the painful decision to terminate the Clean Energy BU, and redistribute its activities between the Process and LNG BUs, with our main consideration being for the personnel concerned. But we do mourn this BU

for which we all, myself in particular, had great hopes. It failed; we did not find our place in this market for many reasons: low profitability, a very volatile market, and numerous competitors.

## What major management changes have you implemented?

In addition to the Clean Energy BU, the supply and procurement organisations have undergone major changes, and so will our computer system in the coming years. The evolution of the last five years has been organisational with the adaptation of our structure; and commercial with the conquest of new markets. Now and in the next five years, the real challenges will be digital. We will invest several million Euros in planned IT projects for product lifecycle management (PLM), customer relationship management (CRM), enterprise resource planning (ERP) finance or even global ERP, to improve ergonomics, and, consequently productivity.

## Over the past five years, CRYOSTAR continued to recruit. How does the next generation fit in?

We recruit not only young people, but all age groups, resulting in a mix with a staff average age of around 40 with ten years of seniority. In general, I feel no gap between younger and the older employees. Younger recruits bring fresh eyes and new methods (such as the use of collaborative 'chats' instead of email). Meanwhile we need to focus on steps to formalize knowledge capitalisation, even if our larger company size offers protection from knowledge loss.

In recruitment, mindset is even more important than skills, as it is the way we preserve our culture — selecting candidates whose values are in line with those of the company. The more we grow, the more we must prioritize our company culture — the major competitive advantage that the competition cannot copy.

#### How are newcomers trained?

We have a specific induction course customized for each new employee, but we go well beyond this with all the training available at the "CRYOSTAR Academy."

This is at the heart of the notion of knowledge capitalization, managed 100% by internal trainers who share their knowledge. This approach values the trainer and allows our staff to register, when they wish, for courses that are not just technical, but also on software or other subjects. Newcomers with specific knowledge can immediately share their skills.

## How do you remain flexible while growing so quickly?

Any company that is experiencing strong growth is exposed to a decrease in agility and flexibility, as it is obliged to implement operating systems through the application of procedures or processes which necessarily lead to a certain ossification of parts of the system. It's a daily challenge to balance having systems which allow teams to evolve in a defined and necessary framework, while ensuring that these

procedures and processes do
not endanger the agility
behind said growth.
Hence the need for
ongoing awareness,
and to stay tuned
to improvements
proposed by
teams.

Back in
December
2 0 1 2 ,
the LNG
market
segment
represented
60% of the
total New
Equipment
backlog. What

Today the LNG carrier market, including related service, represents about 30% of our activity. After a significant decline, of around 75%, this market shows signs of gradual renewal. The amplitude of the last cycle was such that it forced us to find other growth drivers elsewhere. Consequently, we managed the decline rather well, as overall profitability remained healthy, and it opened new horizons. One growth driver was developed around servicing, making it proactive and thus closer to our customers with, for ex-



ample, dedicated sales engineers within the Process BU offering reconditioning solutions for older equipment: purely a service offering to the customer.

Diversification does not necessarily mean moving away from our key markets, but targeting related markets. Thus for example, we move further along the LNG value chain with LNG vehicle fueling stations; or into the liquid hydrogen market; or into the oil and gas market with our expanders. It is the combination of these markets that, acts as the "shock absorber" if one of those markets falls.

## What about business centres?

We are established in India and Russia, and have expanded in Brazil. This coverage is relevant, even if other possibilities arise in terms of implementation, like in the Middle East, which promises great opportunities. In some countries, such as Russia, a local presence is a must, not only for service, but ultimately for assembly or production. Our business centers also play a key financial role, contributing positively to our results.

#### What are the major commercial successes?

Our 4-stage and 6-stage compressors for LNG carriers are a big success, as are hydrocarbon turbines for projects in the Middle East worth tens of millions of Euros over two years.

Other big orders include machines for the Yamal project: the Amur project in Siberia, for which we are supplying machines of 10MW, dedicated to the gas

## SOME OF OUR LATEST MAJOR INVESTMENTS

The world's largest liquid nitrogen test facility for cryogenic pumps € 7.5 million

Pressure test building (only one of its kind in Europe)

€ 2.5 million

Warehouse automation

€ 2.5 million

Smaller projects, e.g. related to safety

€ 2 - 3 million per year

Total, past 10 years

> € 50 million

In the future, if CRYOSTAR continues to grow at the same pace, we plan to enlarge our test stands, as well as our assembly halls.

pipeline between Russia and China; and over a hundred LNG vehicle fueling stations on all continents, along with some of the most modern industrial gas filling stations in the world in Australia, South Africa, and in Germany, where we are approaching full automation.

## CRYOSTAR wants to be a recognized technological leader. What are the latest developments?

Since I took office in 2013, technology has moved forward. Five years ago, we never imagined machines as big, as powerful and as complex as those we are manufacturing today. We have greatly expanded by seeking new resources, both human and material. Today's computer cores are extremely powerful processors, which can complete calculations in a few days that, until recently, would have taken weeks, or even months.

CRYOSTAR's primary purpose is positioning itself either as a technological leader, or as a commercial leader, but it often assumes both roles. We aim to continue to be recognised as the primary source of innovation in our markets, as a pioneer. We are not, and never will be, in the so called "low cost" segment.

We continue to offer novelty, for example, the neo – VP pumps, a complete revision of the legendary VP pump, the "Subtran" pump for LNG applications, with a new range of submerged motor pumps, distinct from those we marketed at the end of the 1990s. There have been many firsts in LNG, with the 4- and 6-stage compressors, and in hydrocarbon machines where we are in constant innovation mode.

In addition to sustained R&D activity, there is a lot of project development at CRYOSTAR. With very few people who solely do R&D, the vast majority are also involved in projects, in constant contact with the market and customers. Meeting project deadlines accelerates development, improving our "time to market".

### What about Quality?

If we compare generated non-quality to the complex-

ity of products, we have greatly improved. The hours/ratio of non-quality has continued to decrease over four years, similarly for the cases of non-quality related to the machine design and due to suppliers. Our indicators show an improvement in quality performance and our efforts continue unabated, through, amongst others, six-sigma methodology.

#### Let's talk Safety

It is important to underline that the majority of our training budget is for safety (35%). But, safety is first and foremost a mindset, including exemplary behaviour every day. We use a programme I believe in, called Behaviour Based Safety (BBS). Based on mutual observation, employees are on the lookout to alert colleagues to dangerous situations, and suggest solutions.

## Is there anything you would have done differently?

For me progress is the result of permanent reassement. Decisions can and should be adjusted when necessary, be they strategic, operational or human, to stay agile. The ultimate goal is to inspire our teams, which are our primary performance driver.

## How do you see CRYOSTAR five years from now?

In my vision of CRYOSTAR in five years, service plays a major role, through a successful predictive maintenance offering, alongside the development and sale of top range sophisticated equipment. Digitisation is translated into concrete projects that have significantly improved staff working conditions. I hope we continue to live up to our golden reputation.



# **CRYOST**AR

## **★ DISTRIBUTION NORTH AMERICA**



At the end of 2017, CRYOSTAR's Distribution Business Unit decided to further its development by creating a new company, CRYOSTAR Distribution North America, to serve its distribution business in the region.

In a move to better serve its customers, CRYOSTAR decided to further refine its Distribution Business Unit in North America. This organizational change was officially launched at the beginning of October 2017. The Gases and Welding Distributors Association (GAWDA) annual convention, hosted in New York around this time, was a great opportunity to start informing our customers and communicating with them about this.

This approach includes the set up of a new company by a new CRYOSTAR distributor partner, Richard Young. The sole mission of this new company, named CRYOSTAR Distribution North America (CRYOSTAR DNA) is to enhance customer service, sales and repairs of cryogenic distribution pumps to the industrial gas and enhanced oil recovery markets in the North America region (United States, Canada and Mexico).

CRYOSTAR DNA will utilize and will rely on the four existing CRYOSTAR service locations in the United States (Whittier CA, Bethlehem PA, Houston TX, and Aurora IL) to provide new equipment, spare parts and regional service.

CRYOSTAR DNA will progressively take over all sales

and customer service activities related to industrial gas distribution pumps, which are mainly dedicated to bulk and logistics applications, as well as packaged gases.

Richard Young will lead CRYOSTAR DNA. He is based in Henderson, NV. At the kick off in October 2017, he commented, "I'm excited to be working with CRYOSTAR and their US team to continue their mission. Our goal is to add value to CRYOSTAR's brand by improving customer relationships and responding to their needs."

Samuel Zouaghi, President of CRYOSTAR SAS, added, "The industrial gas market is the foundation of our success. The refinement of our Distribution Business Unit in North America and the creation of CRYOSTAR DNA put the focus where it needs to be, and we are pleased to partner with Mr. Young and utilize his experience in the industry and focus on customer service and sales. We are confident customers are going to like this change."

Several months on, as we followed up with our customers in the Distribution business we learned that they appreciate this change as they increasingly now work with CRYOSTAR DNA.

## Smart storage arrives at CRYOSTAR's warehouse



CRYOSTAR always aims for excellence in its products, skills and working conditions. And warehousing and logistics are no exception. That's why the company decided at the end of 2015 to invest €1.4 M in improving its warehouse in Hésingue, France. The current layout, flows and organization were no longer in tune with the requirements induced by continuously growing and developing activities, along with the constant need to upgrade performance in order to stay competitive and maintain our business lead.

Our investigations focused on three main targets. First of all, how could we provide the best possible safety conditions for our warehouse employees to stay fit and healthy? Then, how to improve internal and external flows of the goods we are carry, store, prepare, and get the most effective layout? Finally, what are the options to optimize our storage capacity and consequently to minimize the need for expensive external storage solutions.

To meet these challenges, the project took two directions:

- The extension of the warehouse itself.
- The re-organization of storage methods and related flows.

As constructing a new building was impossible, the only way to reach the target was to extend the current warehouse at the front and back. This increased the warehouse footprint by 35%, adding 450m². This space is almost exclusively destined to become working areas with minimal

interaction between workers and storage devices or forklifts, thus improving safety conditions.

### **GOING WITH THE FLOW**

Meanwhile, we brainstormed how to optimize our storage conditions. Automated equipment seemed to be the most suitable solution to fix our problem of non-optimized storage capacity and unsatisfactory organizational flows.

We considered many options, carrying out studies and comparisons. To strengthen our confidence that we were moving towards the right solution, we also travelled to various sites to see the machines running in real conditions and get user feedback.

We finally chose to invest in a "Miniload", a piece of equipment quite close to our existing storage racks but completely automated thanks to a robot stacker transporter which operates all in and out racking movements.

Thanks to the new system we will be able to store 1772 pallets on 18 layers, and will be capable of handling 180 pallets per hour. This device is equipped with four inbound trays, two outbound conveyors and lifting tools on each workstation.

As a consequence, most of the picking operations currently done with non-adapted lifters by the warehouse staff will be handled by the machine itself, reducing the risks of back problems and similar injuries.



Human capital, encompassing soft skills, expertise, and commitment, is the primary lever of performance for CRYOSTAR, where we create an environment that offers the challenge of continuous skills and knowledge development

This environment is reflected starting from the recruitment phase, with the company involved in targeted actions, such as job fairs in the region, job days or educational outreach, like our recent interaction with the Nancy engineering school, École Nationale Supérieure d'Électricité et de Mécanique (ENSEM).

We pay particular attention to job interviews: indeed, it is not only the technical profile of the candidate that is explored, but also their soft skills must be aligned with CRYOSTAR's corporate culture and values.

CRYOSTAR then offers a personalized induction course, which includes support adapted to each new employee. This course concerns the job itself, and integrates a tour of the workshops, to provide practical knowledge of products and practices, and to strengthen links with interlocutors, which has the added benefit further down the line of helping to foster smoothly-run projects.

In this integration phase, and later on, communication with employees plays a key role. All newcomers participate in a breakfast with the President and the Director of Human Resources, during which they receive a friendly introduction to CRYOSTAR history, its markets, its products, its direction, etc. This direct communication approach also encompasses breakfast meetings with the Executive Committee, a mid-year meeting and an annual convention, which all employees attend.

With its ambitious training plan, CRYOSTAR is convinced that corporate training is strategic and that the ability

to learn is a key differentiating factor in obtaining a competitive advantage. To optimise and capitalize upon internal skills, the company has implemented a "CRYOSTAR Academy," which aims to train and address different subjects and/or various fields. This training is given not only by our own specialists and technical advisors, but also more widely by any employee who has relevant expertise or competence to share, on a voluntary basis to benefit everyone.

The purpose of CRYOSTAR Academy is to:

- Facilitate learning,
- Master and deepen areas of competence,
- Share, transmit and secure scarce resources,
- Create an educational toolbox
- · Formalise specific training actions,
- Encourage the sharing of best practices and operational experience,
- Enhance trainers' know-how
- Evaluate trainer performance.

Training sessions cover all company disciplines, in particular management, legal aspects, commercial contracts, embargoes, after-sales, courses on our various products, health, safety, environment and quality (SHEQ), testing, the fundamentals of cryogenics, and expert know-how (e.g. aerodynamics, magnetic bearings). Safety represents 37% of the 2017 training budget and is the most studied topic, covered in 50% of all training courses.

Every year more than 80% of staff take at least one training course, and all staff will have received training within a period of three years. Additionally, CRYOSTAR offers apprenticeship opportunities, ranging from graduation up to the graduation +5 level. For CRYOSTAR, training its human capital is a major advantage, ensuring the company's continued competitiveness, dynamism and innovative spirit.

# AMUR TURBINES

# put to the test

In 2017, CRYOSTAR completed an especially thorough test sequence for the five hydrocarbon turbines destined for the Amur Gas Processing Plant (Amur GPP), the largest plant of its kind in Russia.

## **TG500 TEST SEQUENCE**

The tests involved two units, with each unit consisting of two expander/gearbox units (HP + LP), model TG 500, installed on two separate skids, each with its own dedicated lube oil system and integral gearbox. The cold power of HP turbine is 6.4MW (7.1MW in maximum case).

For optimal use of the test facility, our operators tested the HP and LP machines in parallel. The test sequence of the first unit was:

- Oil system flushing
- Seal gas system flushing
- Axial load (thrust) test
- Functional test of oil system
- Mechanical running test (for each primary and spare high speed rotor)
- Performance test (seven guarantee points)
- Seal gas heater control test (for one machine only)
- Gas leak test.

#### **AXIAL THRUST TEST**

Among the AMUR GPP project's unique challenges was a specific axial thrust test, which we carried out for the first time on TG machines. The high outlet pressures cause a load of several tonnes on the



axial bearing tilting pads. The test simulates the onsite axial thrust load during start-up and in steady state conditions.

The Method Department designed a unique test installation. The casings were pressurized with nitrogen to:

- 44 barg (HP)
- 30.3 barg (LP).

A 2MW motor rotated the turbine shaft, and the tandem dry gas seal was in operation.

Our gearbox vendor, Flender, was present, and the bearing vendor, John Crane, monitored the load continuously with strain gauges. The test was successful, evidenced by the good state of the bearings.

#### **MTC TEST SEQUENCE**

The fifth machine is a turbo-expander compressor unit equipped with active magnetic bearings (MTC300/110).

As usual with CRYOSTAR, we carried out mechanical running tests (MRT) and performance tests. But there

were also many project-specific items:

- Poverka calibration of major equipment
- Seven guaranteed points for both the expander and the compressor
- Use of a compressor dummy wheel and diffusor for expander performance test
- Dynamic tunings in each configuration (main/spare/dummy)
- Full unit test
- Landing test (also called delevitation).

#### A SUCCESSFUL COMPLETION

In parallel, the Control Systems Team carried out factory acceptance testing (FAT & I-FAT) of all unit control panels (UCP) and transmission control protocols (TCP). During this complex test sequence, the flexibility and the commitment of the CRYOSTAR staff (Test, Production, Method, Engineering, D&D, Quality, Supply Chain, Logistics and Project teams) resulted in the full validation of the machines within the given timeframe. Thanks to their professionalism, this set of expanders is now ready for installation and start-up in Russia.



## Renewed success with Petrofac

Petrofac has recently awarded Cryostar two new projects, both of which involve magnetic bearing expander compressors for oil and gas applications. These Cryostar expanders will be installed in Oman, in the Salalah LPG extraction plant and in the Khazzan gas treatment plant.

The new machines belong to the MTC600/240 frame size, further emphasising the success of this best-selling product. All machines supplied to Petrofac incorporate magnetic bearings from SKF, benefiting from this technology's extremely high reliability.

These projects are the eighth and ninth in a long history between Cryostar and Petrofac, based on an ongoing mutual understanding and a shared desire to face challenges together. Cryostar's teams are committed to carrying out these new projects to satisfy the high standards expected by Petrofac, BP and Salalah LPG.

## LNG Transport & Terminals Business Unit

CRYOSTAR saw an excellent start in 2018 for the LNG Transport & Terminals Business Unit, with a contract signed with Korean Shipyard HYUNDAI HEAVY INDUSTRIES to provide compressors and accessories for a total of five LNG ships, plus a number of options. All of these ships have XDF propulsion.

This order confirms the "revival" of the LNG ship market, which suffered a slowdown during 2017.



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