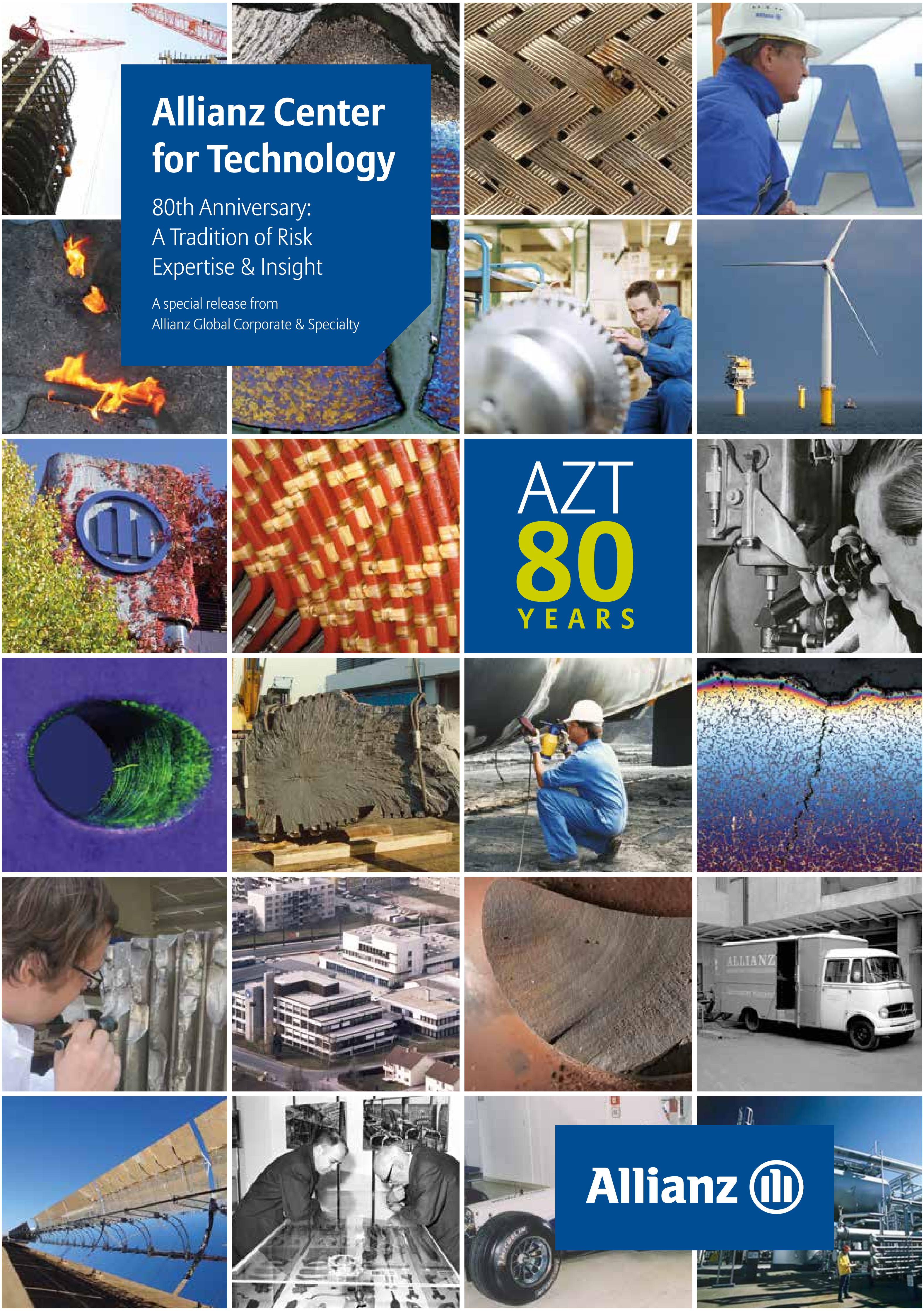
# Allianz Center for Technology

## 80th Anniversary: A Tradition of Risk Expertise & Insight

A special release from
Allianz Global Corporate & Specialty



AZT
80
YEARS

Allianz

The Allianz Center for Technology (AZT) celebrates its 80th anniversary in 2012. For eight decades, the AZT has served as the Allianz specialist unit for risk, safety, technology and sustainable development. The role of the AZT in providing independent technical assistance in claims and loss prevention is unique in the insurance world due to the scope of services provided. The work of the Center focuses on improving technical and operational safety, assessing technical and new technology risks, and analysis of damage and the causes of fire.

This publication reviews the Center's research today and over the last 80 years, and looks forward to some of the future challenges which the AZT and its clients may face.

# Foreword

Just five short years ago, Allianz celebrated the 75th anniversary of the Allianz Center for Technology ("Allianz Zentrum für Technik" or AZT), by releasing its report *75 Years of AZT: Damage research in a historical perspective*. This report provided an in-depth chronology of the AZT and showcased some of its groundbreaking cases.

Independent and impartial, and a unique institute in the insurance sector, the AZT helps clients assess and prevent losses through meticulous damage research and guides them in their management of industrial safety operations. Such expert services have helped shape the way Allianz does business and have added a value to our company and to clients that goes beyond numbers. In short, the AZT is a center of excellence for risk research, and a significant contributor to risk reduction for clients and for Allianz alike.

Much has happened in the past five years. Today, the AZT serves as the lead consulting and research institute to Allianz Global Corporate & Specialty (AGCS), and is a key element in making AGCS a trusted partner for many leading industrial clients.

In 2012, we once again recognize the invaluable work of the AZT. In its remarkable 80 years of service, the AZT has provided a wide range of expert research and analyses for clients and for Allianz. To mark this special occasion, we present this new publication, which takes a closer look at the role the center plays today and at some of the opportunities and challenges that lie ahead in the world of industrial risk.

Along the way, you will hear from several AZT clients and collaborators who provide an in-depth look at how the center operates. You'll also read about various topics in the field of energy technology, as presented by Allianz experts. Our 80th anniversary publication will take you on an illustrated and graphical journey of AZT case studies, historical highlights and the people who are at the very heart of the center.

This collection of stories, images and insight serves to shine a light on a special part of the Allianz family. By doing so, we not only recognize the contribution of AZT to industrial management of more than 80 years, but also the dedication of all the hard-working AZT employees, past and present, who we hereby gratefully acknowledge.

**Axel Theis**
Chief Executive Officer
Allianz Global Corporate & Specialty AG

*Munich – November 2012*

# Introduction

The industrial arm of the Allianz Center for Technology (AZT) was fully integrated into Allianz Risk Consulting (ARC) only five years ago. In many ways, ARC was always the logical home for the center – something that has become more and more apparent through the symbiotic collaboration between ARC, AGCS claims services and AZT.

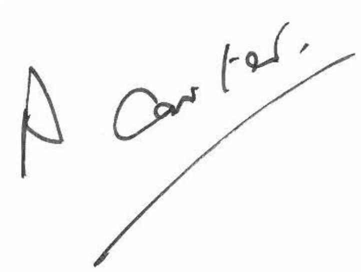
The AZT still has its main laboratory just outside of Munich, though its core team is now based at the headquarters of AGCS. This set-up allows the center's experts to directly engage with our ARC risk engineers, claims specialists and clients, thereby offering an effective and efficient service that is directly customer focused.

But just how exactly does ARC deliver such an added-value package? One particular example that is of special significance to both our clients and to Allianz is our bi-annual AZT 'Expert Days.' This popular event showcases the true insight and expertise of our damage analysis and loss prevention team, and brings together other experts from industry, commerce and science to tackle current technological challenges and trends.

AZT experts also produce a steady output of white papers, fact sheets and case studies that serve to inform clients, underwriters and the general insurance industry about current issues. One example of such expertise is our technical catalog for offshore wind turbines, a subject you can read more about in this publication. The catalog outlines various recommendations that serve as a basis for the assessment of offshore systems.

The center's reputation for its uncompromising approach to research quality is well known. Our clients will often insist to have our experts actively involved on-site for both damage analysis and loss prevention consultation. Everything we do in our business is based on having a strong relationship with the client. This is where the AZT's long-standing history, through its extensive lessons learned and its years of claims and loss investigations, contributes an invaluable service.

In its 80-year history, the center has continually set benchmarks in making technology safer and more efficient. As innovation and ingenuity continue to develop new and complex technologies, you can be assured our experts will be at the forefront tackling these exciting challenges.



**Paul Carter**
Global Head - Allianz Risk Consulting
Allianz Global Corporate & Specialty AG

*Munich – November 2012*

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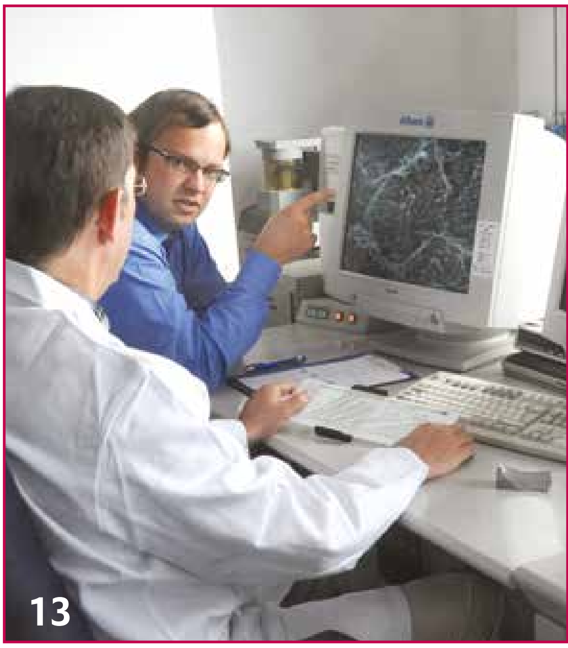

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# Allianz Center for Technology
## 80 Years of AZT

### 1920s: The origins of AZT
Damage research was already an integral part of the Allianz machinery insurance business, long before the Allianz Center for Technology (Allianz Zentrum für Technik, or AZT) was established. In the 1920s, following the first World War and the struggles of hyperinflation, German industrial equipment was in poor shape. Accidents were on the rise and costs for insurance companies were mounting. Allianz began to put together a team of experts to investigate damage causes and work to prevent losses in the future.

### 1932: Establishing an institute
It was in Berlin in 1932 that Allianz set up the predecessor to AZT, the materials testing center, which focused on analyzing materials for strength and carrying out metallographic experiments. The center also worked on investigations with research institutes, establishing a tradition of cooperation with specialists that continues today. The center's reputation grew rapidly. Large external orders were taken on, including the analysis of the propulsion engine of the Hindenburg airship.

### 1937: A new location
As both volume and technical demands of the center's work increased, it soon became necessary to move into new facilities. In 1937, a center was built on the outskirts of Berlin, where up to 17 people could work, depending on the workload. They handled 470 cases a year, benefiting from a booming domestic materials sector.

1920 1925 1930 1935 1940 1945 1950 1955

### 1945: Recovery after the war
The facility survived World War II largely intact, and the testing center resumed operations in 1945. Work centered around two areas in particular: Power plant technology, specifically the analysis of turbines and steam generators, and corrosion problems on pipes, steam boilers and turbines.

### Late 1950s: Business booming again
Growth in the German machinery, chemical and automotive construction sectors in the late 1950s led to an influx of new demands for the materials testing center. Limited space was proving difficult, as was the almost 600-km distance to Allianz headquarters in Munich. Initially, a small office was set up in Munich in 1956, before work began four years later after relocating the entire testing center to the Munich area.

### 1960s: Settling and expanding in Munich

The testing institute in Ismaning, just north of Munich, opened in 1962. Its analysts became mobile, carrying out off-site evaluations of turbines, boilers and engines. An array of new, cutting-edge equipment was purchased, including one of the first scanning electron microscopes in Germany, cementing the center's reputation as a leading authority in the analysis of material breakages.

### 2000 up to today

A logical step was to expand the field of work to non-technical issues, such as losses caused by organizational failures, sustainability and Nat Cat risks.

Today, this is further developed within AGCS itself, whereas AZT serves as carrier for unbundled business; that is, all technical pre- and post-loss services that are not covered by AGCS insurance premiums.

Adapting the setup to a profitable business unit and enabling an intensified backflow of lessons learned by setting up respective processes into AGCS Risk Consulting, AZT has kept its core know-how and established a broad network of experts, thereby extending the capabilities and possibilities; a necessity in an environment of fast progressing technical developments and challenges.

Beyond, AZT's priority is to offer technical services to clients globally via the AGCS global network of pre-loss engineers and international claims entities. The basic idea of understanding and preventing losses for the sake of the insured and insurance sector has remained unexplored, but has proven to be a topic of interest for 80 years.

1960 1965 1970 1975 1980 1985 1990 1995 2000 up to today

### 1969: Allianz Center for Technology is created

By 1969, 65 people were on staff in Ismaning. Allianz decided to create a new subsidiary, transferring the materials analysis division to the "Allianz Zentrum für Technik GmbH". The new center was responsible for coordinating all Allianz activities in damage research and loss prevention, concentrating technical services under one roof.

AZT developed into an institution for damage investigation that focused on the power industry and general machinery with the reputation for objectivity and trustworthiness.

Interdisciplinary work was further enhanced by supplementing material, chemical lab and nondestructive testing, with machinery diagnostics and finite element engineers.

# **Troubleshooting** 101

A glimpse inside the world of a damage analysis expert.

**Dr. Johannes Stoiber and Stefan Thumm**, Co-Heads of the Allianz Center for Technology (AZT), know exactly the type of qualities to look for in someone who wants to work on their team. "Our damage experts are true specialists in their fields. Because we work on damages at technical facilities, we tend to concentrate on technical disciplines. An ideal candidate is someone with hands-on experience in the industry. It makes our work a lot easier if someone is already familiar with the processes we deal with," says Stoiber, who himself has a degree in engineering.

Stefan Thumm and Dr. Johannes Stoiber head the Allianz Center for Technology

Though technical knowledge isn't the only prerequisite. "Soft skills," as they're referred to in the management world, are also an important component. "Damage experts need to be able to communicate well and have the ability to work within a team to pinpoint solutions for clients. Intuition, empathy and a healthy dose of inquisitiveness are also vital. When our experts need to analyze damage on-site, it's not unlike detective work. They need to find out why the damage happened and, therefore, ask the right people the right questions," says Stoiber.

"Diagnosing technical problems is becoming simpler. Nowadays, we have far more resources and possibilities for analysis than we did 10 or 20 years ago," says Stefan Thumm, who co-heads the AZT with Stoiber. "Nevertheless, the practical experience gathered by a technician over the years, while 'learning on the job,' so to speak, is invaluable."

## On the lookout for evidence

Another requirement to be an AZT expert is the willingness to travel regularly. The Munich-based AZT damage team is often dispatched to locations within Europe and beyond. Even with an arsenal of cutting-edge communication technology, on-site damage inspection is irreplaceable when it comes to detailed analyses. "This is the only way we are able to get the real picture," says Arne Bohl, an expert for non-destructive testing and quality assurance.

A sharp eye for detail is a must for AZT damage experts.

The damage event is the "moment of truth" for any insurer. Here, the company fulfills its promise to the client: rapid, uncomplicated support and assistance, both in practical and financial terms. On-site analysis and timely damage clarification – a service the client expects – is simply part of the job for the AZT team. Particularly in Germany, the AZT has long played a clear and undisputed role in the damage assessment process. And now, its services are also being increasingly requested by international Allianz claims management teams.

Once an AGCS claims management team reports a new damage to the AZT, the goal is to reach the scene as quickly as possible. "It's absolutely vital that we approach every damage event as impartially and openly as possible, so that we are in a position to carry out a neutral analysis," explains Thumm. "We have to be able to assess and define a variety of different aspects. What has been damaged? What still works? What needs to be repaired? What can be replaced?"

This is where damage experts turn into detectives. At the site of the damage, the experts must ask questions about the operation of the device, the maintenance as well as the design and manufacturing, closely examine the damage and take photos of every detail. They must gather as much information as possible to work out the cause of the damage and provide recommendations on loss prevention. That's all a part of the damage assessment process.

Then, it's back to the AZT laboratory in Zorneding, near Munich, which the AZT shares with its partner, the Organization for Materials Testing ("Gesellschaft für Werkstoffprüfung" or "GWP"). This is where most of the damaged components – such as turbine parts and gear wheels – are delivered for analysis. Analysis processes include material tests, chemical analyses and microscopic inspections. The laboratory equipment enables for a wide range of inspections to be carried out, including residual stress tests, scanning electron microscopy and phased array ultrasonic tests.

Not your average job: The work of a damage analyst can often take him to unexpected places.

Test and inspection results are documented down to the very last detail in a damage report. In Germany, these damage reports are admissible as evidence in court and serve to clarify the cause of the damage, helping the damage management department handle the claim with the client.

## Damage becomes knowledge

The work doesn't end there, however, for an AZT damage expert. Learning from losses is the credo, which is embraced by every single AZT expert. Furthermore, the valuable insight and knowledge gained from analyzing damage must be passed on to clients and, indeed, to the industry as a whole.

Research and testing results are applied to damage prevention and optimum risk management for the industry. The exchange of technical knowledge and ideas between AZT and AGCS risk consultants plays a significant role. The job of a risk consultant is to find the best possible solutions to managing, controlling and reducing risks. AZT shares its valuable knowledge to support risk engineering and underwriting in customer service and consultancy.

AZT experts also enjoy great popularity as speakers at specialist conferences and congresses that focus on risk management, analysis and troubleshooting involving state of the art and new technology. The experts in Munich are also valuable resources for the review of prototype development. "Through our cooperation with industry in the development and assessment of prototypes, we are able to derive any risks that are posed and, therefore, make them insurable," says Stefan Thumm. "For our company, this foresighted inspection work was a logical next step after damage analysis and the 'lessons learned' process."

The AZT played a key role in the risk assessment of the famed Allianz Arena in Munich.

One notable example of such preventative inspection occurred within the renewable energy sector. In the 1990s, an unparalleled series of damage events at wind turbines caused by manufacturing defects resulted in the uninsurability of such technology, on account of the high damage rate. AZT created a list of criteria for wind turbines that outlined requirements for early warning systems – known as condition monitoring systems. These criteria resulted in a significant decrease in damage events. To the relief of many in the industry, turbines once again became insurable. (Read more about condition monitoring on page 34)

## Think global, act local

The AZT has been the first choice for risk management, damage research and damage analysis in Germany for more than 80 years. But, as industry and risks have changed over the years, so has the AZT and its services.

So, what lies ahead? The team at the AZT expects to see a significant increase in international damage events and, just like AGCS – which the AZT has been a part of since 2007 – the center wants to increase its level of activity not only in mature markets, but also in emerging markets, such as Brazil and those in Asia and Eastern Europe.

A considerable demand for technologies related to power supply, including alternative energy, exists in these markets. Consequentially, the wealth of expertise and experience of the AZT and AGCS is a necessity as these markets emerge.

# Interviews with **AZT Business Partners**

## "We trust what AZT delivers"

Markus Montigny, Cunningham Lindsey

**Markus Montigny** is Managing Director at Cunningham Lindsey, one of the world's largest loss adjusting and claim management companies, with 7,000 employees in more than 60 countries.

*Can you describe the work you do together with AZT?*

We work together on claims in the industrial sector. As a loss adjustor, Cunningham Lindsey is appointed by an insurance company to handle a claim. Personally, I mainly work in the utilities and power generation sector – on gas and wind turbines. We visit the site to discuss and analyze the claim with the parties involved, which often involves broken pipes and damaged turbines. If we find that the cause of the damage is unclear, then that's when we call in AZT to investigate the parts in question. The center has a very strong reputation for material investigation and its expertise can be vital for complicated and technically demanding claims.

*Is this work just in Germany, or on a global scale?*

It's worldwide. At the moment, we are working together on cases in both Turkey and Brazil, for example. Geographically, our focus has become more widespread in recent years as machinery breakdown insurance has changed in Germany: until around 10 years ago, large utilities could insure their equipment with a very low deductible, resulting in a high number of claims. Now, these deductibles are higher, reducing the business in Germany and increasing the focus on cases around the world.

*Can you describe one or two recent cases that you have worked on with AZT?*

A couple of years ago, we had a case at a hydro power plant with a fairly complex generator system, which failed during the commissioning phase. It wasn't immediately clear what the reason was. There was one policy in place that only covered on-site losses, while another covered all losses caused in the factory during assembly or manufacturing. Both insurers said the claim didn't fall under their respective policy, so we called in AZT to carry out an investigation. After a short circuit, which had happened in this case, establishing the cause of the issue is often very difficult as the problem area is usually damaged; it required a real in-depth investigation. Ultimately, AZT was able to ascertain that, in all likelihood, faulty assembly had been the cause.

*So, you are heavily reliant on the accuracy of the reports delivered?*

Absolutely. We check the reports as well, of course, but ultimately we have to trust what AZT delivers. For me, the most important thing is that I understand the report, so that I can then translate it into a language that someone from the insurance side understands. This is a real advantage of working with AZT: The connection to Allianz means that they know what the insurer needs and this helps them stand out in comparison with other research companies. It can save an enormous amount of time.

AZT has collaborated with Cunningham Lindsey on various cases, e.g. on issues with combined cycle power plants.

*What other advantages are there of working together with AZT?*

There's a definite geographical advantage – the fact that our offices are only 30 minutes apart is a plus. It means that I can easily discuss reports in person with the staff at AZT – sometimes even cases that AZT is not involved in itself. Because we have a good relationship, I can call in to ask their opinion on a certain section of a report, or show them a damaged part for a quick cross-check.

*How is AZT viewed within the industry?*

Most of the insurers in Germany know AZT and the center has a very good reputation. The association with Allianz can occasionally be problematic, though. Obviously, if Allianz itself is involved as an insurer in a case, then we are unlikely to call in AZT to help. In addition, I also had a case recently in which I suggested involving AZT, but the insurer involved declined. Although they knew and respected AZT, they had several other ongoing cases with Allianz and didn't want to involve the center.

*What are the main challenges you face in your work?*

Our main challenge is to deliver results in a limited time period. The time frame to carry out the on-site analysis is usually pretty short as standstills can be extremely expensive. On the other hand, in-depth investigations take time. It's my job to negotiate with the parties involved and ensure the process runs smoothly.

*How do you see your working relationship with AZT developing in the future?*

I hope that we can expand into new areas of work. We are seeing more claims in the renewable energy sector, such as gearboxes on wind turbines. I would also like to involve AZT in more cases internationally. One of the challenges here, though, is that most people don't recognize that AZT is independent. It's not really an issue in Germany anymore, but it will take time to change this in other countries. Of course, my colleagues have their own local experts, but I believe that many of them could benefit from the experience and the expertise that AZT has to offer.

# "It's a win-win situation!"

Dr. Julius Nickl, Organization for Materials Testing

**Dr. Julius Nickl** is Managing Director of the Organization for Materials Testing (Gesellschaft für Werkstoffprüfung, or GWP). The damage analysis company has a history of close cooperation with AZT and, since 2008, the two have shared GWP's laboratory and testing facilities just outside of Munich. We talked to both Nickl and Dr. Johannes Stoiber, Co-Head of AZT, about the partnership.

*Dr. Nickl, tell us how the partnership with AZT came about.*
**Nickl:** We had been working in similar fields for some time. The Allianz board of management asked AZT to begin looking for potential laboratory cooperation partners and so they came to us. AZT works a lot with large, heavy duty machinery and industrial parts, but it also needs to work with smaller samples for analysis. That's where we can help out. We have a number of clients that work with smaller parts, from the automotive and medical sector, for example. The equipment required for carrying out the lab work is very similar.

*What are the benefits of this partnership?*
**Nickl:** It's a win-win situation for us. One of the most important factors is that there is a great deal more work carried out in our laboratories. Having a certain workload here allows us to run the various top-level machinery that we have. Clients come to us with a range of problems, so we need to have the capability to provide a variety of solutions.

**Stoiber:** The facilities available here are different to the production labs where quality controls, analysis of layer thicknesses and other more 'basic' tests are carried out. Here at GWP, we are able to work together on much more in-depth, tailored investigations.

**Nickl:** Information exchange between us and AZT is also very important for both parties. And it's not just about learning directly from each other; we have access to a range of other partners and experts via AZT that we wouldn't normally have, and vice versa. Together, we organize technical seminars and events with these partners from both Germany and abroad.

*Describe a recent key project you have worked on together.*
**Nickl:** New boiler tubes, which had to be tested as part of a public research project that looked into new steam power plant technology. These tubes must be able to handle steam temperatures of 700°C and above. Most conventional plants operate at around 450-500°C, but increased steam temperatures would bring increased efficiency. To do this, the materials used have to be improved significantly.

**Stoiber:** One of our engineers had a large number of boiler tube samples from a test rig. He used the lab at GWP to test oxidation scales, thickness and also element distribution to understand the mechanism of oxidation in these materials. It was a difficult job because the layer thicknesses were below one micron. The image quality had to be extremely good.

**Nickl:** This was a project that really showed the mutual benefits of our partnership – AZT was able to provide certain levels of expertise that we don't have, while we were able to offer the right laboratory equipment for the investigations.

Drs. Nickl and Stoiber standing in front of a steam turbine rotor damaged during the 1987 Irsching incident.

*How has your focus of work changed since partnering with AZT?*

**Nickl:** A certain degree of change over time is inevitable but the change in the services that we offer and the methods we use has certainly intensified. It's difficult to quantify, but I believe that our association with AZT has been beneficial in terms of attracting new clients. We used to concentrate predominantly on working within Germany, Austria and Switzerland, but our business has become more international.

*And how do you see this changing in the future?*

**Nickl:** There are two main sectors that are becoming increasingly important: renewable energies and lightweight materials. In the future, we will be working with AZT to look more at photovoltaic panels, for example. From an insurance point of view, it is important to know more about the damage caused by fire and hail incidents. We plan to examine panels that were exposed to these elements to see how power output is affected.

The GWP is the laboratory partner for the AZT that helps enable analysis of smaller parts and samples.

A large part of our current workload comes from production-related questions – how to improve the performance of traditional materials such as cast aluminum or steel. However, lightweight materials take in so many different possibilities, from polymers to carbon fibers and magnesium. This is a growing market. My vision is that in five years or so, GWP and AZT will open up a new center to tackle the various tasks that we have on the horizon.

*What challenges does working with these new materials bring?*

**Nickl:** With a material like steel, we have more than a hundred years of experience; we know how it behaves. With materials such as composites, however, we have much less experience and the methods used for analysis and testing are still very much in development. But the unknown is appealing – it is a challenge that tests our knowledge and skills to the limit. To be successful, you have to have the right team, the right equipment and the right partners to work together with. As a company, we feel secure and confident, because we know that we have a knowledgeable and reliable partner that we can turn to.

# "Reduced costs are in everyone's interests"

Dr. Christoph Lauterwasser, AZT Automotive GmbH

Originally founded in 1971 as the Passenger Vehicle Technology section of AZT, the 30 employees of AZT Automotive perform extensive research into increasing automobile safety and reducing damage costs. Managing Director since 2007, **Dr. Christoph Lauterwasser** discusses the varied services offered by the company and what the future holds for AZT Automotive and the motoring industry in general.

*Tell us about the key services of AZT Automotive.*
On a day-to-day basis, we are probably most commonly occupied with repair technology. This means we are investigating ways to reduce repair costs in a number of areas. We conduct research into vehicle safety, with a focus on personal injury and how we can prevent them. We also have an accident research unit, which analyzes a large number of real-life claims to see what trends and patterns can be identified. The center looks at ways in which to reduce theft claims and, lastly, we regularly offer expert training to Allianz motor experts on how to best handle motoring claims. This is an important way for us to bring our findings into the day-to-day claims processes of Allianz.

*How is it possible to lower repair costs?*
We look into whether it's necessary to replace whole parts, make partial replacements or even just carry out repair work – without having any negative impact on the car's integrity or safety performance. Seventy-three percent of motor own damage claims are the result of collisions, so this is the area that we look at most. The vast majority of claims are relatively minor ones – under €3,000 – which is why we carry out the vast majority of our tests at our low-speed crash test facility here in-house.

*The increased use of lightweight materials must play a growing role in this work?*
Absolutely! For a number of reasons, cars have become heavier and heavier over the last 30 years: increased stability in crashes, higher motorization and various modern conveniences such as air conditioning and electronic equipment. I believe this has now peaked though, as manufacturers seek to cut $CO_2$ emissions by reducing weight. We are seeing more aluminum, plastic and lightweight steel constructions. Carbon fiber is also starting to become a feature. Of course, this affects repair work. The materials behave differently and repairs ultimately becomes more complex. It's our job here to investigate the possibilities, limitations and the effect this has on insurance costs. Our crash tests help to set premiums correctly. It's very important to get premium levels right – too high and you lose business, too low and the company loses money.

*How closely do you work together with manufacturers?*
We work quite closely with all major German car manufacturers. They will often give us cars to work on. Recently, we have been working with one of them on a project to further investigate the use of carbon fiber, how to assess damage and how it can be repaired. Ultimately, it's in their interests to reduce costs for their clients.

Several years ago, we carried out considerable research into front and rear bumpers to see how well they match. If they are of similar size and height, then collision damage is normally quite limited, but we found that it tended to vary from manufacturer to manufacturer. After our research, a recommended standard was introduced and we are now seeing considerable effort from the manufacturers to get this right. It hasn't always been the case, but insurance research institutes such as AZT now enjoy a good understanding with car makers; they value our input.



AZT Automotive works closely with car manufacturers to test and analyze car parts and new automotive technologies.

*What about the body shops?*
It's important that we work closely together with them as well. We recently had a visit from the German association of body shops, where we discussed some of the recent developments in repair work with new materials. It's crucial for independent body shops in particular to receive input and training in these areas.

*So, you provide training to external institutions as well as Allianz staff?*
Only to close cooperation partners. In fact, this is one of our key areas of work. We have around 30 different training sessions here per year, often over several days. Usually they are for Allianz employees, but we do host external events as well. It is vital that the Allianz appraisal experts are kept up to date with what the different possibilities are – they are the ones in contact with the body shops, which, of course, have slightly different objectives to the insurer. We are constantly working on new concepts and ideas for our training, for example offering Web-based sessions as preparation for any on-site training.

*What sort of research areas do you expect AZT to be focusing on in the near future?*
New motor systems such as electric and even hydrogen-powered vehicles are becoming more prevalent. We will be looking at the impact this has on car structures and repair work, and how this may affect insurance premiums. Also important is the role of driver assistance systems – collision avoidance, lane departure warning systems and telematics.

*Have you already detected any benefits from this sort of technology?*
For some systems, claims frequency and the number of serious accidents are decreasing. However, given that the average age of cars on the road is seven to eight years, it takes time for technological and design progress to truly be felt on a large scale. Now that car bodies have improved so much, the next step is to gain more and more benefits from elements such as driver assistance systems but we are still on a learning curve here.

*Is there any danger that these systems could prove distracting for drivers?*
I think that eventually they will become part of the normal driving experience, although that may take a little time. There are other distractions, such as talking on the phone or eating. Last year, we conducted an investigation into driver distraction and road accidents - we reviewed the statistics and different literature available and also interviewed 600 people across Germany, Switzerland and Austria about their own driving behavior. Figures vary internationally, of course, but we found that at least 10 percent of accidents are caused by driver distraction. The research generated a fair amount of publicity. We held a press conference and there were more than 200 articles written and a handful of television interviews.

*How important is this sort of publicity for you?*
It's very important! Whether it's from the media or from other research centers or manufacturers, having visitors here to the center is vital. I think there is still a belief in some areas that there is a team that sits in an office in Allianz headquarters somewhere and comes up with the company's calculation tools and vehicle ratings somehow. It's vital that we demonstrate that we have a specialist center here with a body shop, testing equipment and a team of expert research staff behind these calculations.

# "Trust is key"

Thomas Michalski, STEAG Voerde West

**Thomas Michalski** is Head of Turbine Maintenance at STEAG plant Voerde West. Besides a broad variety of more than 200 distributed facilities to generate energy from renewable sources, STEAG also operates a number of coal-fired and industrial power plants within Germany and several other countries. His company's machinery breakage insurance with AGCS means that Michalski works together with AZT to investigate the causes behind certain machinery damages.

*Describe your role at STEAG.*

I work at the Voerde power plant on the Rhein river in western Germany. We have four units in total and I am responsible for looking after repairs, daily operation and inspections.

*How often do you have to deal with damage to the machinery?*

Small problems are completely normal; everyday occurrences, such as frost damage in winter. A lot of these issues can be solved simply by re-welding, but at some point, of course, there are larger problems that require involvement from the insurance company. This normally happens a handful of times a year. And once every few years, we'll have a major damage that means a part has to be exchanged or requires major repair work – a steam turbine or an air heater, for example. The more serious problems – where the cause is not always clear – are the times that we are most likely to involve AZT.

*Describe the cooperation between yourself and AZT.*

We are very open with each other, which is crucial when it comes to establishing the causes for any damage. Trust is very important. Ultimately, our areas of expertise complement each other. We have the knowledge of the market and of the machinery we use, so we know how and when to operate the power stations, at what capacity and so on, while AZT has the technical expertise for the machinery and its materials. They have the background knowledge of how operation has an effect on damages. In my experience, it has always been a harmonious experience. When it is necessary to involve AZT, then they inspect and record the damage, before carrying out an investigation. Once this has been completed, we discuss with them the best solution: Do we need to investigate further? Do we need to change the way we work or operate? AZT provides a very thorough service – much more than simply conducting an investigation and submitting a report.

*Tell us about a recent case that you have worked on together*

We operate four steam turbines, which are all starting to show their age a little. In fact, the oldest is 42 years old. During an inspection two years ago, we discovered cracks in the turbine blade. Cracks like these tend to grow the more you use the turbine and can ultimately lead to the blade tip coming off, for example. Given the potentially serious nature of the damage, we took the case to AZT to investigate. Now, we are trying to find the best way of living with this old, slightly damaged turbine blade without suffering any major damage. At the moment, it does not need to be replaced and so AZT is developing a testing and operation program to allow us to do this.

*Would it not be better to replace the turbine?*

The problem is that a lot of turbines like this are starting to show signs of wear and tear. For international plants, a replacement might be considered an option, whereas due to the changes within the German energy sector, conserving the lifespan of turbines is the best way to operate our technology. Moving forward, I believe this will involve a greater cooperation with AZT. As we continue to use the older machines, they are likely to begin to show different signs of damage.

*Do you feel there are any areas in which AZT could offer you a better service?*

In terms of damage analysis, the service AZT offers is excellent. There are certain extras that they no longer offer, though. AZT used to put together a handbook of industrial machine damage [*The Handbook of Loss Prevention*] which included different highlights and findings from its work. This is an excellent source to learn from and look up specific things, but unfortunately, it has not been updated for a long time. It would be great if it was. The last volume was published before I began to work in the industry, but having inherited a copy, I still find it tremendously useful – it sits in my office and I refer to it on a regular basis.

AZT expertise is requested more and more at many power plants to help meet the challenges of the future (image: STEAG).

# Non-Destructive Testing at AZT **Then and Now**

There is value in exploring beyond obvious defects to find root causes of machinery damage. AZT's longstanding expertise in non-destructive testing helps get to the bottom of damage.

**By Reinhold Schaar**

Non-Destructive Testing (NDT) has been a speciality at AZT for decades, and Allianz was a founding member of the "Röntgenstelle" at the official material testing office in Berlin, which later developed and became the German Society for Non-Destructive Testing (Deutsche Gesellschaft für Zerstörungsfreie Prüfung, or DGZfP).

From the beginning, the center focused specifically on analyzing and minizing damage for policy holders and establishing practical ways to prevent damage wherever possible. Today, AZT operates a laboratory partnership with the Organization for Materials Testing (Gesellschaft für Werkstoffprüfung, or GWP) in Zorneding, near Munich, and uses its global network of specialist partners for different areas of work. The spectrum ranges from simple tests and monitoring to scientific investigations like transmission electron microscopic examinations (TEM) and complex projects with clients such as wind generator manufacturers.

## NDT — a critical part of various loss investigation steps

Non-Destructive Testing plays an essential role in analyzing damage. NDT is applied in several investigational steps, starting with damage description, then sampling and analysis to help find the primary root cause of the damage.

During damage description, visual testing methods are of most importance. Specific photography and lighting techniques often highlight the characteristics of a damaged area more clearly than the naked eye. To document moving processes, video cameras are used in addition to more advanced methods, like 3D movement and position analysis, 3D deformation analysis and shearography. By using rigid and flexible endoscopes, pipeline inspection gauges with miniature cameras and lighting systems are able to inspect areas that are difficult to access.

The classic NDT procedures, including ultrasonic, penetrant, magnetic particle, radiographic, leak and electromagnetic testing, are applied to check for inhomogenity, before the damaged area gets cut out of the object and additional testing samples are detached. Instrumental NDT analysis including the measurements of layer thickness, wall thickness and hardness with mobile equipment, allow for the assessment of the damaged component on a much larger scale as compared to destructive investigations.

In many sampling cases, NDT is necessary to free the main damaged area without altering or damaging it further. This could involve, for example, freeing an internal discontinuity or inspecting the inside of a pipe to look for further cuts. The use of the Computer Tomography (CT) scanning can be advantageous, when the samples taken are small enough. A CT scan allows investigators to document the condition of the material in high quality in a movable 3D image before further cutting.

Figure 1: Crack in the frame of a progressive press

## NDT for damage prevention

Mostly classical NDT methods are used in quality assurance but also for damage prevention. Failure experience by AZT shows that some considerable past losses occurred because appropriate NDT methods were not available or not correctly applied; for example the bursting of a low pressure steam turbine rotor in Irsching, Germany in 1987, or that of a gear pinion shaft on a gas turbine in Leipzig, Germany in 1994.

Significant improvements, especially with respect to the ultrasonic testing method, have since been achieved. By using advanced non-destructive procedures such as phased array ultrasonic testing, this type of damage on large forged steel components can be avoided in the future.

Other examples are endoscope investigations currently being conducted for the purpose of preventive maintenance on wind turbine gearboxes, after damage has occurred.

## Case study – progressive press

A progressive press is used to form simple components through a step-by-step procedure until the final shape is obtained. In an AZT case of a damaged component, the feather key was dislodged. The cause was thought to be a "double decker," or a laminar imperfection, that developed during pressing. The damage was repaired and the press was put into operation again, but a month later, the machine failed to deliver the necessary pressing precision, and many products were defected. After the operating team made numerous efforts to repair the press, they discovered that there was a large crack in a bearing seat in the frame (Figure 1).

AZT was called in to provide the policy holder with technical advice and to establish the cause behind the crack in the frame. The high costs and time required to deliver a new frame from the manufacturer in the United States to the plant in Germany meant that a repair was the only feasible solution.

The examinations performed by AZT had to be conducted in such a way that repair work was not affected. As the technical documents for this press were no longer available from the client nor the manufacturer, a sample of the material was extracted from an area outside of the damaged zone and studied in detail. The material in the designated repair zone was checked with ultrasonic and magnetic particle inspections (Figure 2). No other deficiencies were found.

Figure 2: Phased Array Ultrasound Test (PAUT) of the area surrounding the crack

## Expensive extra costs

As a result, the only realistic repair solution was an expensive disassembly of the pressing equipment, followed by transportation to a specialized welding workshop. Necessary heat treatments and component measurements were performed before and after repairs to limit possible distortions or that such be compensated for through manufacturing measures.

Before engaging in welding repairs, AZT recommended to the client to have the press frame thoroughly checked by a NDT-testing company. After the repairs, the welded areas should be tested again to ensure quality. Unfortunately, as often the case with other investigations, testing after disassembly was skipped for cost reasons, in spite of AZT's recommendations. This came at an expense, as the tests performed after the repair work revealed several other cracks in different areas, meaning the frame had to undergo welding and partial heat treatment to repair it fully. This resulted in significant additional expenses and delays.

Lessons learned from this case study revealed that when investigating damage, it is vital to carry out a thorough inspection of the entire installation, even if additional costs are involved. This allows any damage to equipment to be repaired in one go, no matter how minor, and helps avoid costly subsequent repairs and even consequential damages.

## Looking beyond the obvious

With more than 200 non-destructive and what are essentially non-destructive testing methods available, it is vital that the correct process is selected by experienced and qualified personnel according to DIN EN 473 or ISO 9712, which will become valid in 2013. It is important to remember that it is not always the most visible faults that lead to damage. Only by knowing the actual and not the presumed or suspected cause for the damage is a permanent solution possible.

# Avoiding **Gearbox Failures**

Non-destructive gearbox and tooth volume testing.

By Arne Bohl

## Seeing the details

In instances of damage to machines or technical equipment, the causes are usually hidden to the naked eye. With the aid of an ultrasonic inspection technique, tooth volume testing allows insight into areas of components inaccessible through common surface investigation. AZT performs this inspection procedure, which yields important advantages.

First, potential defects, which could develop up to the point of the failure of the component (tooth chipping), are recognized at an early stage. Second, as a result of inspection, a meaningful assessment of the state of the gear and the driving equipment becomes possible. And finally, the minimization of downtimes and stoppages results in significant cost savings, and helps optimize planning reliability.

## Testing technology developed by AZT

The testing of interior defects is performed with the assistance of conventional and phased array ultrasonic inspection technology. Additional tests include general contact pattern evaluation, surface crack detection (optional), detection and analysis of the surface defects, like electroerosion, formation of grey staining and other mechanical damages of the flank surfaces, and testing for possible form deviations, which can be detected on the shafts.

Figure 1 & 2: Tooth volume testing and gearing damages

Auxiliary means are used during inspection, which includes foil and plastic impressions for light or scanning electron microscopic evaluation, and photographic documentation.

## Documentation

Comprehensive documentation of findings feature tables with detailed indication inscriptions and the distribution of indications in gear teeth. Additionally, there are photographic documentations and possibly light or scanning electron microscopy available. When necessary, AZT provides recommendations regarding further operation of the plant.

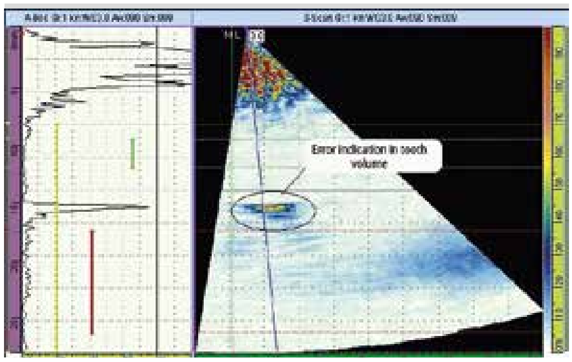



Figure 3: Volume area with reflection points

## Tooth volume testing

The primary objective of this special investigation, developed by the AZT, is identifying and analyzing flaws in tooth volume of gears (spur gears and bevel gears) in different types of plants, including gas and steam turbines, wind energy turbines, rolling mill drives, mill drives and ship propulsions.

# Analyzing **Vibrations**

The use of machinery diagnostics to understand and solve vibration issues.

By Thomas Gellermann and Harald Pecher

It is no secret that machines generate vibrations when in operation. What is less well known, however, is the acceptable level of these vibrations. At what point do they start to cause damage and where exactly do the different components of vibration come from? These are topics the AZT has been working on for more than four decades to assist its clients in analyzing and solving problems caused by vibration.

AZT's machinery diagnostics team uses state-of-the-art equipment, such as multi-channel measurement systems, to conduct investigations into the effects of vibrations on drive trains of rotary machines, including turbines, compressors, generators and load gears.

There are several application areas. In cases of acute vibration issues, diagnostic measurements are carried out on short notice. Bearing and shaft vibrations are investigated, as well as resonance frequencies on turbine blades, for example. The team is then able to recommend, monitor and evaluate specific corrective measures.

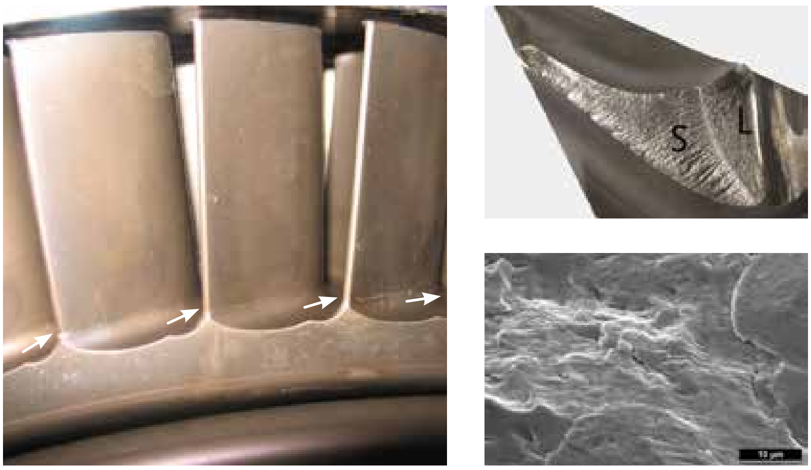



Figure 1
*Left:* Blade fractures (indicated by arrows) along edges.
*Top-right:* Exposed fracture (S = fatigue crack; L = laboratory crack).
*Bottom-right:* Fatigue striations shown enlarged 2,000 times.

In recent years, power plant operators more frequently ask for vibration analysis prior to and after a scheduled overhaul of their turbo sets. The independent analysis and evaluation by AZT is thereby an important measure of quality control. This is due to the fact that different contractors commonly conduct the overhaul of individual drive train units, such as those of high-, medium- or low-pressure turbines and generators. If vibration issues occur during commissioning, AZT is able to analyze it on the basis of vibration measurements. This helps reduce down times and increase reliability of the turbo set.

After a damage has occurred, one important element of the investigation is the analysis of operational data and vibration trends. The data, usually provided by the Process Control System (PLC), often contains important information about the circumstances and course of damage. In addition to the damage investigation results, the data analysis provides AZT experts with complementary insights into the mechanics of the damage, and establishes the right measures to eliminate the causes.

## Detailed vibration investigation

There are certain damages that can be traced back to vibrations for which the precise causes remain unclear, even after a post-damage analysis. In cases like these, detailed vibration investigations are carried out after the machinery has been repaired and is in operation again. Such investigations reveal which operational phases cause the vibrations and help determine what measures must be taken to reduce or altogether eliminate these vibrations. In addition, AZT's decades-long experience in this field means the center is able to provide recommendations for monitoring and safeguarding continual operation. If necessary, AZT provides measurement equipment to monitor and record the vibration of a turbo set over several months and to evaluate the vibration behavior via remote access.

As an example, a vibration investigation was carried out on a single-stage Curtis turbine, which had fatigue fractures on the blades, after it was brought back into service. The appearance of the fractures (Figure 1) hint at temporally high blade vibrations, which might be caused by short operating periods at resonance conditions. The vibration investigation ruled out resonant stimulation as the reason for the blade's damage. Instead, the continuous vibration monitoring (Figure 2) has revealed repeated short periods of high bending loads due to significant water intake from steam flow. This led to a considerable increase in the axial thrust and bending stress on both the wheel and the blades, which, consequently, caused the fatigue fractures in the blades. As a result, the water drainage system of the steam lines was inspected and several failures were found, including wrong slops of piping, leaking check valves and blocked drain lines. After strengthening and improving the drainage systems, the accumulation of water in the steam line was eliminated.

For some time now, AZT has noted the increasing number of blade failures due to malfunctioning drainage systems (see footnote 1 and 2). One possible explanation is that piping nowadays is no longer the responsibility of the turbine manufacturer. Therefore, special diligence should be given to the construction and design of the drainage system, as well as to the maintenance.

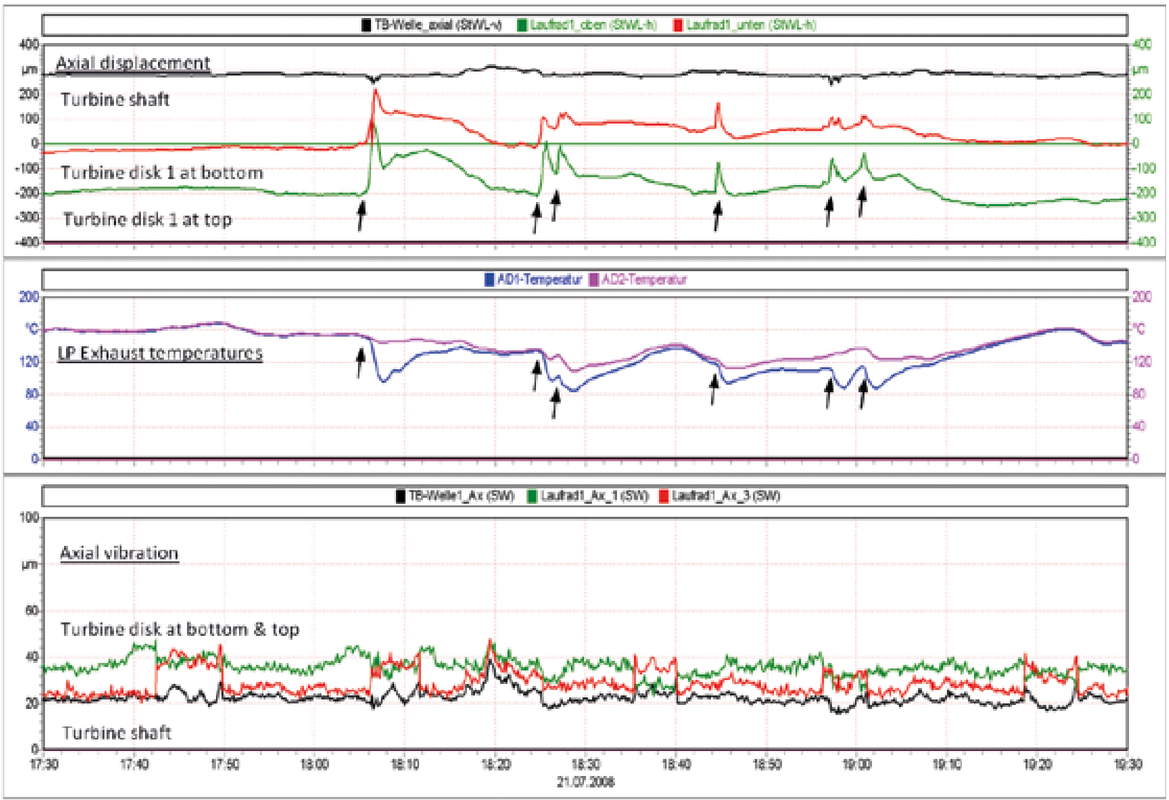



Figure 2: Vibration progressions showing various results from the introduction of water (indicated by arrows).
*Top:* Axial relative displacements (gap signal).
*Middle:* Exhaust temperatures ND1 and ND2.
*Bottom:* Axial vibrations of the blade disk and shaft of the ND1 turbine

*[1] Th. Gellermann: Folgen des Wassereintrags in eine einstufige Dampfturbine und dessen diagnostische Erkennung, 6. VDI-Tagung „Schwingungsüberwachung" am 24./25.05.2011 in Stuttgart, VDI-Berichte Nr. 2151.*

*[2] St. Thumm, M. Eckel, R. Beauvais: Großschäden an Dampfturbosätzen - Ursachen, Reparaturen, Weiterbetrieb, VGB PowerTech 11/2010*

# Hydraulic Hose Lines
# The Importance of Preventing Leaks

A potential danger to both personnel and machinery, damages to hydraulic hose lines can be serious business.

By Rudolf Weber

Vehicles, construction equipment, offshore installations – hydraulic hose lines can be found in a range of different machines with moving parts. Within these machines, hydraulic hose lines are the most likely component to cause damage.

Not only can such damage incur significant financial costs, it can also be dangerous. The physical dangers posed by leaking hydraulic fluid range from skin disease and allergies to damage of internal organs, should the fluid find its way into the body through contaminated water or the penetration of the skin, for example. Any leakage around hot surfaces or near ignition sources, such as welding or cutting equipment, also presents a considerable fire hazard.

Causes for damage can vary greatly, and AZT has gathered extensive experience through its many investigations in this area. The leaking of highly pressurized hydraulic fluid can be traced back to various factors, including incorrect selection of hose lines, manufacturing defects, faulty installation, exterior and interior damage (such as heat or pressure pulses) or poor maintenance. The following three cases outline the cutting-edge research that AZT carries out into the causes of hydraulic hose damage and how they can be prevented.


Image 1: Damaged hydraulic hose line

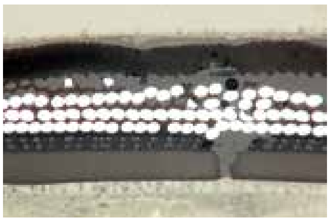
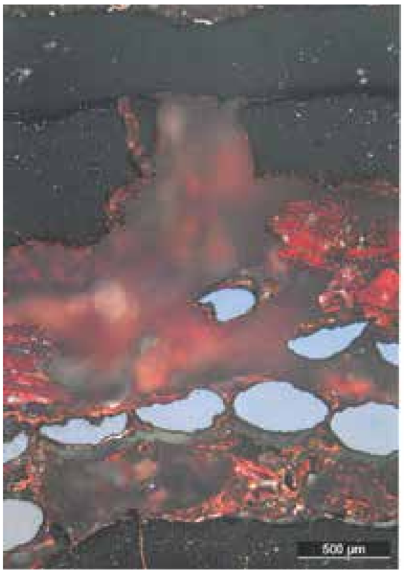


Image 2: Section of a faulty hydraulic hose line

## Case 1: Vehicle damage and environmental pollution

AZT investigated numerous vehicles that suffered damaged hydraulic hose lines after approximately one year of operation. Research concluded that the hose line's reinforcement (steel netting mesh) was embedded in chlorinated rubber (chloroprene). As a result of operation, moisture reached the outer surfaces of the hose, penetrating the rubber material. Insufficient stabilization and chemical resistance of the chloroprene rubber led to hydrogen chloride becoming separated, which, when combined with the moisture, led to corrosion of the steel netting mesh. This weakening of the mesh resulted in the hose line bursting from the interior pressure.




Cover

Interlayer

Steel Mesh

Corrosion Product

Image 3: Steel wires affected by corrosion (light) in the rubber matrix (dark)

## Case 2: Mechanical damage caused by faulty installation

The hose lines shown in Image 4 and 5 were used in different mobile construction machinery. The dent mark in Image 4, running diagonally to the hose axis, indicates that the hose was deformed by clamping and the steel netting mesh within the hose wall damaged. Normal operating pressure then caused the hose to break at this point. Usually, this kind of mechanical damage cannot be recognized after the hydraulic line has burst (image 5). This is where computed tomography (CT) scans can help (Image 6). This procedure allows deformations in the hose wall from clamping or crushing against the steel mesh to be detected and documented without damaging the hose. In both cases shown above, the installation failures led to environmental pollution from leaked hydraulic fluid.


Image 4: The linear impression on the surface of the hose indicates a hose which was trapped or crushed in the area where the damage occurred.

Image 5: Burst hydraulic hose line with a leak formation.

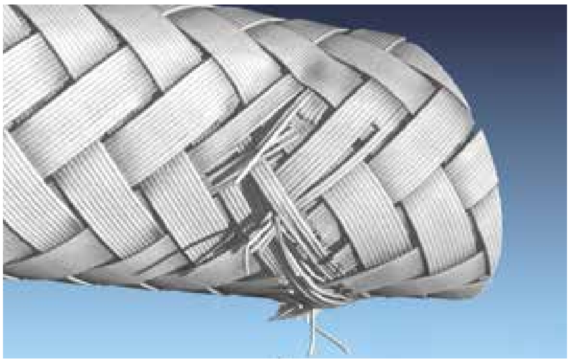


Image 6: CT scanning of the area of the leak, from Image 5. The dent in the area of the leak indicates that the hose was clamped and damaged.

## Case 3: Fire damage caused by fluid leak

In this case, the hydraulic hose on a production facility was torn off the fitting, as a result of normal operating pressure (Image 7). A nearby source of ignition then caused the hydraulic fluid that leaked out to catch fire, leading to business interruption and extensive refurbishment work in the workshop. The material investigation shows that the cause of the leak was excessive wear and tear and not conditional of manufacturing. The excessive wear and tear could have been prevented by regular monitoring of the hose and timely replacement.

Image 7: Fire as a result of a torn hydraulic hose line (image: AZT).

## Lessons learned

Establishing the cause of the damage allows AZT experts to recommend improvements and modifications to avoid problems such as rubbing, cable bend, clamping and crushing or material faults that help prevent further damage in the future.

# Gas Turbine **Failures**

The complexity of systems used in gas turbines makes identifying the causes of damage a difficult task. Repair and overhaul work can often be a catalyst.

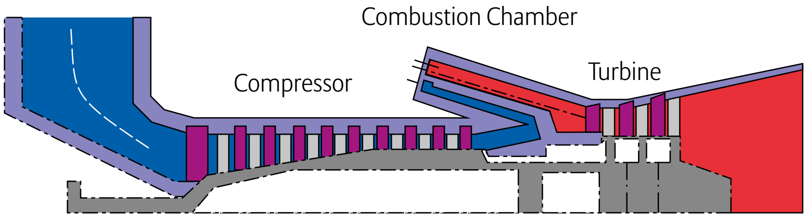
By Dr. Bernhard Persigehl and Dr. Johannes Stoiber

Gas turbines are used around the world for a variety of different purposes, from producing electricity – usually in combination with a steam power process – to ship propulsion or as a mechanical drive for a pipeline compressor. These different uses can lead to a range of damage, but in AZT's experience, rather than serial damages, they tend to be individual damages as a result of specific operational conditions or errors in manufacturing and installation.

## Design of a gas turbine

A gas turbine is composed of three main components: the compressor, the combustion chamber and the turbine, which are shown in Figure 1a with their respective temperature profiles (Figure 1b). In the compressor, energy is added to the aspirated air, leading to an increase in pressure and temperature to approximately 16 bars and 400°C respectively. With the compressed air, the fuel is burnt in the combustion chamber. The hot combustion gases (approximately 1,500°C) flow through the turbine, which turns at a speed of 3,000 rpm in the case of a 50Hz application, and drives an electrical generator. The higher the hot gas temperature, the more efficient and powerful the gas turbine.

Figure 1a: Main components of a gas turbine.



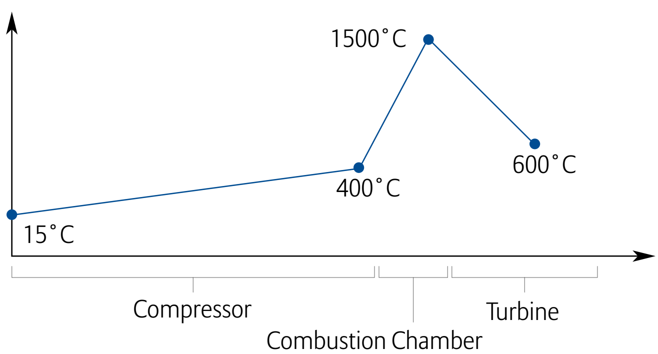




Figure 1b: Component temperature profiles

This operational process results in high thermal and mechanical stresses on the individual components of a gas turbine. The compressor is predominantly subjected to dynamic vibrations, which must be taken into account during the design. High temperatures mean the combustion chamber must be protected with heat resistant materials (including thermal barrier coating) and special cooling techniques. The turbine undergoes mechanical stresses as a result of centrifugal forces, thermal loads from the high gas temperatures and the thermo-mechanical strains from the change in temperature incurred during start-ups and shutdowns. The use of highly heat-resistant nickel-based alloys, thermal barrier coatings and innovative cooling techniques are necessary to ensure the designed life expectancy of the turbine's components is met. Many of the components exposed to the hot gas must be dismantled and reconditioned during a major overhaul in order to be serviceable during the next operation period.

# Damage through iron fire

The case described below refers to a 320MW gas turbine, which is used in a compressed air storage power station. In this type of power station, the electricity is stored in the form of compressed air. During the loading operation, the compressor is driven by a motor and thus consumes electricity. During the discharge, the compressed air stored in an underground cavern is directed to a combustion chamber and subsequently to the turbine, which drives a generator. Consequently, the gas turbine process of air compression, combustion and gas expansion, is temporally separated.

This turbine – made from high- and low-pressure sections – had to be taken out of service because of increased bearing vibrations. After opening the high-pressure turbine, extensive material degradation and broken blades were discovered (Figure 2). A missing locking plate in the first rotor blade row initially suggested the impact of a foreign object had caused the damage. However, this did not fit with the fact that the increased bearing vibrations did not appear until shortly before the turbine was shut down and that the damage pattern was characterized by a rotationally symmetric degradation of all the blade rows (Figure 2).

Only comprehensive laboratory analysis (carried out by AZT and the Original Equipment Manufacturer, or OEM) could establish the cause of the damage: Overheating of the turbine led to an unusual mechanism of iron fire, effectively melting away the high-alloy steel blade rows.

This type of torch-cutting effect can only happen if the melting point of the metal oxide is lower than that of the metal. Unlike iron, this is not the case with nickel. The first blade rows made from nickel-based alloy, were not affected.

AZT worked together with the manufacturer and the operator to reconstruct the complex chain of events that led to the damage: air bubbles in the control oil system and the lift pressure of the turbine's cooling valve that was set too low, caused the opening of this valve during start-up. Cooling air flowed into the low-pressure combustion chamber through the valve, directly past the exhaust temperature sensor that regulates the fuel supply to the high-pressure combustion chamber. The increase in the volume of cooling air meant that the fuel quantity leading into the high-pressure combustion chamber also increased.

A tremendous temperature rise resulted in the blade rubbing off the distorted cover plates in the turbine's second blade row (to the right of Le2 in Figure 2). An iron fire was sparked from the frictional heat and spread as a result of the excess air throughout the high-pressure turbine, melting every row in a rotationally symmetric way. This steady process did not lead to an increase in the bearing vibrations over a longer period of time. Only after restarting the turbine did several weakened blades (as a result of the melting) break off, thus generating the vibrations and causing the shutdown of the turbine.

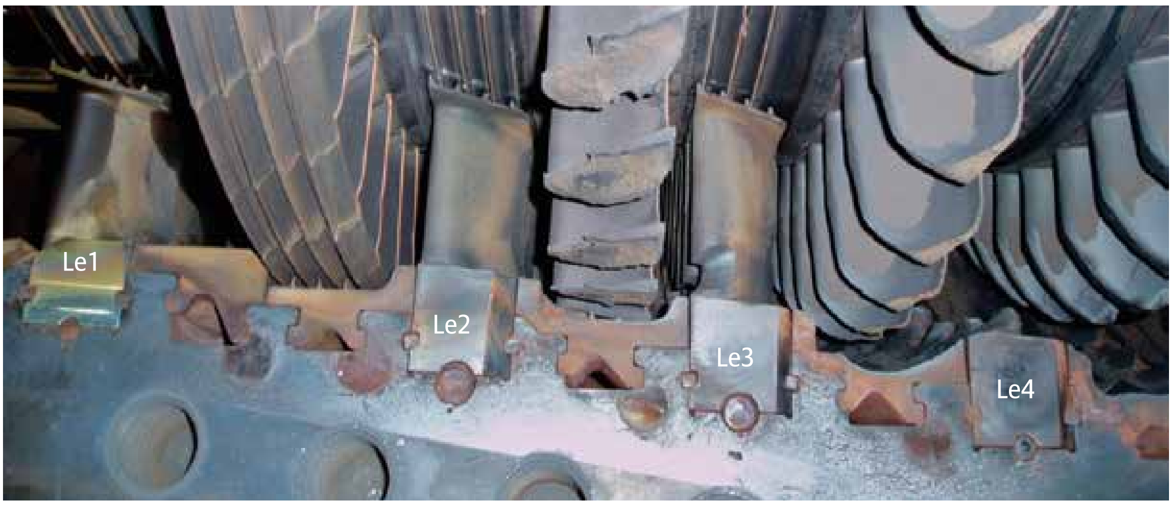



Figure 2: Damage pattern in the high-pressure turbine (image: AZT).


Figure 3: Compressor damage (image: AZT).

## Wrong positioning of Inlet Guide Vanes

In a separate investigation carried out by AZT on an 11MW gas turbine, every blade in the first row of the compressor was broken (VLA1 in Figure 3) as a result of strong vibrations. The subsequent rows of blades were severely damaged by the broken blades from the first row. The reason for the vibrations affecting the first row of blades was a malfunctioning positioner of the adjustable Inlet Guide Vanes (IGVs). As a result from the breakage of the coupling of the positioner (Figure 4), the IGVs were rotated by the actuator into the wrong position, which led to an increase in compressor discharge pressure and mass flow.

A tensile test of a structurally identical reference coupling indicated that the adhesive joint between the support and the compensating piston was defective (Figure 4). It was obvious that the damaged coupling was not an original part. The scanning electron microscope revealed the presence of foreign objects between the two glued parts, which led to insufficient tensile strength in the adhesive joint.

## Challenges to overcome

In order to identify the primary causes of gas turbine failures, detailed laboratory investigations are often necessary. The examples shown here highlight how challenging it is to ensure safe operation of a gas turbine due to the complexity of the system and various fault possibilities.

In recent years, AZT has observed an increase in damages following overhauls, repairs and retrofit measures. To reduce future failure potential, improved quality management during manufacturing and assembly, as well as the comprehensive analysis of the entire system when upgrading individual components, have to be addressed.

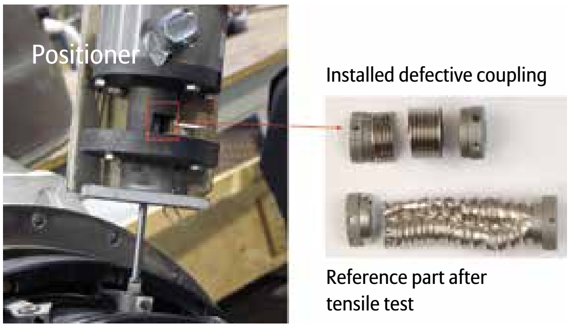



Figure 4: Broken coupling piece

# Getting to the **Root of Things**

How AZT helps trace precise causes behind damage to low-pressure turbines.

**By Dr. Martin Eckel, Harald Pecher and Stefan Thumm**

One of the main focuses of AZT's work in recent years has been investigating damage to low-pressure turbines. In particular, the center concentrates on damage to the blades, which represents the biggest cause in loss of turbine availability (Figure 1).

The specialist VGB Steam Turbine Conference in early 2012 was the scene for an in-depth presentation by an AZT team of experts into the center's findings on the topic. The VGB federation provides expert networks and consulting services to its more than 500 members around the world, of which AZT is one. (Refer to the interview with VGB's Peter Richter on page 53 for more.)

## The root of the problem

AZT's investigations observed the following fracture mechanisms: low-and high-cycle fatigue, vibration, corrosion fatigue cracking, stress corrosion and forced rupture. Dynamic fractures are caused by high dynamic forces that act on the blades. These can be caused by a wide variety of factors such as aerodynamic stimulation mechanisms, such as flatter at high loads, ventilation at low-load operation and stimulus from torsion vibrations.

In addition to mechanical stress, erosive or corrosive influences often play a decisive part (Figure 2). For example, corrosive influence can mean that fractures in blades grow up to three times faster than normal.

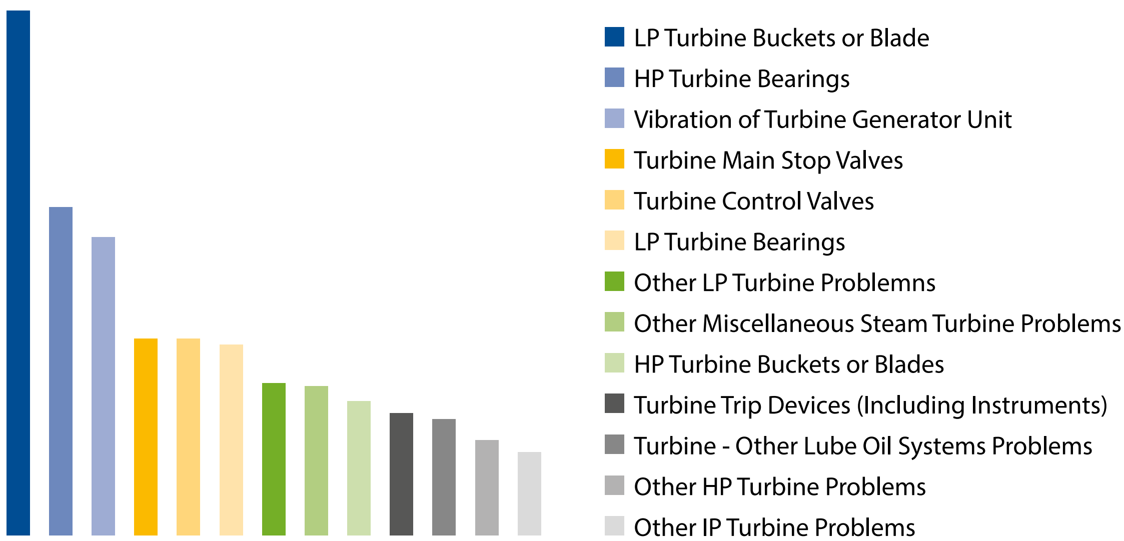



Figure 1: Loss of availability from different causes of damage (relative comparison) (Source: EPRI/NERC)

Stage L-2 after 170.000 Ohs / 1.500

Stage L-1 after 10.000 Ohs / 1.000

**Parameter of influence:**
- Corrosive medium
- Residual stress
- Ratio of bearing contact area to total area (partition clearance)
- Surface (fretting, corrosion)
- Over speed

**Possible Measures:**
- Inspection concept and time interval
- Optimization of steam quality and (continous) control
- Geometrical optimizations

Figure 2: LCF in root section of a rotor

## Full-scale root cause analysis required to prevent damages

To find the causes of damage, the ability to calculate natural modes, frequencies and stress distribution is vital. Additionally, the evaluation of the manufacturing documentation, operating conditions and protection concepts are decisive, along with the lab investigation into the broken parts.

Since the stimulation mechanisms often occur only in certain phases or operating conditions, the analysis of the operational data must be included in the overall damage analysis. Costly non-contact measurements of blade oscillations, however, are increasingly used for analysis and prevention.

Once more is known about the causes for damage, it may be possible to implement effective testing and repair methods, as well as operating adjustments that help avoid further damage and operational interruptions.

## Outlook

The enhanced use of modern development tools – such as CFD calculations and a combination of CFD and FEM calculations (computer-aided flow and mechanical calculations) – together with sophisticated testing will contribute to reduced risks in the future. At the same time, however, requirements for turbines and blades are going to increase due to efficiency improvements and enlarged blade lengths. In addition, more flexible operational conditions required by grids due to a steadily growing portion of electrical power from wind and solar plants add severe constraints.

The trend to decrease minimum loads is especially viewed as critically, as this will increase low load operation; something that is already identified as a major factor in many blade damages.

The challenge ahead will be to find suitable verifications and measures to maintain safe operation under these conditions.

# **Energy** for the Future

By helping to improve the proper material selection for new coal power plants, AZT's expertise is contributing towards cleaner energy production.

By Horst Kutzenberger

With a complete transition to renewable energies still some way off in the future, coal remains a vital resource in our energy production. It is likely that within the next 20 years, a multitude of coal power plants will be constructed and many of the existing ones will need to be modernized due to aging.

(Source: Shutterstock)

With this is mind, and in light of both national and international climate protection agreements, there are two main objectives to consider in coal-fuelled energy production: A conservative use of resources and the reduction of $CO_2$ emissions from the plants themselves.

## Increasing efficiency

A key way of reaching these objectives is the use of new technologies to increase plant efficiency. The crucial issue to address is raising the steam temperature, as well as steam pressure, from 540°C to 700°C and from 200 bar to 350 bar respectively. Through this increase, it will be possible to generate more energy with the same amount of coal, while reducing harmful emissions at the same time.

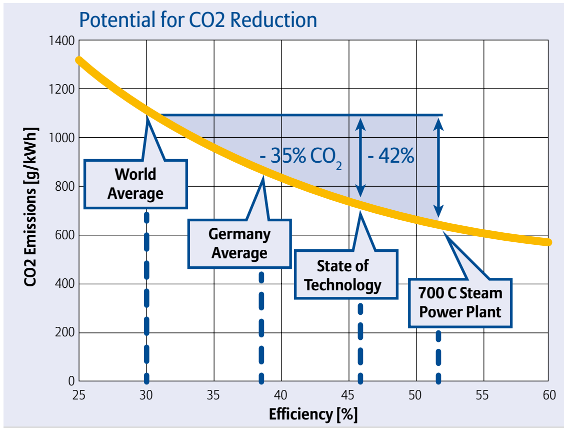



Figure 1: Development of potential $CO_2$ reduction/efficiency. (Source: BMWi, Turbomachinery 2006)

Steel materials currently used in power plants are unsuitable for these conditions. Not only do they possess insufficient strength properties, but the oxidation properties in overheated steam and the corrosion properties in flue gas also come up short. This is true from both a technical and an economical perspective, with reliability being the key.

For these reasons, new, highly heat-resistant steels and nickel-based alloys are being developed. However, there is not yet sufficient data available on their corrosion and oxidation behavior at high temperatures. Under the influence of overheated water vapor at high temperatures, the interior surfaces of the boiler tubes are subject to an oxidation process. This oxidation process is important and desired in a certain amount, as the layer that develops as a result of it protects the tubes from corrosion. The properties of the oxides, their development and their stability are, therefore, crucial criteria in finding the right material to use.

In order to investigate further, the initiative COORETEC (short for $CO_2$ Reducing Technology) was started by the German Ministry of Economics and Technology with the aim to develop a fossil-fuel power plant for the future. Within this initiative, AZT took part in a sub-project alongside other research institutes, power supply companies and industrial and commercial firms, to look into the creation of suitable protective oxide scales for materials in a 700°C power plant. With the aim of identifying the best materials to be used at these high temperatures, the project evaluated the effects of operating conditions on corrosion and oxidation behavior.

## The role of AZT

The Materials Testing Institute at the University of Stuttgart (MPA) developed and operated a high-temperature oxidation test station, which was used to keep the tubular sections for flowing and overheated steam at a pressure of 70 bar and temperatures between 575°C and 750°C over a period of 8,500 and 20,000 hours. The testing of the samples was divided according to the three groups of materials (martensitic and austenitic steels, as well as nickel-based alloys) and performed by Hitachi Power Europe, MPA Stuttgart and AZT.

Together with its partner, the Organization for Materials Testing (Gesellschaft für Werkstoffprüfung, or GWP), AZT conducted metallurgical examinations of the austenitic steel tube sections, such as measuring the thickness and condition of the layers of oxide, as well as analyzing the element distribution within the layers. The purpose of the investigation was to gain further insight into the formation and development of the protective oxide layers in relation to the material, temperature, tube geometry and stress, as well as into the spalling behavior (deterioration of the material's surface) and procedures for improving the oxidation behavior.

The investigations revealed that the growth and the spalling behavior of the oxides differ considerably with each material. While the martensitic steels barely showed any spalling behavior, during testing periods of up to 20,000 hours, certain types of austenitic steels tended to spall relatively thick layers much more quickly. In practice, this means a risk of pipe obstruction or the entry of particles into other components such as the steam turbine.

## Different levels of oxide

Surface distortion of the pipes, which appear as a result of the shot-peening process – a metalworking procedure designed to extend the life of parts – has a clear influence on the oxidation behavior of the different material groups. AZT and its research partners established that the development of the oxide layer was accelerated after the treatment of martensitic steel, which increased the risk of spalling. By contrast, in the case of austenitic steels with higher content of chromium (23 percent to 27 percent) shot peening led to a clearly reduced growth in comparison to an untreated pipe interior. This is why the oxide layers are only a few µm thick.

Even in their original condition, the nickel-based alloys (approximately 20 percent to 25 percent Cr) showed narrow areas of internal inter-granular oxidation, which then spread during the testing. There was no spalling of the oxide.

In summary, all results from the laboratory tests performed by AZT where compiled with other results in a database by the University of Stuttgart. The insight obtained from the research project as to the behavior of the new materials, is used as an aid in deciding for a certain material while planning a plant. This contributes to the safe and economic use of new materials within highly-efficient coal power plants of the future. Experts expect these first new power plants to start production around 2020.

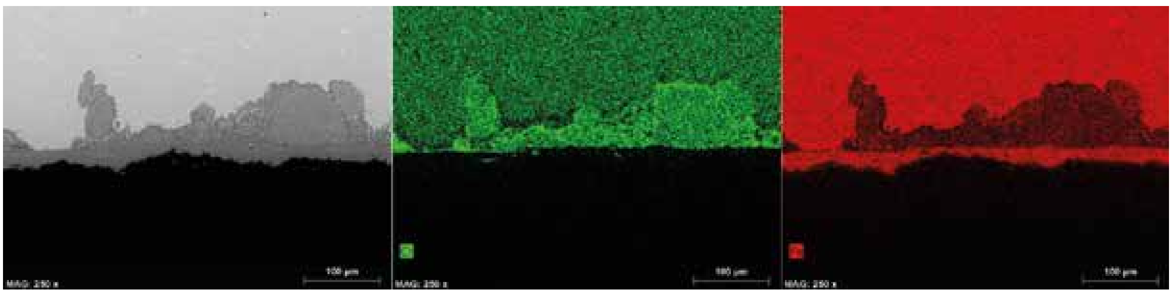


Figure 2: Example of an oxide layer of the 18Cr11NiNb material as seen through a scanning electron microscope (left), and the distribution of chrome (in green) and iron (in red).

# Wind Turbine Drive Trains

Understanding damages and increasing reliability.

By Thomas Gellermann and Dr. Thomas Griggel

## The current wind energy situation

The growing demand for renewable energy sources has seen a significant increase in the use of wind energy. Germany is currently home to wind power plants with a total power capacity of approximately 30,000MW. This corresponds to the nominal power output of around 30 to 35 large fossil energy power plants. It is important to remember, however, that the output of a wind power plant is naturally dependent on the wind. The average power output of an onshore wind power plant in Germany is around 1,500 full-load hours per year – less than 20 percent of the installed capacity. Though far higher values are obtained in coastal and especially offshore locations. For example in 2011, the German offshore wind farm Alpha Ventus even reached 4,450 equivalent full-load hours, far exceeding expectations.

The rapid development in the size of these plants has generated an important growth market and, with it, a variety of challenges and some major technical problems. AZT has investigated wind turbine damages since the beginning of the 1990s, with particular focus on the mechanical drive train, which is subject to high dynamic stress during operation. Both AZT's own experience and different studies have confirmed that individual components of the drive train fail a lot sooner than their estimated designed lifespan of 20 years. Consequently, in addition to normal maintenance, significant repair work to major components must be anticipated.

## Exposed to the elements

Gusts, turbulence and wind shears mean that wind speeds can fluctuate considerably (Figure 1). These, alongside the known variations in torque and power output of wind energy plants, lead to constant changes in rotor thrust. Variations in wind speed and direction across the area covered by the three rotor blades means they generate different thrust levels, resulting in considerable lateral force and tilting effects on both the drive train and the structure.

Modern wind turbines have a rotor diameter of around 120 meters. The area they cover while rotating is approximately the same as two football fields. With turbines set to grow in size (150 meters plus), stress on the rotor blades and the drive train, in particular the main bearing and gearbox, is likely to increase.

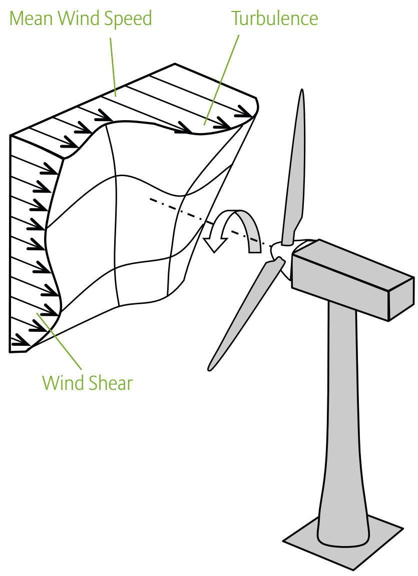



Figure 1: Schematic wind field pattern

## Drive train damage

One of the main focal points of the plant is the components of the mechanical drive train and its gear teeth (main gearbox) and bearings (rotor, main gearbox and generator). AZT has carried out a number of damage investigations into these parts, with some examples listed below dating from 1993 to 2012. They have allowed the center to identify common areas of damage in wind turbine drive trains.

### *Gearing damages*

AZT's investigations into the main gearbox of wind turbines have revealed that almost 60 percent of gearing damages are related to mechanical loads, which are higher than the bearable stress of the components. The cause of these loads can range from insufficient dimensioning and constructive defects to overloads during operation. The state of lubrication, the quality of the materials used and the production process are further common causes leading to gear damages. Individual damages may have more than one cause.

### *Tooth flank damages on the pinion shaft*

The damaged sun pinion shaft in Figure 2 is part of a planetary gear, which was used as an input gear stage of a wind turbine. The rotor shaft of this turbine had a three-point suspension, which is formed by the main bearing and the two lateral torque arms mounted on the sides of the gearbox (Figure 3). The tilting loads, generated by the rotor blades, are transmitted by the rotor shaft into the input gear stage.

The contact pattern shows a strong uneven load distribution. The flank surface is deformed and damaged by pitting and grey staining. The AZT investigation showed that the uneven contact pattern between the sun pinion and the planetary gears is generated by displacement and misalignment. This effect is mainly caused by the three-point suspension of the rotor shaft, which transfers shear force and displacements onto the gearbox.

The effect of the shaft misalignment in the tooth mesh contact can be reduced, for example, by applying a suitable modification of the tooth flank geometry. However, today's standard tooth flank corrections of grinding can only be optimized for one operating point. To reduce the effects of tilting loads and shear forces within the planetary gear, a separate rotor support and a flexible gearbox support could be used instead of the three point rotor suspension (corresponding AZT investigations have been published on this subject).

Figure 2: Sun pinion with tooth flank damages resulting form an irregular load distribution.

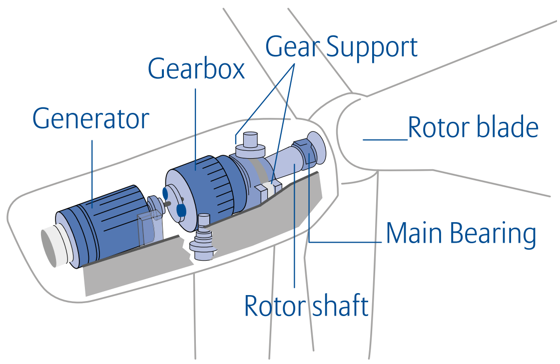



Figure 3: Three-point support of the rotor shaft

### *Damages of rolling bearings*

The AZT investigations of rolling bearings discovered that the main focus points for damages were represented by insufficient lubrication (45 percent), shocks applied during standstills (28 percent) and excessive stress (26 percent). Other causes are slippage, ring movement, misalignment, electric current, corrosion and manufacturing defects. The studied rolling bearings were used in the main gear and for the rotor suspension.

Figures 4 and 5 illustrate the damaged spherical roller bearings, which are used as rotor bearings and for the support of the wheels of the planetary gears in the main gearbox. In the case of both bearings, one of the two raceways is damaged extensively. This indicates an uneven load distribution between both raceways resulting from high axial loads with a unilateral effect, where the highly axially stressed raceway also receives most of the radial load. Additionally, shocks occur during standstill and operation.

Figure 4 & 5: Damaged spherical roller bearings – planetary bearings (left) and damaged spherical roller bearings – rotor bearings (right).

The laboratory investigations of the rotor bearing (Figure 5) indicated that, in addition to the high stress placed on the raceway surface, there was a lack of lubrication in the rolling contact.

## Maintaining performance

The operating time of damaged parts investigated in AZT's laboratories is often less than five years. Therefore, a suitable concept for maintenance and overhauls is necessary for wind turbines. There are several maintenance strategies which can be applied (Figure 6).

In the case of damage-related maintenance, the plant is operated until it malfunctions. This usually generates very high repair costs, because the damage is often extensive and requires longer to repair. Periodic maintenance is also relatively costly, because the overhauls take place at fixed intervals, irrespective of the condition of the equipment.

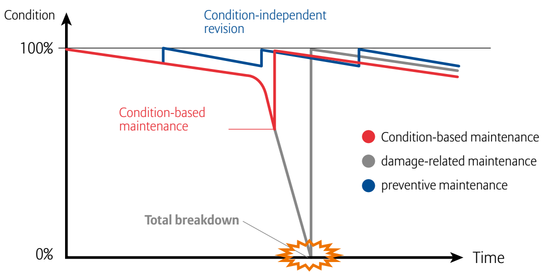



Figure 6: Comparison of the different maintenance concepts.

For economic reasons, condition-based maintenance is the preferred approach. This aims to maximize the lifespan of the components and minimize damage. An essential tool for the automatic recognition of changes in the condition of drive train components is Condition Monitoring Systems (CMS). In 2003, AZT published a comprehensive catalog of requirements for these systems to establish quality standards for vibration-based CMS. These requirements are regularly used in the market and employed by Allianz for risk improvement.

CMS have proven beneficial because necessary repairs can be planned for the low-wind season and downtimes can be reduced. Condition monitoring is growing in popularity. According to a survey conducted by AZT in 2012 with a selected number of European and American system providers, there are more than 23,000 vibration-based condition monitoring systems installed internationally for drive train monitoring.

Design and validation are key – monitoring helps. The extensive damage research and additional investigations carried out by AZT have shown that the assumed loads in the design of components are not always sufficient. Simulation methods should bring qualitative and quantitative improvements in load assumptions.

Comprehensive prototype measurements for testing new plants are, however, still essential. The study of operational behavior and loads are important. This helps determine weak points in design and construction and helps implement corrective measures before the start of serial manufacturing. Furthermore, the main components of prototypes should be disassembled and investigated after a representative operational time of one to two years.

To increase the reliability of multi-megawatt and offshore wind turbines, AZT recommends vibration-based CMS to be standard equipment. The limited accessibility of offshore plants in particular is a strong argument for extending condition monitoring to other components and refining drive train monitoring with additional methods. AZT published a paper recently on how the scope of CMS for multi-megawatt and offshore wind turbines can be further extended.

# **Power** of the Underground

Geothermal power may offer an environmentally friendly method for generating electricity, but technical improvements must be made for it to reach its full potential.

By Dr. Ulrich Hohmann

While geothermal power plants do not yet significantly contribute to power production in Germany, they are already enjoying something of a boom around the world. Globally, there are more than 500 in use, generating more than 10,000MW of electricity. The International Geothermal Association expects this figure to reach 18,500MW by 2015.

Despite the small number of plants in operation in Germany, AZT has dealt with several cases of damage in geothermal plants. In particular, the center has focused on problems in thermal water pumps and the machinery used to generate electricity; that is the heat exchangers and turbines (see Figure 1).

## Under pressure

The core element of a geothermal installation is the thermal water pump. It is usually installed several hundred meters within the production well, which has a diameter of just a few centimeters. The operating conditions feature not only high pressures and temperatures, but also high corrosion potential from the water and erosion from rock particles, all of which cause significant wear on pumps and drive motors. Testing or repairing such equipment is time-consuming and costly, as the pump has to be extracted from a great depth. Delays to projects and long non-operational periods can lead to significant expenses.

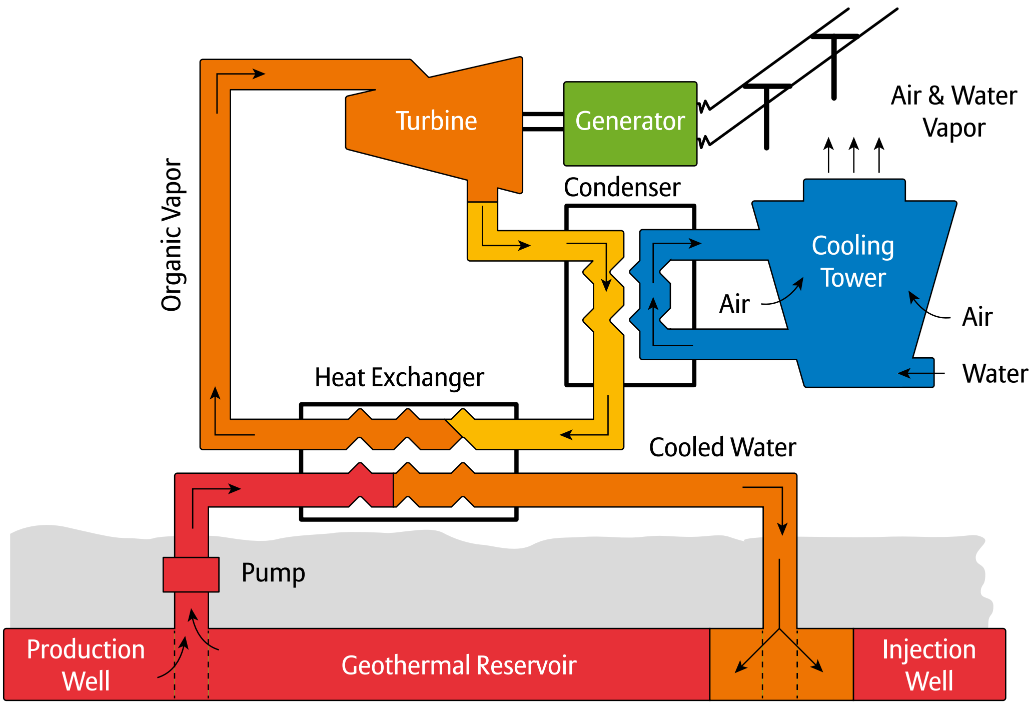



Figure 1: A geothermal power plant in detail.

In principle, geothermal energy can be used to produce electricity in a number of ways, although only the Kalina and Organic Rankine Cycles (ORC) are used in Germany. The relatively low thermal water temperature (approximately 130°C) requires special vaporization equipment for the turbine to efficiently produce electricity from the heat. In the case of the Kalina cycle, a mixture of water and ammonia is used as a circulating medium. During this process, a partial vaporization takes place and only the ammonia-rich steam is driven through the turbine. Behind the turbine, steam and a water-rich liquid phase are merged and cooled in a pre-heater and condenser. In the ORC process, only organic materials such as isobutene are used. These are fully vaporized, supplied to the turbine and subsequently condensed by the pre-heater and the condenser.

In both processes, the thermal energy of the water is transferred to the medium in the heat exchangers. Similar to the geothermal power plants, plate heat exchangers are usually used. In comparison with the tube heat exchangers, the plates offer a large surface area and are cost-effective. The disadvantage of this type of heat exchanger is the large sealing surfaces between the plates. These result in low pressure and temperature limits for the plates.

## Dangerous leaks

Observations over the past few years have shown that leaks appear repeatedly on plate heat exchangers. This presents a special problem due to the toxicity and flammability of the employed fluids. The causes for the leaks are manifold, but the decisive factor is that heat exchangers are operating at near capacity. The thermal water pump malfunctions described earlier cause frequent start-ups and shut-downs - an unstable way of operating, which leads to an uneven use of the sealing surfaces over time and the loosening of sealing materials.

Figure 2: Partial view of the plate heat exchanger with a leak (Image: Siemens)

In addition to leaks, it was also established that the thermal water had attacked the sealant materials. The water can carry significant quantities of organic matter, which can have a negative impact on the durability of sealing materials. When selecting materials, it is important to remember that they must be resistant to both the thermal water and the process medium. In some instances, it may be necessary to use expensive custom-made gaskets.

The investigations and analysis conducted so far by AZT show that there is room for improvement in terms of individual components and operating a power plant in a cost-effective manner. In particular, the design of current plate heat exchangers does not allow for safe and long-term operation. AZT recommends installing tube heat exchangers, in particular with respect to the toxic fluids, which are employed.

# Turning Waste Into **Energy**

Boilers for the energetic utilization of biomass, Refuse-Derived Fuel (RDF) and waste material.

By Dr. Ulrich Hohmann

With the search for an optimum solution still ongoing, better fuel management can help extend the lifespan of grate-fired boilers. Biomass power plants have been built in facilities such as paper factories for decades, allowing free or low-cost waste materials and residue to be put to profitable use. Political developments designed to encourage the use of more environmentally friendly fuels, such as Germany's Renewable Energy Act, mean that in recent years, more and more plants have been erected, leading to surplus capacity. As a result of the increased demand, the costs of waste materials has increased in such a way that the economic operation of waste incineration plants is becoming more and more difficult.

Wood-based waste material, Refuse-Derived Fuel (RDF), industrial waste and untreated domestic waste are mostly burnt in grate-fired boilers, with the resulting energy being used for power production. The sketch in Figure 1 shows the function of a grate furnace. Fuel is transferred through the charging hopper to the feeding device on the feeding grate. Cooling air is fed via the ash hopper below the grate.

Intriguingly, the operational load placed on boilers is comparable for all the fuels mentioned. As a result of the distinct heterogeneity and the particularly high corrosive potential of the fuels, this type of boiler is subject to high thermal and corrosive stress. The main parts affected are the boiler tubes, refractories and firing grates, which often do not meet their operating life expectancy. Consequently, unplanned standstills can be accompanied by very high costs.

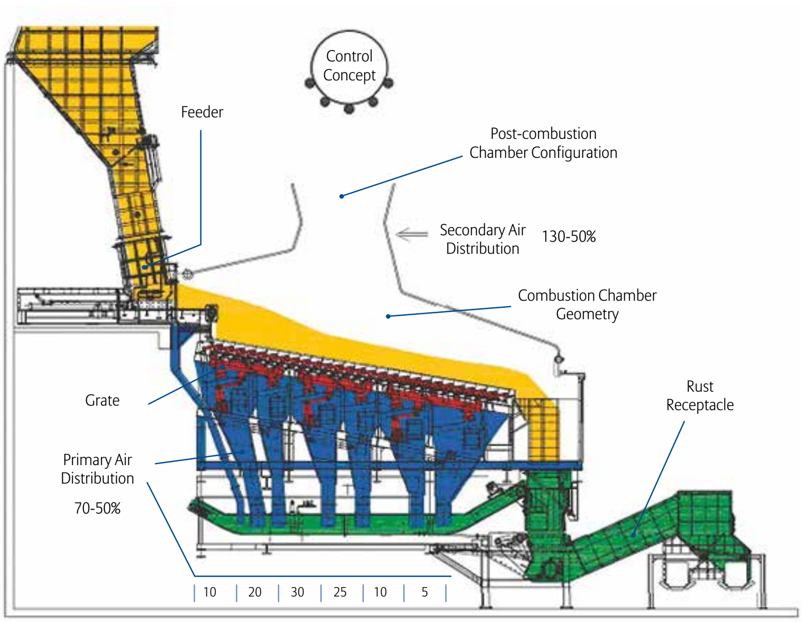



Figure 1: Stoker-fired furnace in detail.

## Searching for solutions

Depending on the quality of the fuel, serious abrasion can occur on vaporizer and super-heater tubes within one year. This is due to salts in the fuels, which are released during the combustion processes and then transported with the flue gases onto the pipes. Over time, ash deposits build up that cause the underlying surfaces of the pipes to corrode. Even though the relationship between the forming of ash deposits and corrosion has been established, a cleaning method that leaves the pipes free of deposits is yet to be identified.

One option is to coat the pipes with protective layers of corrosion-resistant nickel-based alloys. Different types of spray coatings or welded protective coatings that show partial resistance are available. However, such application is limited to evaporator tubes operating at lower temperatures.

## Multiple sources of stress

To help insulate and protect against corrosion, the membrane walls of the boiler are partially lined with refractory. Where ramming mixes were used in the past, today silicone carbide (SiC) tiles are used to protect the membrane walls. However, tests conducted by AZT have shown that these ceramic materials are also subject to corrosion, resulting in plates losing their heat resistance and separating from the membrane wall in large areas.

The furnace grates represent the third high-stress area. High heterogeneity, especially in terms of water content and bulk density of the fuels, can keep the primary air below the grate from being sufficiently distributed. The results are unbalanced combustions and an increased flow of slag. In extreme cases, this can lead to the grate being blocked, thermal damages to the grate or even the complete collapse of grate (see Figure 2). In addition, the unbalanced combustion and the high localized temperatures can lead to extreme corrosion and thermal erosion of the grate bars. The only way to counteract such degradation is through improved "fuel management," which means using only suitable fuels that are properly mixed.

Figure 2: Damage of the grate as a result of overheating and corrosion

## Signs of disintegration

In recent years, AZT has dealt with numerous cases of damage to the refractory lining in boilers. The team uses in-depth analysis of the complex corrosion mechanisms to establish the cause of the damage. One example is the center's investigation of $Si_3N_4$-bonded SiC tiles. The tiles are predominantly used in the first flue of a boiler. The corrosion affects mortared, rear-casted tiles, as well as rear-ventilated tiles.

The $Si_3N_4$- binding matrix of the tiles has the necessary porosity for thermal fatigue resistance to prevent them from becoming damaged by repeated heating and cooling. Due to temperature gradients, vapors of alkali and earth alkali salts diffuse into the open pores of the binding matrix, condensate on the surface of the pores and react in a complex manner with the binding matrix, essentially disintegrating the $Si_3N_4$. The electron microscope images in Figure 3 show these signs of disintegration on pores.

The disintegration of the binding matrix is a strong indication of the formation of silicon oxide (SiO), which is a gaseous corrosion product of $Si_3N_4$. In a temperature range of (500 °C – 1,000 °C), this type of SiC-corrosion involves negligible partial pressures of oxygen. This implies reducing atmospheres behind the alkali rich layers while the atmospheres of the pore volume are oxidizing.

Figure 4 indicates that acicular crystals formed in the large cavities are, surprisingly, composed of "pure" calcium silicate. The presence of calcium silicate crystals indicates reactions of SiO (the gaseous corrosion product of $Si_3N_4$) and vapors of calcium chloride as being part of the flue gas.

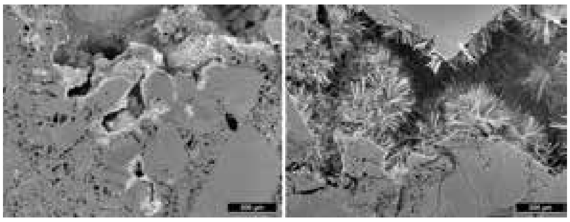


Figure 3 & 4: Corrosion of SiC plates (left) and forming of crystals in the cavities (right).

## Better fuel management

Boilers that use biomass, waste products or RDFs for the production of energy, are subject to a high degree of wear as a result of the corrosive conditions. The repeated attempts to counteract this effect by using higher-grade materials have achieved only limited success so far. According to AZT's research, a reduction of this erosion can only be achieved through better fuel management, even if current economic conditions leave little room for maneuver.

# Staying Ahead of the **Curve**

## Cases of damage in parabolic trough power plants.

By Jörg Strohhäcker

The use of parabolic troughs for steam generation dates back 100 years. Their size and extensive use of delicate materials such as glass and thermal oil mean they are susceptible to different causes of damage.

Parabolic troughs were first used in 1912 to generate steam for a 45-KW steam pump in Meadi, Egypt. The five rows of collectors had a length of 65 meters each, an aperture of four meters and a total reflecting surface of 1,200 $m^2$. Commercial use of this technology began in the United States in 1984. There are now nine solar power plants in California and one in Nevada generating a total power output of over 400MW. Worldwide, there are currently parabolic trough power plants with a total capacity of approximately 650 MW and a yearly output of approximately 2,300GWh when in operation. Numerous other plants are planned or under construction in the US, Spain, South Africa and other locations such as Morocco, Algeria and Egypt.

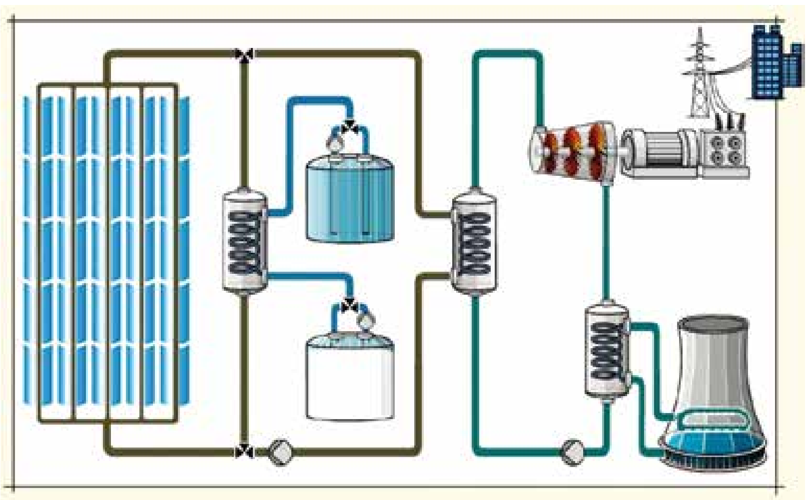



Figure 1: Components of a parabolic trough power plant

## How it works

The main components of a parabolic trough power plant are the solar field, the two salt storage tanks and the power block (Figure 1). Within the solar field, the parabolic mirrors concentrate solar radiation on the absorber tubes, in which heat-resistant thermal oil is used as a heat transfer medium. This oil transports the heat to the heat exchangers, where steam is produced, while one of the salt storage tanks is loaded simultaneously. The steam then powers a turbine, and electricity is generated through a connected generator. In order to be able to maintain operation during the night, the salt that was heated during the day is pumped through a heat exchanger into a cold salt tank, releasing energy into the oil circulation.

A state of the art 50MW power plant is made up of more than 200,000 parabolic mirrors covering around 500,000 $m^2$ and more than 20,000 absorber tubes with a total length of approximately 90 km. More than 2,000 tons of thermal oil transfers the solar energy to a salt storage with a total volume of approximately 30,000 $m^3$, as well as through a heat exchanger to the turbine. The water consumption for the cooling tower is more than 800,000 $m^3$ each year.

Figure 2: Parabolic mirrors with receiver pipes.

## Damage in the solar field

During the first operating period of a parabolic trough power plant, frequent glass pipe breakages have occured. As a result, the parabolic mirrors situated beneath were partially damaged by pieces of falling glass. The glass pipe breakages, most of which run perpendicular to the tubular axis, appeared mainly around the front receiver end pieces, usually immediately behind the glass-to-metal seal with a bulge caused by the manufacturing process (Figures 2 and 3).


Figure 3: Typical glass breakage near the glass-to-metal seal.

AZT's investigations focused on several different possible damage causes. The first centered on factors generated by the manufacturing process, as the area around the glass-to-metal seal is susceptible to breakages from increased pressure in the glass caused by changing temperatures. The quality of the glass-to-metal seal was tested on several broken tube samples for the formation of bubbles and internal residual tensions.

The second area of investigation focused on factors generated by the installation. When the distance between the aluminum reflector/insulation plates and the glass tube not big enough is, they can rub against each other. Sand or dust particles can form in the gap and lead to tiny scratches on the glass, which speed up breakages when the glass is subjected to stress from temperature changes.

Special operating conditions can lead to problems such as excessive vibrations from the fluid flow or pressure surges, and excessive temperatures in the area of the receiver ends. Temperature measurements on the installation indicated that temperature spikes of approximately 250°C can occur in the immediate vicinity of the glass in the glass-to-metal seal; that is, in the insulation area. In particular, fast cooling processes, such as water-jet cleaning, cause increased stress on the glass tubes.

Comprehensive analyses results revealed a high likelihood that a combination of installation influences and the high stress caused by the changes in temperature, led to the glass breakages. This tendency was increased by additional mechanical stress, like pressure surges and vibrations.

## Damage in the power block

Another AZT investigation examined leakage from the externally insulated vent pipe of a reheater, which is heated by thermal oil at 400°C and 40 bar. After removing the insulation, the thermal oil ignited. Fortunately, the fire could be extinguished before much further damage occurred.

The reheater is vented twice a day. In other words, the vent pipe receives a through-flow for only a short period of time. The pipe is split open lengthwise in the area of the trace heating, without a necking on the break line (Figure 4). The line of the trace heating was near the cracked pipe (Figure 5). As the entire power block is situated outdoors, trace heating is necessary to prevent thermal oil from freezing when the exterior temperature falls below 12°C.

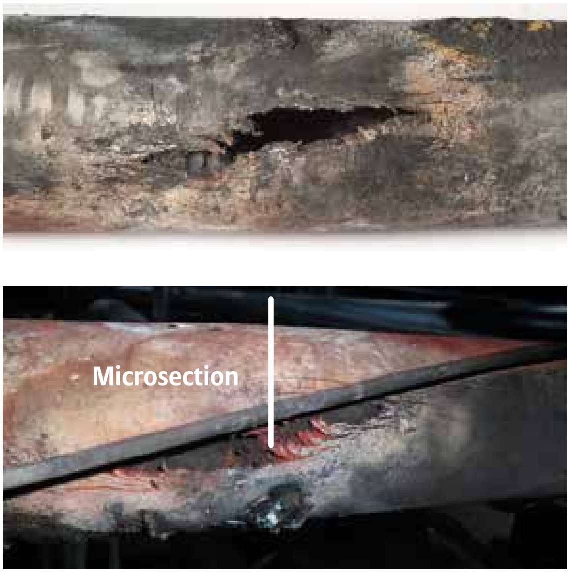



Figure 4 & 5: Split area (left) and trace heating line above the breakage area (right).

The results of the investigation showed that the interior of the pipe was filled with black deposits, similar to soot, in the area of the breakage. These originated from thermally cracked thermal oil. The multilayer structure of the deposit indicates a delayed formation from changes in temperature, which can occur as a result of the repeated starting of the vent pipe during daily operation (Figure 6).

Figure 6: Deposits on the pipe interior.

In the area of the breakage, there are wide, inter-granular cracks on both the interior and exterior, and an overheated coarse grain structure formed on the outside of the pipe (Figure 7 and 8). Hardness readings sunk below the specified minimal values. The damage pattern of the pipe breakage resembles short-term creep damage, or a forced rupture, as a result of thermal overload by the trace heating.

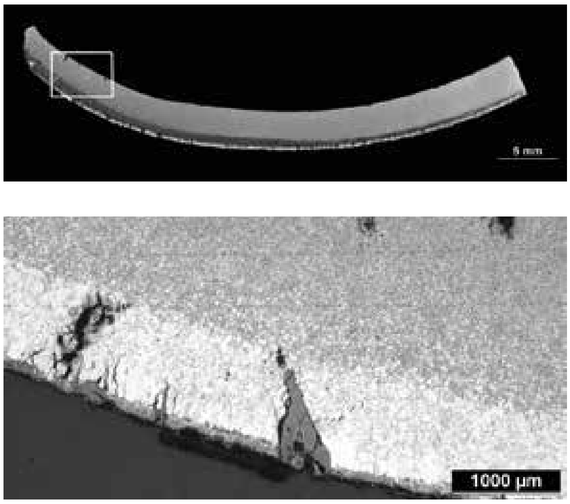



Figure 7 & 8: Cross section of Figure 4 (left) and cutout of Figure 7 (right).

## Lesson Learned

The overheating of the vent pipe system could have been prevented by the installation of a temperature monitoring system.

# **Unexpected** Critical Aspects

## Hazards and perils resulting from solar power plants.

By Andreas Bemm

An increase in the use of solar power has seen a growing number of damage cases with photovoltaic systems. While the components of a solar power plant are standard and simple, the sum of their parts is complex. In addition to their complexity, their sheer size and exposure to the elements can lead to a variety of factors that must be considered from the planning phase onward.

The move away from nuclear power toward more renewable sources of energy such as solar power is gathering pace. Usually, solar power can be generated by transforming the electromagnetic radiation energy from the sun into electrical, thermal or chemical energy. Vital for the production of energy is the direct, single-step conversion of the radiation energy from sun into electrical power through photovoltaic systems (PV systems).

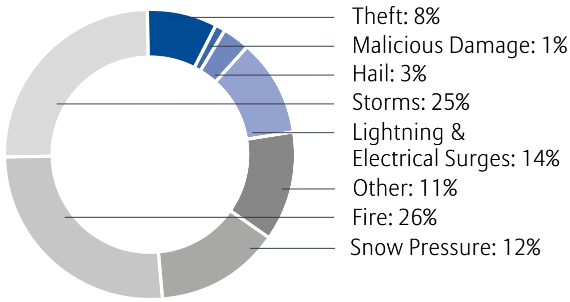
In Germany, energy from PV systems already represents a significant portion of the country's total electrically generated energy. In May 2012, PV systems reached a peak production of 22GW, approximately 40 percent of the total power output, or the equivalent of 15 large nuclear power plants. This growing contribution to energy production requires an increased focus on the economic efficiency, availability and security of supply, especially when it comes to larger PV systems.

## AZT and photovoltaic systems

PV systems represent investment products that should technically be very safe, durable and economically efficient. AZT has accompanied a variety of PV projects from construction through installation, and has performed damage analysis investigations. Experience shows that damage can be traced back to insufficient planning and design, defective materials and the wrong selection of materials, poor installation quality, inadequate protection against technical errors and lightning or electrical surges.

Statistics from the Association of German Insurers (Gesamtverband der Deutschen Versicherungswirtschaft, or GDV) indicate the distribution of damage frequency from 2004 to 2007.

**Damage Frequency 2004 - 2007**




Alongside damage from storms and snow (37 percent), fire, lightning and electrical surges represent most of the causes (40 percent).

As a result of the increasing age of the installations, it is expected that operational interruptions, damages and defects caused by aging materials will become more frequent. Many of these damages could be avoided if the basic principles of professional technical planning, construction and installation, as well as quality assurance, were adhered to.

In this context, the work begins at the pre-planning stage and ends with an operational and maintenance concept, as well as with comprehensive technical documentation

Figure 1: Example of a large PV power plant
(Source: Shutterstock)

of the installation and concept description. However, many of those involved, such as planners, constructors, investors and operators, are often either unaware of the technical hazards and perils, or they cannot assess them correctly. This applies in particular to the dangers of insufficiently planned or constructed photovoltaic plants and installations. A possible reason is the supposedly simple technical structure of PV installations, which, due to their structure, are easily scalable and constructed without extensive prior experience.

## Systemic particularities

In principle, PV systems cover large areas. This leads to long cable routes and cable windings with a large number of clamping units. In rooftop systems, this can regularly lead to disturbances in the grounding and lightning protection system. This shortcoming of the system is often not recognized by the constructor and the planner, which is why AZT recommends involving a lightning protection expert at the beginning of the planning phase.

The large surface area covered by the installations and their long cable routes require a large potential equalization system and well-coordinated lightning and surge protection. Another difference to normal electrical installations, especially to those found in building technology, can be found in a PV systems' DC components, which operate at a system voltage of up to 1,000V DC. This means that in addition to the normal AC voltages, the PV installations also have high DC voltages, which affects materials, switchgears and safety equipment used.

The short-circuit capacity in the DC part of the installation is small in comparison to the nominal power of the module. When damage occurs, this leads to difficult shut-off conditions. These examples are just a few of the system characteristics that have to be taken into consideration during conception.

A 50MW solar park, for example, boasts a surface area of 1,620,000 m², with a modular surface area of 500,000 m². In order to be able to install the nominal power, 700,000 modules of 75 watts-peak each were installed. The interconnection of the modules alone results in more than 700,000 DC plug connections. These large numbers indicate that even a malfunction or failure rate of 1/1,000 per year could still result in up to 700 damages each year.

## Hazards and perils

In general, all technical plants are subject to innate, as well as external hazards and perils.

**Hazards and perils originating from a PV installation**

- Electrical voltage: DC voltage of up to 1,000V
- Fire: as a result of a lightning, technical defect, overloading or electrical arc
- Electromagnetic compatibility: circuit feedback, network stability
- Environmental damage: especially in cases of fire and disposal
- Static overloading: roof construction, for example

The danger presented by DC voltage is often discussed in the media, which focuses on the potential risks to firefighters when extinguishing a fire. Putting out a fire on live components is not without danger, but if the known safety distances are adhered to, then extinguishing a fire is possible and, in fact, relatively common practice. This applies to both AC and DC voltage. Nevertheless, some firefighters will still ask for the modules to be switched off.

If a modular installation that addresses this concern were to be constructed (comparable with the installation in Lieberose) the installation would have the following technical specifications:

**Module data**
Module power: 75Wpeak
Open circuit voltage: ~94V
Voltage at nominal power output: ~71V
Current: 1.1 amps
Short circuit current: 1.21 amps

**Power plant data**
Plant power: Ppeak= ~53 MWpeak
Number of modules: ~700,000

The data indicates that the module already has a voltage of 94V. In order to keep within the extra ***low voltage prerequisite*** (<120V DC), it is necessary to use a DC shut-off device after or on each module. This means 700,000 additional areas to monitor, with 700,000 switches and the corresponding control and measuring lines that go with them. Additionally, there are more than 1.4 million additional contact points or plug contacts necessary, which are exposed to the weather.

As a result, there are more than two million additional potential errors that could generate fire damage. The effects this has on the efficiency, availability and security are obvious, particularly when switch defects could prevent the installation from being switched off. Just think of firefighters tackling a fire at an installation they believe to have been shut down, only for parts of it to still be live.

In conclusion, not every protection proposal leads to an increase in availability and security of the PV plant.

Fundamentally, the higher the complexity of the installation, the greater the interdependence. This example shows that increased complexity generates additional dangers and an exponential growth in potential errors. Ultimately, the goal must be to reduce the complexity and the interdependencies and to design and build the plants to be intrinsically safe.

**Hazards and perils originating from external factors**
In addition to the dangers caused by technical problems, there are also potential dangers presented by the surroundings. This can include natural hazards such as fire, pressure from snow and ice, hail, flooding, earthquakes and lightning, in addition to problems like vandalism and theft. These must be considered during the planning and design phase.

## Critical aspects

Risk minimization must be taken into account at the planning and construction stage, as well as during operation and maintenance, in order for the installation to be able to fulfill the durability, efficiency, availability and security requirements.

In this context, certain steps must be taken. Firstly, safety goals must be defined and project quality must be ensured. Protection from lightning, electrical surges, fire and natural hazards are to be considered, as well as other elements, such as theft and vandalism. Building materials, waterproofing and foundation construction are also key considerations. The goal should be to minimize complexity and dependencies, and to adhere to the principle "keep it simple" whenever possible. AZT has developed a comprehensive guide on PV systems, which is available at agcs.allianz.com under the 'Insights – Brochures and Publications' section.

### AZT service for PV plants

AZT engineers serve as interdisciplinary consultants for preventative risk management of technical issues related to PV systems. This includes electrical aspects, stress caused by natural elements, such as wind and snow, and safety and protection concepts. In addition to damage investigation, AZT examines and analyses basic failure mechanisms of PV systems.

# Electrochemical Energy Storage in the Public Power Supply

The growing use of renewable energy requires competitive and effective forms of power storage. The experts at AZT are actively monitoring the most recent developments for the key technologies in this sector. Thereby, clients can be supported with well-founded risk assessments and damage analysis. In this context, electrochemical energy storage is coming more and more into focus.

By Rudolf Fischer

Electromagnetic energy – also referred to as electrical energy or electricity – is easily transported and distributed. In addition, it can also be converted into all other forms of energy. However, as a storage medium, it is only suited to be stored in very small quantities.

This means that the collective amount of electricity in public power supply networks must always correspond to the overall demand at that particular time. In this situation, it is always easier to adapt the supply to the demand, instead of controlling the demand. Since the overall demand can change very quickly within a network, sometimes quicker than the large base-load plants can handle, a fleet of power plants inside an electrical network also includes smaller medium-load and peak-load power plants. Their energy production is more easily adaptable to the fluctuations in consumption.

The wider a unitary network is and the better it is developed in terms of number and capacity of the transmission lines, the better the distribution of the local consumption fluctuations across all generators. Energy produced flows to parts of the network that currently need it. Such networks only require a small number of expensive peak-load power plants.

Another way of maintaining balance between supply and demand is to influence the demand. Industrial consumers, for example, sign contracts which allow the electricity suppliers to take a certain amount of consumers off the grid for a determined period of time (load shedding). On the other hand, a remote switching to a cheaper rate motivates customers to turn on special appliances (e.g. storage heaters) during off-peak periods.

## Guaranteeing supply

Recent years have seen a steady increase in the amount of renewable energy fed into the grid. The network now includes a growing number of generators that produce energy not according to demand, but rather according to the rapidly fluctuating supply of renewable energy from sources such as the wind and the sun. The current generation systems and network structures are making it increasingly difficult to guarantee a secure, uninterrupted power supply.

As a result, experts are increasingly discussing means of stricter consumer regulation. Smart grids enable consumers to be integrated into the network control via data exchange and local intelligence, as appliances are equipped with electronics that enable them to participate in network control processes. This helps improve network stability. Even in such grids, however, the amount of electricity produced must always be equal to the demand.

A network can also be stabilized through energy storage. As explained, the direct storage of electricity is only feasible for very small quantities of energy, but there is a solution. It involves transforming electricity into a different form of energy, which is easily stored, then converted back into electricity when needed. An example of this are pumped-storage plants. Driven by electricity, pumps transport the water into an upper storage basin. When more electricity is needed the water is released down from the storage basin and flows through the turbines, which drive the generators that produce the electricity required for the grid.

Electrochemical storage units (often known as battery storage units), represent an increasingly interesting type of storage power plant. Such storage units are composed of a number of electrical storage cells (also known as accumulator or battery cells), which are connected in series and charged via a direct current. Within the cells, the electricity is transported by the electrically charged atoms or molecules (ions), which carry the material needed for charging the cell between the electrodes. This changes the chemical composition of the electrodes in such a way that a direct voltage is generated between them. When the stored electricity is needed, the direct current is allowed to flow in the opposite direction, through the storage cells and the appliance. The direct voltage present in the cells transports the electricity through the cells to the consumer load until the cells are completely emptied, or discharged.

These types of storage cells can only be charged using direct current and can themselves only provide direct current. To be able to connect them to the public supply networks, which operate on alternating voltage and current, the electricity must first be converted from alternating current into direct current. During the discharging, the direct current becomes the alternating current again. Both operations are performed with the help of power electronics.

| | Lead-acid Storage Battery | NiCd Storage Battery | NiMH Storage Battery | Li-ion Storage Battery | Sodium-Sulphur Storage Battery |
|---|---|---|---|---|---|
| Energy Density | 30 Wh/kg | 40 Wh/kg | 60 Wh/kg | 160 Wh/kg | 100 Wh/kg |
| Discharge Cycles for 100% depth of discharge (round figures) | 500 | 1,500 | 1,000 | 2,000 | 2,500 |
| Operating Temperature Lower than | 50˚C | 50˚C | 50˚C | 50˚C | 360˚C |

Reducing depth of discharge (e.g. 80% of nominal value) also diminishes gettable energy density but increases number of discharge cycles.

Figure 1: Types of accumulator cells

## Recent developments

There has been a range of interesting innovations and developments in storage capacity and storage cell cost in recent years. The structural components of power electronics are currently manufactured in high numbers and are thus conveniently priced for battery storage. This makes electrochemical energy storage interesting for two main tasks.

Battery storage can be used  to compensate for slow load cycles, such as with wind power plants close to the coast, which can experience a daily cycle of calm on- or offshore winds. The capacity of the battery storage units is calculated in such a way that the accumulated energy spans the calm periods, ensuring a steady flow of energy into the network. Even with large consumers that need energy intermittently, the stress on the supply network can be compensated by using battery storage units. The aging of the storage cells as a result of the loading and discharging cycle is well documented for such large cycles, meaning predictions regarding economic feasibility of the individual applications can be made accurately.

Another application is becoming increasingly attractive for energy suppliers. For industrial plants or residential areas, which are only connected to the network by individual lines, storage units can help compensate for randomly distributed but short peak loads. Although a complete discharge is seldom, the minimum capacity of the battery must always be available. The aging resulting from such micro-cycles has so far only been researched for a small number of battery types. There are currently only estimates available regarding the service life expectancy of new and more efficient storage cells.

## Outlook

For reliable economic predictions as well as the proper assessment of related technical risks for this type of installation, sufficient experience with prototypes needs to be collected. AZT experts believe that this storage technology will be a key factor in the growth of renewable energy and will therefore continue to closely and actively monitor the developments in this sector.

# **Shedding Light** on Blackouts

Ever-increasing challenges in the emerging risks field.

By Michael Bruch and Andreas Bemm

(Source: Shutterstock)

Power cuts are becoming ever more frequent, with large-scale blackouts an increasing and costly occurrence. AZT helps clients manage risks through assessment, development and implementation of risk mitigation measures.

Week-long blackouts that shut down production at companies and critical infrastructure like telecommunication networks, financial services, water supplies and hospitals – this is an increasingly realistic scenario. And, while the majority of national grid power failures last only a few hours, the world's energy networks are becoming more vulnerable to systemic failure. The reasons for this include the lack of incentives to invest in aged national grid infrastructures in Europe and the United States, as well as the fact that energy from decentralized, "volatile" renewable sources is not well-suited to electricity grids that were designed many decades ago. Additionally, as more and more grids are interconnected, a blackout in one region can trigger a domino effect that could result in supra-regional blackouts. Heightened risk from terrorism, cyber attacks and solar flares also add to the situation.

Many companies are unprepared for business disruptions caused by blackouts, and are often unaware of the true costs and impact they can have on their operations. Research from AGCS shows that the financial impact of even a small power cut can be catastrophic. Analyses from blackouts in the United States show that a 30-minute power cut results in an average loss of US$16,000 for medium and large industrial clients, and nearly US$94,000 for an eight-hour interruption. Even short blackouts – which occur several times a year – add up to an annual estimated economic loss of between US$104 and US$164 billion.

## An emerging risk

The significance of power cuts and the risk they pose is not lost on the insurance sector. The Emerging Risks Initiative of the Chief Risk Officer Forum, which consists of nine members representing AIG, Allianz, AXA, Generali, Hannover Re, Munich Re, RSA, Swiss Re and Zurich Financial Services, was launched in 2005 to raise awareness of major emerging risks relevant to society and the (re)insurance industry. In 2011, the initiative was chaired by Allianz and the increasing risk of power blackouts was identified and described in a risk study as one of the predominant emerging risks for customers, insurers and society.

(Source: Shutterstock)

In addition, AZT engineers analyze the scope and causes of losses from power blackouts. This can range from physical losses in aluminum production, data losses, for example in production lines, to availability issues in IT data centers.

Based on the results of these analyses, recommendations for repair and refitting measures are made. Once carried out, AZT also monitors the performance of these measures.

The information gained from these loss analyses form valuable input for client recommendations on how to avoid business interruptions caused by power blackouts and how to develop new risk mitigation solutions. AZT engineers advise clients on how to assess the impact an electrical blackout could have on critical infrastructures so that clients can review and determine whether they have the right controls in place to help mitigate the risk.

Critical infrastructures are defined by the German Federal Ministry of the Interior (Bundesministerium des Innern, or BMI) as important organizations and institutions that would in cases of failure or impairment result in long-term disturbances and safety issues for the general population. Examples include socio-economic services, such as public health, emergency and rescue, and government, as well as fundamental technical infrastructures, such as telecommunications, electrical power supply and information technology. AZT also gives technical advice on the development and application of power supply concepts where a high level of reliability and safety is required.

## Treading new territory

Insurance coverage is available on the market to offset the risks of power blackouts. But most of the policies that cover business interruption are usually triggered by physical damage, such as a fire on-site, which is the case for, on average, just 20 to 25 percent of business interruption losses. Power grids, however, generally contain internal safety mechanisms, which cause the power supply to be shut down before physical damage occurs; this demands new risk transfer solutions.
Even if this emerging risk continues to rise, AZT engineers can bring substantial benefits to clients and underwriters to manage this through all steps, from identification and assessment, up to development and implementation of risk mitigation measures.

### Non-Damage Business Interruption Coverage

Covering non-damage business interruption is unknown territory for most insurers. But in response to these new risks, AGCS offers a highly customized solution to support multinational clients. The new product was developed in collaboration with clients, underwriters and engineers. The core risk management measure is a properly managed business continuity plan that takes perils, including power blackouts, into account which shall be covered. The risk assessment that forms the basis for the pricing is done by internal engineers and underwriters after a personal session with the client's risk manager and BCM officer/enterprise risk department. The result of this assessment offers an overview of interdependencies between the insured locations, the impact for suppliers and customers, and the impact for major transportation hubs with respect to the assumed business interruption scenario.

# The next **80 years**

## "Product design is a great chance for AZT"

Martin Eckert, Siemens

As Head of the Captive Project & Third-Party Business at Siemens Financial Services, Martin Eckert is responsible for the insurance-specific consulting and brokering activities for the entire Siemens project portfolio, which includes manufacturing, installation and operation of a broad range of advanced technology products. Siemens has a strong presence in the fields of industry, energy, healthcare and infrastructure solutions. With AGCS as one of the leading insurers for many of the projects under his responsibility, **Martin Eckert** and his team work together with AZT in various areas.

Offshore wind power is a major focal point for Siemens and an area in which AZT continues to develop. (Source: Getty Images)

***Can you describe your working relationship with AZT?***

One of the main benefits of working with AGCS is the fact that AZT is there to offer additional support to the technical underwriting approach of AGCS. To have an insurer with that level of expertise in the background is a real advantage. On the occasions when we face field issues with our equipment – that means technical challenges, defects and/or damage to our supplies or any other quality aspects, then we sometimes rely on AZT's input. They independently analyze the cause of the problem and propose amendments, acting as a sparring partner to our Siemens engineers. There are also occasions when we may have a contractual dispute with a customer. Then we or the other party call in AZT as a widely accepted independent technical expert. In general, AZT is and has been a valuable partner for Siemens and Siemens Financial Services on many occasions. Of course, we have a lot of in-house technical expertise at Siemens, but it's very beneficial for us to have a well-known external partner with a broad acceptance level. Hence, AZT can supply our engineering staff with new, different perspectives on product development processes, product integrity and technical solutions.

*How important was the presence of AZT in your choice of AGCS as an insurer?*
One of the most important criteria in our tender for Siemens' main technical insurance master covers was the level of capabilities for technical underwriting. And that doesn't just mean having a few risk and claims engineers, it requires a broad basis of engineering skills – people who can work on the same level as our experts. The combination of AGCS and AZT could be seen as a benchmark for the engineering insurance market. If we were to go elsewhere, then we would expect a similar set of skill, linking insurance and broad technical expertise. Here, we have both.

*Can you describe some of the projects or cases that you have worked on with AZT?*
Perhaps the most well-known and the most significant case was damage to a power plant in Leipzig, back in 1996. First investigations indicated a fracture to the gearbox of the gas turbine generator. Obviously, it was critical for both Allianz and Siemens to identify the circumstances of that incident and its main contributors. Given the damage caused, it was very difficult to establish, but ultimately AZT confirmed the Siemens findings that it was a one-off incident. The investigation led to an improvement in ultrasonic damage testing – an important development.

As I mentioned, AZT also supports us in our research and development. The center accompanied and confirmed part of our last-stage evaluation of a low-pressure part in our steam turbines, for example.

We also worked together with AZT on a geothermal plant in the south of Germany. They investigated certain elements such as heat exchanger and steam turbine and recommended technical improvements in order to secure insurability. In a nutshell, there are a lot of open, technically oriented discussions between AZT and Siemens founded on a strong mutual respect.

*How do you view AZT's expertise in the area of renewable energy?*
It depends on the specific area you are talking about. In wind power, where Siemens is strong especially in the offshore market I believe that AZT's involvement follows AGCS' market positioning. In my perception, AGCS is on its way to becoming a major player in this field. In other areas, such as solar or hydro, I recognize from various events that AZT is very active and can provide useful insight, especially in disclosing potential hazards for roof-top and large-scale photo voltaic projects. As Siemens is developing these renewable business areas, such information is useful for the procurement chain and the structuring of the risk transfer to the insurance industry.

*How do you see the relationship with AZT developing in the future?*
It depends to a certain extent on how we at Siemens decide to spread the risk with our equipment; whether we transfer the insurable risks to the market or choose for higher self risk financing. Even if there might be different levels of involvement in the insurance side, the technical risk remains the same or will even increase with new technologies. Hence I could certainly envisage working together more on risk management and technical development.

In terms of the strategical focus of AZT, I have noticed that the border is not always clear - when is someone working for AZT and when is someone working for AGCS or ARC? Are they offering purely technical support or is it part of the underwriting process already? This needs to be more clearly defined. It also depends on where AZT wants to focus, though.

*How so?*
When I first started working in the field of technical insurance, AZT was working for a broader number of external clients. Since moving from Ismaning in 2007, there is a much greater concentration on AGCS business. The question is: How many resources does that leave for external third-party business? I don't think you should give that up completely. I believe that we and consequently the reputation of AZT have certainly benefited from the fact that AZT works on different projects with a variety of clients. I also think that there is great potential for AZT to become involved at early stages of the product design process. This may be less relevant for Siemens with its many engineering resources, but I think a lot of smaller companies could benefit from the know-how on offer there.

Damages to fossil-fueled power plants are expected to continue to increase in the future - a trend the AZT and VGB PowerTech are taking note of.

# "The importance of sharing knowledge"

Peter Richter, VGB PowerTech

**Peter Richter** is Chief Engineer of Steam and Gas Turbines at VGB PowerTech. The federation was established more than 90 years ago as a technical body for power plants in Germany. Today, it has in excess of 500 companies from more than 30 different countries among its members, including AZT. VGB provides expert networks, research and consulting services to its members and beyond. We spoke to Peter Richter at the recent VGB steam turbine conference in Hamburg about AZT's role within the power plant sector.

*How important are conferences such as this one for the industry?*

Very important. One of our main tasks at VGB is to facilitate information exchange among manufacturers, operators and research institutes. For me, it's encouraging to note that they are becoming increasingly popular. When I started in 1999, we had around 90 people attending, but this week, 490 guests have registered. The desire to learn from the experiences that others have already made has grown – there are more and more younger participants as well as attendees from further afield such as Asia and India, all of whom bring new ideas and perspectives.

*And what is AZT's role at the conference?*

Three AZT employees are holding a presentation on damage mechanisms for low-pressure turbines. We've always found AZT presentations to be very beneficial at these conferences – the company can really draw on its experience with clients outside of VGB, from around the world.

*Would you say that AZT is unique within the industry?*
Yes – no other company combines its technical competence with such insurance industry know-how.

*How else does VGB cooperate with AZT?*
The involvement between the two goes back well over half a century. One of AZT's main focuses lies in researching the causes behind the damage to power plant equipment, so obviously we have certain shared interests. We actually have our own laboratory at VGB, but it is smaller than the one at AZT, so we recognize that AZT has the capability to perform more tasks and generate more expertise than we can. AZT covers a broader range of industrial clients, whereas VGB specializes more in providing its services to the energy sector. When VGB develops industry standards or guidelines, then we regularly draw on the experience that AZT has.

*How often would you meet to discuss industry developments and technical issues?*
We meet twice a year at these expert conferences as well as seeing each other a handful of other times during the year for damage analyses among our members. When either party has a problem and thinks that the other could help, then we exchange information and opinions and help each other whenever possible. Ultimately, the aim of both AZT as insurance provider and VGB as service provider to the energy sector is to avoid damages, and therefore costs.

*What are the prospects of developing this relationship further? Is there anything else you think AZT could offer?*
The Handbook of Loss Prevention desperately needs updating. This is a valuable reference work throughout the industry – as a readily available, pragmatic source of industry standards, there is nothing better, but it has not been updated for years. We could probably give some assistance for the power plant section. But know-how is not for free: unfortunately, research and development money has been cut in our sector in recent years. The simple fact is that not as much money is being invested in fossil fuel-driven power plants as we believe should be.

*Because there is a greater focus on renewable energies?*
Predominantly. However, we shouldn't forget that we are a long way off being able to rely completely on renewables to supply our energy – fossil fuels are still very important. It will be interesting to see how this continues to affect the machinery being used, some of which is quite old. Availability will certainly be affected. Fossil-Fueled plants in Germany are currently running at around 96-97 percent capacity, but this will drop below 90 percent in the not too distant future. How will the performance respond? We don't really know. It's likely that damages will become more common, though, and we will find ourselves increasingly reliant on the skills of both AZT and VGB.


AZT holds its '**Expert Days**' on a bi-annual basis and invites leading experts from the industry, economy and science to talk about the latest developments and trends in technology. In 2011, the Expert Days focused on "Digital Environments", while in 2009, the topic was "Renewable Energies".

The 2009 conference was a great opportunity for the insurance industry to exchange expertise and presentations from various experts in the renewables field, such as Siemens, BARD, RWE and Bosch.

The Expert Days 2009 focused on considerations of technical and economic risk with regards to the generation of renewable energy - participants discussed state-of-the-art technologicaldevelopments in addition to insurance-related aspects, such as claims experience. In more than 15 talks manufacturers, scientists and insurance experts presented their most recent information on security issues in connection with renewable energy.

# An Eye on the **Future**

After eight decades of claims handling, loss prevention and lessons learned, the success story of AZT is just beginning. Now, globalizing services and managing emerging risks lie on the horizon.

Looking ahead: Globalizing services will continue to be a priority for the AZT in the future.

For Johannes Stoiber, a clear path is being carved for AZT's future. "There is a significant opportunity for AZT to become more and more involved in the international claims handling process," says Stoiber. "We want to continue exploring the potential in mature markets but we also want to place a focus on growth markets like Brazil, Asia and Eastern Europe." The demand for AZT services in those regions has been growing over the past years, as new high-tech companies here are on the verge of entering the global market.

However, it is not just new regions the AZT wants to take on. Emerging technologies in renewable energies, such as wind, solar and geothermal, also offer exciting new possibilities for the center. The industry is currently facing many introductions of new technologies in the market, such as "wind to gas", smart grids and carbon-capture technologies. Also, the rising complexity in energy production – for example the mix of nuclear, conventional and renewable energies and new regulations – as well as concepts such as e-mobility, pose challenges. "Our expertise is far-reaching, and as industries adapt to new technologies, so do we," says Stoiber. AGCS sees itself as an early warning system for future risks. AZT is an integral part of this and plays an important role in assessing the changes of tomorrow.

Globalizing AZT services fits neatly into AGCS's overall objective of building on its worldwide network, though challenges exist. Operating outside of Germany means understanding local and regional requirements, conditions and processes. "Claims are handled differently in different countries, and so there is a real need to have someone on the ground in each of these areas who knows how to deal with such situations and how AZT can fit into that picture," says Stoiber. The strong global network of AGCS with local colleagues from risk consulting, market management and claims is key and a huge advantage for managing this challenge.

The AZT experts from Munich have covered significant distances worldwide over the past few years, offering local support in claims handling and analysis, in prototype testing, loss prevention, quality check-ups and other projects internationally.

Since the center's full integration into AGCS in 2007, its AGCS clients workload has increased by around 45 percent – a number that is certain to continue to climb given AZT's global ambitions for the future. The next 80 years undoubtedly hold much promise.

# Going Global - AZT Activity Worldwide

## North America

**Canada**
- Analysis of steam boiler failure
- Hydro gearbox failures and inspections

**USA**
- Gas turbines failure
- Gas turbine inspection at workshop
- Wind turbine review
- Generator damage
- Compressor gear-box damage

## Latin America

**Brazil**
- Gas turbine failures analysis
- Gas compressor damage inspection at a steel factory
- Inspection of new parts at nuclear power plant
- Failure Inspection of hydro power plant Itaipu

**Mexico**
- Gas turbine failures analysis
- Steam turbine failure survey

**Colombia**
- Gas turbines failure inspection
- Water issues at a steam turbine power plant
- Cement mill damage analysis

**Chile**
- Conveyor system gear failure at a copper mine
- Hydro power plant inspection

**Argentina**
- Transformer damage inspection

## Africa

**Tunisia**
- Gas turbine assessments

**South Africa**
- Press damage
- Boiler construction site crane collapse
- Steam power plant condenser failure

**Egypt**
- Steam turbine revision quality assurance
- Gear box inspections

**Morocco**
- Storage tank damage analysis
- Steam turbine damages

**Tanzania**
- Gas turbine compressor failure

**Ivory Coast**
- Gas turbine inspection

## Eastern Europe & Russia

**Croatia**
- Analysis of gas turbines failure

**Serbia**
- Bucket-wheel excavator damage

**Slovenia**
- Assessment of railcar carriage damage

**Slovakia**
- Crane rope failure
- Vibration measurement
- Parquet manufacturing

**Poland**
- Damage on rotary furnace
- Steam turbine damage

**Romania**
- Damage on a splint dryer
- Steam turbine damage
- Quality assurance: balancing of a new steam turbine

**Czech Republic**
- Chimney failure
- Vibration measurement
- Inspection of gear boxes
- Coal-fired Power Plant

**Hungary**
- Induced draft fan failure
- Steam turbine failure

**Greece**
- Measurement campaign on a wind turbine

**Finland**
- Nuclear power plant steam turbine quality assurance

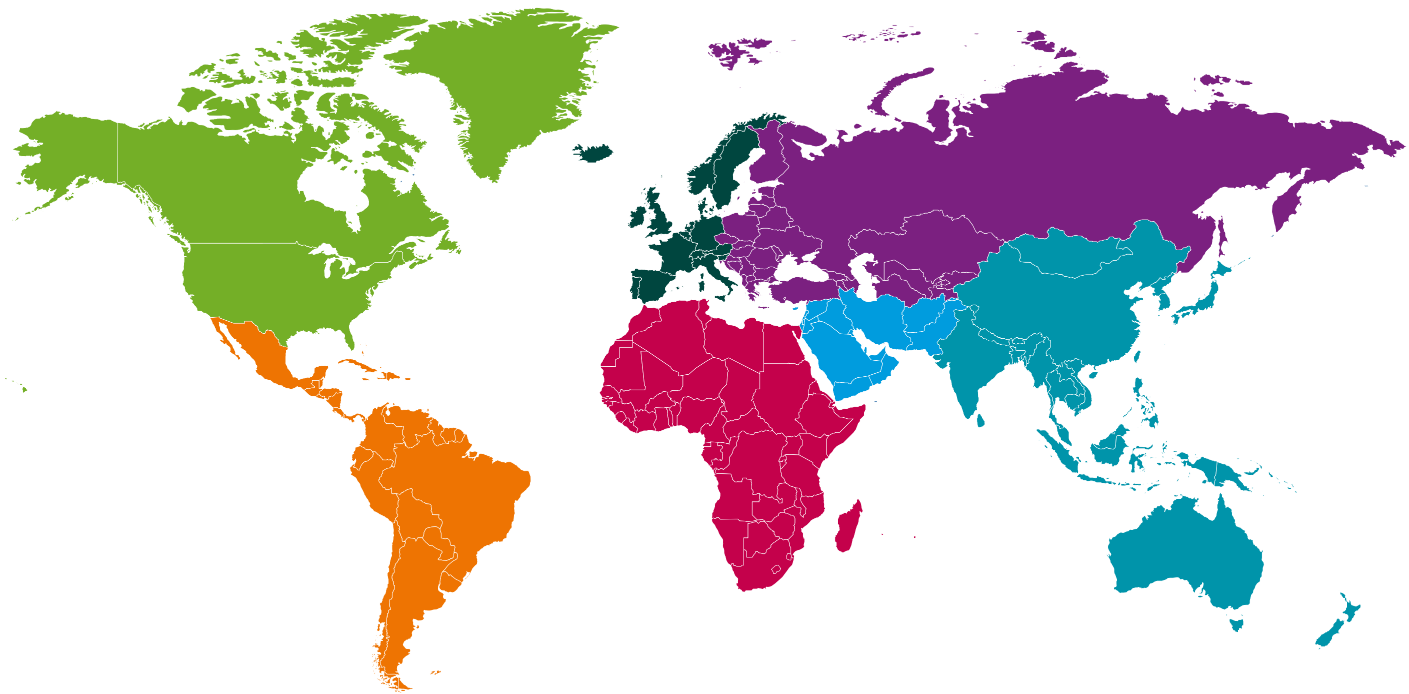
**Turkey**
- Gas turbine failure
- Transformer damage
- Steam turbine inspection

**Russia**
- Aluminum factory

**Bulgaria**
- Steam turbine failure

## Middle East

**Saudi Arabia**
- Gas turbine damages
- Drinking water abstraction plant inspection
- Diesel generator failure



## Asia + Pacific

**Turkmenistan**
- Commissioning issues of a refinery

**China**
- Gas turbines failures
- Press issues
- Wind turbine gear box failures
- Fire damage inspection of Shanghai trans-rapid train

**Japan**
- Workshop on offshore wind turbine prototypes
- Large steam turbine claim investigation
- Steam turbine rotor inspection at a nuclear power plant

**Indonesia**
- Automotive factory water damage
- Quality assurance on gas turbine overhaul

**Malaysia**
- Gas turbine revision

**Singapore**
- Steam turbine lifetime assessment
- Steam turbine retrofit

**Bangladesh**
- Electrical motor damage

**Vietnam**
- Coal-fired power station assessment

**Australia**
- Steam turbine damage analysis

## Central Europe

**Traditional AZT market**

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