We keep your drive running!

iGfM

Condition
Monitoring

中文版

2019

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GfM二十岁了！

1999年7月，GfM Gesellschaft für Maschinendiagnose公司由Dr.-Ing. Rainer Wirth，Dipl.-Ing. Axel Haubold和Dipl.-Ing. Kai Uchtmann共同创办。自公司创建伊始，我们的目标就是提供比市场上更好的服务和系统。三位创始人当时已经在信号分析和工业齿轮箱滚动轴承振动诊断领域拥有学术上和数年的实践经验。

从一开始，公司目标就是将高级机器诊断服务导入批量生产的产品并开发一套在线系统，能够真正识别所有异常、不产生错误的警报，并且在很大程度上减轻了人工分析的工作量。 公司成功开发了在线产品并命名为Peakanalyzer。采用智能算法自动搜寻阶谱和包络阶谱，以查找与可能的损伤模式的频率匹配的显著性峰值。基本上，这使得任何一个人都可能成为机器诊断工作者。

传动的机械负载几乎不会对诊断质量产生任何影响。较长的测量时间可确保频谱分量的高分辨率。阶次分析的一致应用能容许在测量期间相当大的速度变化。可连接传感器的数量几乎是无限的。

对于移动任务，PeakStore5是一款小型便携式诊断设备，重量仅为2.5kg，一次充电可采集超过5小时12个传感器的信号。

2019年7月1日，20周年庆

GfM目前拥有17名员工，已成为许多机械传动运营者可靠、反应迅速且称职的合作伙伴，几乎涵盖所有行业应用。起重机在线监测与风力发电机组在线状态监测一样受欢迎。水泥厂或船闸中的传动以及燃气轮机的监测都是普遍的应用。 为了排除故障，移动振动诊断任务可以根据需要通过扭矩测量和扭力振动分析进行补充。

我们的重点始终是服务和产品的质量，以及我们的技术和员工的专业知识。籍此，我们实现了客户的最佳利益。我们将坚持并坚信GfM一如既往的可持续发展。

Happy Birthday

The GfM will be twenty!

In July 1999 the GfM Gesellschaft für Maschinendiagnose was founded by Dr.-Ing. Rainer Wirth, Dipl.-Ing, Axel Haubold and Dipl.-Ing. Kai Uchtmann. From the beginning, the goal was to provide better services and better systems than were available on the market. The three founders already had academic and several years of practical experience in the fields of signal analysis and the practical vibration diagnosis of rolling bearings in industrial gearboxes.

From the beginning, it was a matter of qualifying high-level machine diagnostic services into a mass-produced product and developing an online system that truly recognizes all irregularities, negligible false alarms, and, moreover, largely relieves people of analytical activity. That's succeeded. The online product is called Peakanalyzer. An intelligent algorithm automatically searches order spectra and envelope order spectra for conspicuous peaks that match the frequency of possible damage patterns. Basically, that makes a person who works as a machine diagnostician, not otherwise.

The mechanical load to which the drive is exposed has hardly any influence on the diagnostic quality. Long measurement times ensure a high resolution of the spectral components. The consistent application of the order analysis results in a very good tolerance of quite considerable speed changes during the measurement. The number of connectable sensors is practically arbitrary.

For mobile tasks, there's the PeakStore5, a small, portable diagnostic device that weighs only about 2.5 kg and can capture the signals from 12 sensors on a single charge for more than five hours.

Birthday is on July 1, 2019

With now 17 employees, GfM has become a reliable, responsive and competent partner for many operators of mechanical drives. And in virtually all industries. Online monitoring of cranes is just as popular as online condition monitoring of wind turbines. Drives in cement plants or locks as well as the monitoring of gas turbines are popular applications. For the purpose of the Trouble Shooting, mobile vibration diagnostic tasks are then supplemented by torque measurements and torsional vibration analyzes if required.

The focus is always on the quality of our services and products, as well as the expertise of our technical and commercial employees. Thus we achieve the optimal customer benefit. We will stick to it and are convinced that GfM will remain so sustainable.

1999年的振动测量, 笨重而且缓慢 –
Vibration measurement 1999, heavy and slow

状态监测增加您的利润！

想象一下，您已经在 2 月份知道哪些轴承必须在 9 月份更换！您甚至还知道，所有其他传动部件都正常工作。那岂不是很美好吗？

没有任何压力、恐慌和不安全感，您可以从容地组织维修工作。您可以按时订购备件、工具和必要的人员、及时完成维修。

这不是一个乌托邦。现代状态监测可以做到这一点。即使对轴承和齿轮的最小损坏也是可监测的。通常，这可能发生在故障前的几个月。

当然，安装状态监测系统需要花费成本。但是这笔投资足以在第一次损坏后摊销。

优势一目了然：

➔ 使用状态监测，您通常会发现，大多数传动部件显示没有异常。这对于工厂操作者来说这是非常舒适的，因为超过90% 的由于惯性或磨损造成的损害在很长一段时间以前就被发现。

➔ 但是如果发生损坏，CMS 可以及早检测到，以便安排维护工作。避免了"灭火行动"。

➔ CMS 将帮助组织维护工作。甚至在打开传动之前，您已经知道必须修复哪个组件。维护可以更有效地运行。大大缩短了停机时间。

➔ 可长期规划备品备件、维修工具、维修人员及所有资源。可以避免快递和维护人员加班等额外费用。

➔ 通过状态监测,可以重建损伤过程。识别破坏性影响因素并优化传动。

几乎每辆车上都装有安全气囊。通常它们并不使用。然而，没有人会认为安全气囊是一项糟糕的投资。因为大家知道，一旦事故发生时，你会因为安全气囊得到更好的保护，这也是为什么所有的财务疑虑都很快消失的原因。

必须对机械传动的状态监测系统进行相似的评估。只要传动运行不损坏，每个监控系统最初可能被认为是糟糕的投资。但是，如果能有一次早期检测到损坏，则节省的生产停机时间成本往往超过CMS 的投资成本很多倍。

Condition Monitoring Increases Your Profit!

Imagine, you already know in February, which bearing have to be replaced in September! And even better: You also know, that all other drive elements are working properly. Would not that be sensational?

Without any stress, panic and insecurity, you can calmly organize maintenance works. You will order the spare parts, tools, the necessary personnel and everything will be repaired, on time.

This is not an utopia. Modern Condition Monitoring can do it. Even the smallest damages on bearings and gears are visible. Usually, that's possible already several months before breakdown.

Sure, the installation of a condition monitoring system will cost a little money. But this investment will be amortized already after the first damage.

The advantages at a glance:

→ *Using Condition Monitoring, you will usually find out, that most of the drive elements show no abnormalities. For the plant operator this is very comfortable, because more than 90 percent of all damages, caused by inertia or wear, can be detected a very long time before.*

→ *However, if a damage occurs, it can be detected by the CMS early enough to schedule maintenance works. "Fire-fighting operations" are avoided.*

→ *The CMS will help to organize maintenance works. Even before opening the drive, you exactly know, which component have to be repaired. Maintenance can run more efficiently. Downtime can be shortened.*

→ *Spare parts, maintenance tools, maintenance staff and all resources can be organized in the long term. Extra charges for express delivery and overtime bonuses for the maintenance staff can be avoided.*

→ *The development of a damage can be reconstructed by Condition Monitoring. Harmful influences can be identified. The drive can be optimized.*

An airbag is installed in almost every car. Usually, they are not used. Nevertheless, no one comes up with the idea, that airbags are a bad investment. You know, that you are better protected in case of an accident and that´s why all financial doubts disappear very quickly.

A Condition Monitoring System for mechanical drives have to be evaluated similarly. As long as the drive is running without any damage, every monitoring system is a bad investment. But if only one single damage can be detected early enough, the saved loss of production exceeds the investment costs of the CMS many times over.

状态监测保障人身和机器安全!

家庭中的机器和设备经过严格的测试，因此在适当使用时被认为是非常安全的。这种苛刻的要求很难在生产工厂中实施。此外，更高的机械性能也增加了风险。

传动部件的意外故障可能会对单个机器产生影响，最终会对整个生产线造成冲击。在最坏的情况下，整个工厂可能受损。此外，现场人员的风险也会增加。

状态监测可以很早就识别出机械传动的大部分损坏情况。例如，滚动轴承上检测到早期损伤，监视轴承以便能够立即对任何细微的变化作出反应。同时还可以启动修复工程。

优势一目了然:

➜ 状态监测及时检测损伤。

➜ 机器和生产线的损坏是可以避免的。

➜ 降低了现场员工的风险。

过热的轴承与可燃材料相结合可能引起火灾。即使你准备得很好，这样的火灾在早期就熄灭了，但仍然存在一些负面的影响。此外，你必须回答消防部门和专业协会的各种问题。

状态监测系统为及时识别机械传动事故的来源做出了重要贡献。相应的损害是可避免的。

Condition Monitoring Protects Man and Machine!

Machines and devices in households subject restrictions. Therefore they are considered to be very safe at an appropriate use. Such strict requirements can hardly be implemented in the area of production plants. In addition, much higher mechanical performances are transferred. That leads to an increasing risk.

The unexpected breakdown of drive elements may have an impact on single machines and finally also on the entire production line. In the worst case, the whole factory work floor can be destroyed. In addition, the staff on-site is endangered.

Condition Monitoring can identify a lot of damages of mechanical drives at a very early stage. For example, if premature damages are detected on a roller bearing, the bearing can be observed. So it is possible to react to the slightest change, immediately. At the same time, maintenance works can be initiated.

At a glance:

➜ Condition Monitoring detects damages in time.

➜ Damages on machines and production lines can be avoided.

➜ The risk of the staff on-site decreases.

An overheated bearing combined with combustible material may cause a fire. Even if you are well prepared and such fires are extinguished in the early stage, some negative feelings still remain. Furthermore, you have to answer the questions of the fire department and the professional association.

A Condition Monitoring system provides a significant contribution to identify the sources of accidents on mechanical drives, in time. Consequential damages are avoidable.

状态监测促进环境保护

除了环保的能源生产外，精心利用自然资源也是环境保护的一个重要方面。 原材料的提取、运输，钢铁的生产以及滚动轴承和齿轮的生产需要大量的能源。此外，也产生了巨大的废气排放量。

预防性的维护方法已经实行了几十年。零件在其最大预期寿命很长时间以前就被替换。这不仅非常耗费成本，还需要原材料和能源。当然，这是在很长一段时间内唯一可行的方法。

如今有了基于状态的维护方法。状态监测可以准确地确定哪些部件已损坏。更重要的是：可以记录哪些部件没有损坏，可以继续运行。

滚动轴承的实际预期寿命可能比计算预期寿命高几个百分点。因此，如果不采用预防性维护方法，则可以节省大量成本。

详细说明：

➔ 状态监控可以记录哪些传动部件完好无损。

➔ 完整的传动部件可以超出其计算寿命运行，因此如果不与安全或技术方面发生冲突， 可以更好地利用。

➔ 传动部件的使用寿命的延长，直接有利于保护环境。后人会感谢我们。

当然，人类有保护其种类的权利。这也包括开采和使用原材料。当我们过早地更换滚动轴承和齿轮，浪费原材料和消耗生产备件的能源，只是因为我们无法监测传动元件的实际磨损情况，我们真的能承担这份责任吗？

基于振动测量的状态监测虽然不能准确确定滚动轴承的具体磨损程度。但在今天，可以准确识别有缺陷的传动部件，不至于导致其他传动部件的损坏。

Condition Monitoring for Environmental Reasons

The protection of the environment does not only involve the eco-friendly production of energy. Using our natural resources responsibly and carefully is also an important aspect. The extraction of raw materials, their transportation, the production of steel, the manufacturing of bearings and gears are very energy-intensive. Furthermore, the exhaust emission is enormous.

The method, that was practiced for decades, was the preventive maintenance. Parts were replaced long time before they reached their maximal life expectancy. This is not only very cost-intensive, it also requires raw materials and energy. Of course, this approach has been the only opportunity, for a long time.

Now, the condition-based maintenance is established. Condition Monitoring can exactly determine, which parts are damaged. And even more important: It is possible to document, which parts are undamaged and can run another campaign.

The actual life expectancy of roller bearings can exceed the calculated expectancy for several hundred percent. Drastic cost-reductions can be made, if not, for example, security-aspects require preventive maintenance.

In detail:

➔ *By Condition Monitoring, it is possible to document, which drive elements are intact.*

➔ *These intact drive elements can run beyond their calculated life expectancy, if there is no conflict with any safety or technological aspects.*

➔ *The longer use of drive elements protects the environment. Later generations would be grateful.*

Of course, the human race has a right to preserve its kind. The mining of raw materials and their use belongs to this. But could we really bear the responsibility, that we change bearings and gears too early, that we waste raw materials and energy for the production of spare parts, just because we are not able to monitore the real condition of drive elements?

Condition Monitoring, based on vibration measurements, can not determine exactly the degree of the rolling bearing damage. But even today, it is possible to identify defective drive elements. As a result, the other drive-components are undamaged.

状态监测与工业 4.0

工业 4.0 概念目前正充满生机。联邦政府仅启动了一项第四次技术革命的倡议，并提出了一些关键词。具体设计留给了经济体。因此，人们在各种会议上可能听到截然不同的解释。整个体系正在由"我们不需要！"发展到"我们已经这样生产！"。

这是什么意思呢?

可以在各种文献中找到各种系统化说明。通常，通过水和蒸汽动力的机械化被称为第一次技术革命。第二次技术革命是通过装配线和电力实现的大规模生产。第三次是数字革命，其特点是使用电子和计算机技术实现生产过程的自动化。通过第四次技术革命，意味着在高度灵活的生产条件下实现产品的个性化定制。例如，在工业批量生产中实现单个数量的生产。

与状态监测又有什么关系呢?

关于工业 4.0，维护并不是政治关注的焦点。但这并不新鲜。毕竟，只有当设备不工作时，才会谈论维护。尽管如此，维护通常在保障生产中起关键作用。而这不会随着工业 4.0 而改变。相反！由于对灵活性的要求，对工厂的技术要求也大大提高。早期阶段了解机器的损坏状态将变得更加重要，以确保确定时间段的可靠性。因此状态监测也属于工业4.0范畴。

状态监测为保障生产的可用性和可靠性提供了巨大的可能性!

Condition Monitoring and Industry 4.0

The term industry 4.0 is currently brought to life. The federal government has only launched an initiative for the introduction of the fourth technological revolution and placed a few keywords. The concrete design is left to the economy. Consequently, people talk about very different interpretations at conferences. From "We don't need!" to "We are already producing this way!" the whole range is operated.

But what is meant?

In the literature various systematisations are found. Often, the mechanization by means of water and steam power called the first technological revolution. The second technological revolution is then the introduction of mass production with the help of assembly lines and electrical power. The third one is the digital revolution, characterized by the use of electronic engineering and computer technology to automate production processes. By the fourth technological revolution the strong customization of products under conditions of highly flexible production is meant. Often, as an example, industrial series production down to batch size of one is called.

And what does that have to do with Condition Monitoring?

The maintenance does not feel the focus of political attention particularly regarding industry 4.0. But that is not entirely new. Since until now, it is often talked about maintenance only if something is not working. Nonetheless, maintenance plays a significant part in ensuring that production works. And this is unlikely to change in industry 4.0. On the contrary! The technical demands

on production plants are already rising enormously by the requirement for flexibility. It will be important to know the damage state of a machine at an early stage to provide reliability for a determinable period. And latest by this way Condition Monitoring belongs to industry 4.0.

Condition monitoring offers gigantic possibilities for securing the availability and reliability of production plants!

水泥厂，发电厂和矿山的球磨机

工业上有各种类型的磨机，例如立式磨机、球磨机和辊磨机。磨机由一个或多个电机驱动。为了降低速度，使用一个或多个齿轮，其又可包括履带齿轮级、锥齿轮级和行星级。 动力通过轴或大齿轮传递到磨机。滚动轴承上的振动也比较厉害。

但无论使用哪种类型的磨机，通常都是全天候运转的。驱动功率达几百千瓦甚至两位数兆瓦的范围。再研磨的吞吐量相对较高。这些大型机器通常没有库存备件，根据需要订购和制造。因此，一旦故障会将带来巨大的收入损失。

在线状态监测系统可以检测早期阶段的异常。 此外，通常在交付和安装之后的状态记录也是很重要的。这可以通过离线诊断来实现。另一方面，如果问题完全出乎意料地发生，则可以通过振动和扭矩测量的组合来快速缩小范围，并通过目视或内窥镜来辅助检查传动。

球磨机的齿轮箱 – *gear box of a ball mill*

Peakanalyzer 应用于球磨机：

球磨机由 2,800 kW 电机和三级斜齿轮箱提供动力。

在电机驱动端和非驱动端径向各安装一个加速度传感器。在四个传动轴径向上共安装四个加速度传感器。另一个加速度传感器沿轴向安装在齿轮箱输入轴上。径向安装的传感器检测轴承和齿轮，轴向安装的传感器主要用于检测耦合异常。

此外，在齿轮箱输入轴上，还安装了速度传感器。实际速度的测量对于诊断和阶次分析的应用非常重要。

Mills in Cement Plants, Power Plants and Mines

In industry, there are different types of mills, e.g. the vertical mill, the ball mill and roller mill. Usually mills are powered by one or more electric motors. For speed reduction one or more gears are used, which in turn may contain spur gear stages, bevel gear stages and planetary stages. Power is transferred to the mill via a shaft or girth gear. The waves are usually mounted on roller bearings.

But no matter what type of mill is used, the mills are typically operated around the clock. The drive powers up to a few hundred kilowatts to the double-digit megawatt range. The throughput of ground material is correspondingly high. And usually replacement parts are not available for such large machines and must be ordered and manufactured as needed. Therefore the failure of a mill entails enormous revenue losses.

Beschleunigungssensor am Getriebe – *acceleration sensor at gear box*

An online condition monitoring system can detect irregularities at an early stage. However, also the documentation of the state after delivery and installation is often of importance. This can be achieved with an offline diagnosis. In contrast to, if there occur any problems surprisingly, the cause can be narrowed down quickly by the combination of vibration and torque measurement, possibly supplemented by the examination of the gear by visual inspection or endoscopy.

Peakanalyzer on a ball mill:

This ball mill is driven by a 2,800 kW motor and a three-stage helical gear unit.

Two acceleration sensors are provided on the motor, one on the drive side and one on the non drive side, radially. On the four gearbox shafts, an acceleration sensor has also been placed radially, on each side. Another acceleration sensor is installed on the transmission input shaft in the axial direction. The radially instaled senors detect bearing and gear effects, the axial installed sensor is primarily intended for the detection of anomalies on the coupling.

Furthermore, a speed sensor has been installed on the transmission input shaft. The knowledge of the actual speed is important for the diagnosis and the application of the order analysis.

起重机

起重机应用非常广泛。但是昂贵的状态监测系统并不都是划算的。但是对于以下生产过程高度依赖的起重机，状态监测则是必须的：

– 高负载的特殊应用的浮式起重机

– 铸造厂的起重机

– 炼钢厂和轧钢厂的起重机

– 港口的集装箱起重机

起重机上可以监测电机、齿轮、轴承、皮带轮和滑车的轴承。通过在线或离线状态监测，可以在早期检测到异常现象。通过目测，必要时辅以内窥镜检查，可以确定诊断结果。通常强烈的动态现象也可以采用扭矩测量的方法。

CMS 应用于起重机 – 挑战特殊任务：

所有起重机传动始终只移动一定距离。 起重机吊钩只能从底部向顶部或从顶部到底部传动，但不能进一步驱动。小车只能在起重机宽度范围内工作。一方面，可用于数据收集的时间有限。另一方面，却需要很长的测量时间来确保良好的诊断质量。**GfM** 采用独特的触发算法解决了这一挑战。

浮式起重机 – *Floating crane*

Cranes

Cranes are required for lots of applications. A sophisticated Condition Monitoring is not always profitable. However, for cranes, from which a complex production process directly depends, a monitoring is absolutely needed:

– *Floating cranes with extremely high load capacity for special applications, or*

– *Cranes in foundries, or*

– *Cranes in steel- and roller mills, or*

– *Container cranes in ports.*

The motors, the gears, the drum bearings, the bearings of the pulley and of course all drives and wheels of the crane travelling and the trolley travelling, are monitored. By condition monitoring, online or offline, irregularities can be detected at an early stage. Visual inspection, if necessary supplemented by endoscopy, can confirm the diagnosis. Heavy dynamic phenomena can often be described by a torque measurement.

CMS on a crane – a special task:

All drives of cranes only run for short distance. A crane hook can only be driven from the bottom up or top-down. The trolley jib can run as far as the crane is wide, but no further. Therefore, the available time for data collection is limited, on the one hand. On the other hand, a long measurement time is required to ensure a good diagnosis quality. This task has been solved by the adaption of specific trigger algoithms.

集装箱起重机 – *Container crane*

造纸机械

造纸机械中有各种旋转辊子。它们确保液体原料混合物转化为流浆箱和卷取机之间的干纸。辊子通过不同的电机齿轮组件实现旋转。

即使一个轴承上的缺陷，也会严重扰乱生产过程。在这种情况下，机器必须停止，然后再重新启动。这是一个相当复杂的过程。因此，特别推荐用于造纸机械的预测性维护。

使用 Peakanalyzer 先进的状态监测系统，可以更好地提高机器利用率并提高成本效率。定期性的离线振动诊断通常也可以避免大部分故障。在造纸机械中，有时可以通过扭矩分析非常精确地描述旋转不规则性，从而找到原因。

CMS 应用于造纸机械:

Peakanalyzer 非常适用于监控齿轮箱，当然也适用于所有电机和滚动轴承。传感器连接到测量点，通常通过中间接线盒连接到 Peakanalyzer。不同 Peakanalyzer 中的传感器也可以在 Peakanalyzer Manager 中统一处理成一套状态监测系统。

速度可以在传动上测量，也可以从控制单元提供的信号中读取。

CMS on a paper machine:

The Peakanalyzer is ideally suited for monitoring the gear-box, in particular, but also for all motor- and roller bearings. The sensors are attached to the measuring points and usually connected by an junction box with the Peakanalyzer. The sensors of different Peakanalyzer are logically summarized in the software Peakanalyzer Manager and treated as a single condition monitoring system.

The speed is measured at the drives or can also be imported from a signal that is sent from the control center.

加速度传感器 – *Accelerometer*

Paper Production

There is a variety of rotating rolls in paper machines. They ensure that the liquid raw mixture is transformed to dry paper between headbox and reeler. The rollers are rotating because of different motor-gear assemblies.

Even a defect on only one bearing can disrupt the production process considerably. In this case, the machine has to be stopped and later started up again. This is a fairly complex process. Therefore, the predictive maintenance is especially recommended for paper machines.

A modern Condition Monitoring with the Peakanalyzer provides a decisive contribution to a better machine capacity utilization and improved cost efficiency. But the periodic offline vibration diagnosis is often sufficient to avoid a large percentage of failures. In paper machines sometimes occurring rotational irregularities can be described very accurately by torque analysis and thus assign a cause.

Markets

轧机

轧机的特征是许多传动和辊子工作在在恶劣的环境中，以及不利的温度条件下。如果有一个传动发生故障，都会严重干扰生产。速度通常是变化的。有些系统可以反转。

确保无故障运行的最佳解决方案是采用在线状态监测系统。在电机、齿轮箱和底座轴承上进行振动诊断。通过扭矩分析可以最好地检测动态影响。

离线测量也适用于记录新工厂的状态，以及协调供应商和用户之间的异议，或者定期检查损坏状态。

轧机的扭矩测量：

在具体情况下，目的是变更产品生产。但是不清楚该工厂是否合适生产。没有传动扭矩和所有动态部件的具体参数。

在此应用基于应变传感器的扭矩测量可快速提供所需的信息。

Torque measurement at a ring rolling mill:

In this specific case, the intention was to modify the product. It was unclear whether the plant sufficiently was dimensioned for it. There were no concrete values for the drive torques and above all for the dynamic components.

The application of a torque moment measurement point based on strain gages provided quickly the required information.
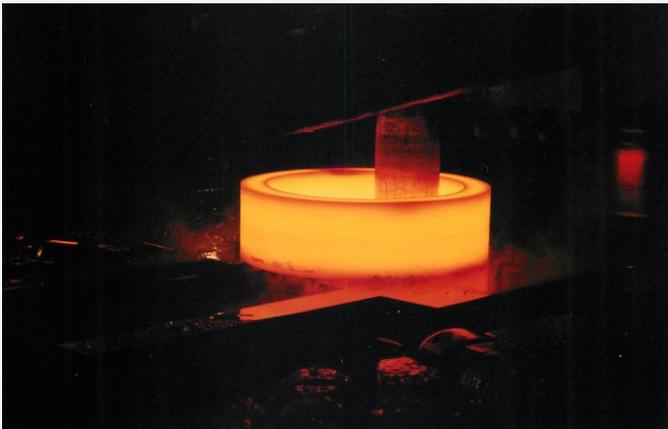
轧机 – *Ring rolling mill*

Rolling Mills

Many drives and more rollers in a harsh environment, partially under unfavorable temperature conditions, are characteristic of rolling mills. If just one drive fails, production will be disturbed. The speed is often variable. Some systems run in reversing.

The optimal solution for securing a largely trouble-free operation is the monitoring by online condition monitoring systems. For engines, transmissions and pedestal bearings vibration diagnosis is advisable. Dynamic effects are determined at best by torque analysis.

However, offline measurements are suitable either for documentation of the state of a new plant and for mediating discrepancies between the supplier and the operator, or for checking damage states regularly.

Markets

缆车

无论是架空索道还是轨道电车、架空滑车或缆车、架空铁路或索道铁路，它们都有一套由电机、齿轮箱和滑轮组成的传动装置。

如果传动发生故障，则会产生经济损失，因为游客不再去滑雪场，或者厂商不再提供材料。状态监测的任务就是防止出现这种情况。

即使是定期进行的离线振动诊断也有助于防止意外停机。通过在线状态监测系统则可以实现最高可靠性。

Peakanalyzer 应用于 Skymetro:

Skymetro 是一个特殊的案例，一个带缆车的空中轨道列车。它连接苏黎士克洛滕机场天际中心和卫星港区 E。列车由两个传动链 A 和 B 驱动，每个传动链由两个 465 kW 电机和一个三级斜齿齿轮箱组成。

由于对索道的特殊要求，存在建设上的冗余。但事实上，状态监测系统确保了可利用率。

Cable Cars

No matter if it is an aerial tramway or an orbit tramway, a chair lift or a cable car, an aerial railway or a funicular railway, they all have a drive which usually consists of the engine, the transmission and the circulation disc.

In case of a drive breakdown, an economic loss is generated because tourists no longer go to the ski area or production companies are no longer supplied with material. The task of the Condition Monitoring is to prevent this scenario.

Even a regularly conducted offline vibration diagnosis helps to prevent unexpected shutdowns. The highest possible reliability is achieved of course by means of an online condition monitoring system.

Peakanalyzer at Skymetro:

The Skymetro is an air cushion tramway with cable drive. At the Zurich Airport, Kloten, the tramway connects the Airside Center with the Satellite Terminal Dock E. The trams are driven by two drive trains A and B, each with two 465 kW motor and one three-stage bevel-spur gear.

Because of special requirements on the cableway there are constructive redundances. But the condition monitoring system ensures the availability, in fact.
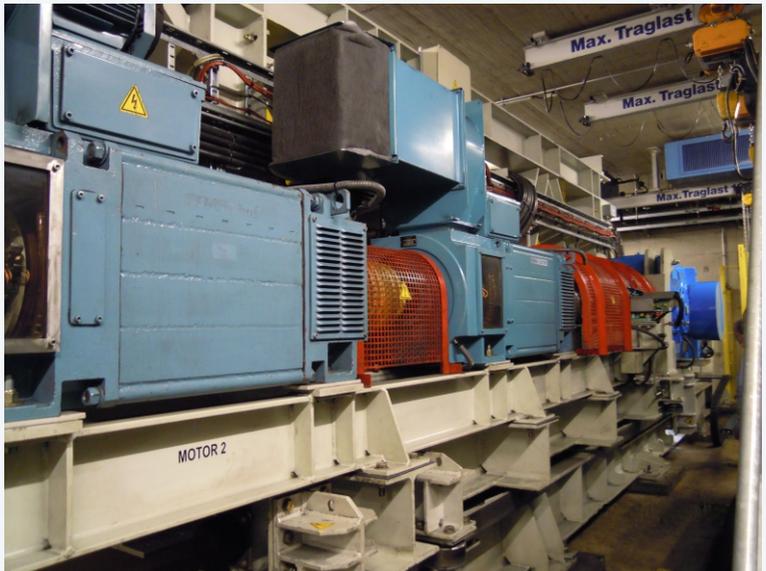
Skymetro 的传动链 – *drive train of the Skymetro*

升降桥, 铰链桥, 锁, 船升降机, 升降机

在许多技术领域中存在滚动轴承，一方面承载高运动负载，另一方面其转速非常低。通常，这种轴承在一次运行中不会实现完全旋转，或者旋转速度会发生极端变化。有时由于长时间的处于静止而导致润滑不足，这可能导致损坏。

由于低转速，传统的振动诊断方法通常无法用于可靠的诊断。

GfM 开发了一种方法，可以诊断极慢速运转的轴承。使用紧邻待诊断轴承的传感器进行测量。为了测量，轴承必须以最大可能的偏转进行转动。只要振动产生，测量结果可用于评估内圈、外圈和滚动元件的局部轴承损坏。

Lift Bridges, Bascule Bridges, Locks, Boat Lifts, Elevators

In many technical fields there are roller bearings which in the one hand move big loads, but whose rotational speed in the other hand is very low. Often such bearings realize no full rotation in one operation, or the rotational speed is subject to extreme variations. In addition to classical damage mechanisms sometimes it comes to inadequate lubrication due to long standstill phase, which can also lead to damage.

Due to the low rotational speed, classic vibration diagnostic methods are often useless for a reliable diagnosis.

GfM has developed a method that allows the diagnosis of extremely slow-running bearings. The data acquisition is performed with sensors in the immediate vicinity of the bearing to be diagnosed. For the measurement, the bearing is rotated to the maximum possible deflection. The measurement results allow the assessment of local bearing damage on the inner ring, outer ring and rolling elements, as far as vibrations arise.

Markets

诊断过程：

➜ 在轴承上安装多个位移传感器和一个速度传感器。

➜ 使用 PeakStore 进行数据采集。

➜ 在办公室进行评估。

Process of the Diagnosis:

➜ On the bearing several displacement sensors and a speed sensor are applied.

➜ Data are collected with the PeakStore5.

➜ The evaluation takes place in the office.

露天采矿中的斗轮挖掘机和堆垛机

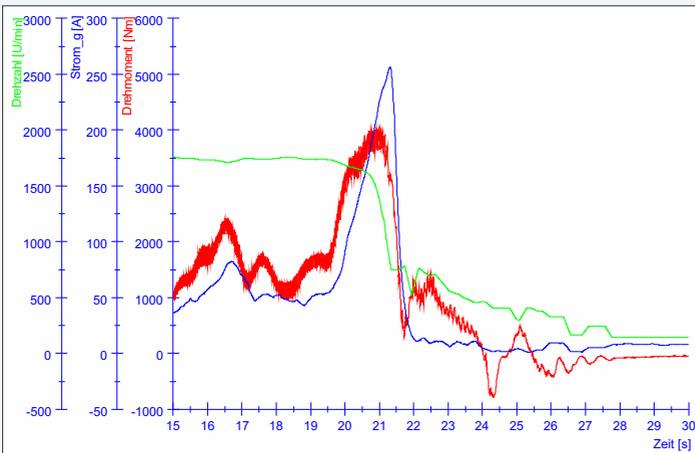在露天采矿中，有令人印象深刻的机器在恶劣的气候条件下进行复杂的工作。斗轮和斗轮挖掘机低速运转。性能和速度以及由于过程导致的不连续性。输送机长达数公里，由于高度不同影响到动态特性。

尽管这些机器已经成熟并经过验证，但有时也会出现问题。振动诊断适用于检测滚动轴承和齿轮箱的损坏。这可以通过离线测量或在线状态监测系统来协助完成。

如有需要，也可以通过使用振动测量结合扭矩分析快速排查问题。因此，GfM 也为客户提供"故障排除"服务。

斗轮挖掘机停机时的测量结果显示：

➜ 电机电流迅速变为零。

è 速度降低到零。

è 重复正反负载的高频谐波。

斗轮挖掘机的转速，电流和扭矩 –
Speed, current an torque an a bucket-wheel excavator

# Bucket-Wheel Excavators and Stackers in Surface Mines

In mines, there are impressive machines that do complex work under adverse climatic conditions. Bucket-wheel and bucket-chain excavators run with low speeds. Performance and speed as well are characterized by discontinuity due to the process. Conveyors are several kilometers long and overcome differences in height, leading to dynamic influences.

Although these machines are fully developed and tested, there occur problems as well. To detect arising damages on rolling bearings and gears the vibration diagnosis is suitable. This can be done by an offline measurement or by means of online condition monitoring systems.

Also completely unexpected problems can be quickly limited by using vibration measurements, if necessary in connection with torque analyzes. Therefor the GfM offers the service "Troubleshooting " as a product.

Markets

Measurement results at shutdown a bucket show:

➜ *The motor current goes rapidly to zero.*

➜ *The speed goes lower to zero.*

➜ *The torque includes a high frequency harmonic and achieves negative values several times, which indicates a commuting, therefore, a repeated load reversal.*
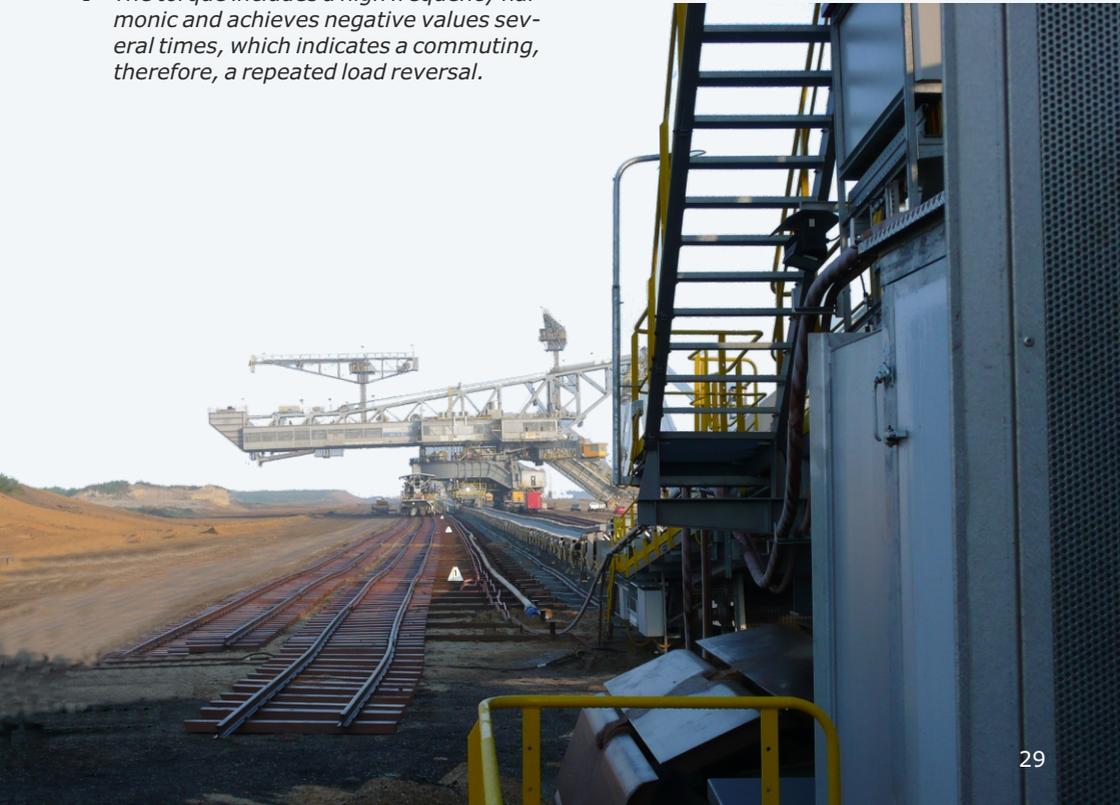
机床

机床中的主轴通常在运行期间具有非常高的速度。来自切削和磨削过程的噪声会叠加到滚动轴承损坏的相对低能量噪声排放上。并且滚动轴承有时是预紧的。所有这些都是经典机器诊断方法的障碍。

Peakanalyzer 监测带滚动轴承的机床主轴，以应对异常运行条件的出现。异常情况可能是由于机械表面不规则或润滑不足导致。

诊断原理可分两步，包括对振动参数的强制性趋势监测以及可选的运动损伤频率分析。

首先，必须在未损坏的机器上学习允许的参考值。在监测模式下，Peakanalyzer 将当前测量值与参考测量值进行比较，并报告可能表示异常的任何偏差。如果需要，消息可以通过数字量输出或者通过 Profibus 传输。可视化可以通过信号灯实现。振动变化和消息之间的最快响应时间为1.5秒。

为确保测量的可比性，可以进行分类。作为分类参数，使用速度，并且如果需要，可使用最多 12 个其他过程变量。然后将测量结果与同一类别的参考测量结果进行比较。如果检测该类别尚未获得参考值，则使用第一次测量并假设没有损坏来生成参考值。

现在可以通过对运动损伤频率的全自动分析来跟踪振动特性的趋势监测。这有点复杂，适用于所有机器元素，这些元素可以在运动学上清晰地描述，并且其运动学数据存储在 Peakanalyzer 中。计算出一阶谱和包络线阶谱。在这些阶谱中搜寻重要的频谱分量。最后检查这些重要的频谱分量的运动损伤模型。如果匹配，则产生报警。

额外的，可以选择安装控制面板以便仅在特定时间开始测量。

传感器通过粘接，螺钉或磁性连接安装在声学接近待监控的传动部件上，并与 Peakanalyzer 电气连接。控制单元也必须连接到Peakanalyzer。Peakanalyzer 使用Peakanalyzer Manager 软件进行配置。Peakanalyzer Manager 可以人工分析所有频谱，包络包络谱、阶谱和包络线等。此外还包含了许多分析工具。

滚动轴承内圈损坏 –
Damage on inner race of a roller bearing

Machine Tools

Spindles in machine tools have in operation mostly very high speeds. Noise from cutting and grinding processes are superimposed on the relatively low-energy noise emissions from rolling bearing damages. And roller bearings are sometimes preloaded. All this is an obstacle for the classic machine diagnostics.

Machine tool spindles with rolling bearings are monitored by the Peakanalyzer to the emergence of abnormal operating conditions. Abnormal operating conditions can result from mechanical surface irregularities or deficient lubrication.

The diagnostic principle is two-tiered and consists of the obligatory trend monitoring of vibration parameters and optionally of the analysis of kinematic damage frequencies.

First permissible reference values have to be learned on the undamaged engine. In monitor mode, the Peakanalyzer now compares the actual measurement with the reference measurements. It signals possible deviations that may be an indication of an irregularity. Signalling takes place via a digital output and if required via Profibus. The visualization can be done via a signal lamp. The smallest of guaranteed response time between changes in the vibration and message is 1.5 seconds.

To ensure the comparability of measurements, a classification is carried out. As class parameters the speed and, if required, additionally up to 12 other process variables are used. The measurements are then compared with reference measurements of the same class. If a new class is detected to which no reference measurements exist, the first measurements are used for generating reference values. In this case a no damage state is assumed.

This trend monitoring of vibration characteristics may follow a fully automatic analysis of kinematic damage frequencies. This is somewhat more complex and will work for all machine elements which are kinematically clearly describable and of which kinematic data are stored in the Peakanalyzer. First order spectra and envelope curve order spectra are calculated. In these significant spectral components are searched. These significant spectral components are finally checked on kinematic damage patterns. If they match, an alarm is generated.

Optionally, a control panel can be installed in order to start the measurement only at certain times.

Sensors have to be installed via adhesive, screw or magnetic connection acoustically close to the drive elements to be monitored and need to be connected electrically with the Peakanalyzer. Also the operating unit has to be connected with the Peakanalyzer. The Peakanalyzer is configured using the software Peakanalyzer Manager. The software Peakanalyzer Manager makes it possible to analyse all spectra, envelope spectra, order spectra and envelope curve manually. In addition there are a number of analysis tools available.

风力发电机组

风力发电机组通常设计使用寿命为 20 年。然而，它们受到特定负载的影响，这就是为什么传动链的各个部件不能在没有维护措施的情况下达到该使用寿命的原因。为了实现良好的结果，最重要的就是实施基于状态的维护。

因此，状态监测系统在风力发电机组中已经是标准配置。有了它们，就有可能及时发现以下异常现象：

– 滚动轴承损坏和主轴承不平衡，

– 齿轮箱上的齿轮和轴承损坏，

– 滚动轴承损坏和发电机不平衡，

– 不对中故障。

通过状态监测，通常可在达到实际临界条件前几个月检测到损坏。因此可以：

➔ 长期计划和组织维修工作、人员和辅助工具，

➔ 及时有针对性地采购备件，

➔ 缩短维护时间并可以安排在低风速期间。

市场

典型的风力发电机组配置：

通常，两个加速度传感器安装在发电机上，五个加速度传感器安装在齿轮箱上。风轮主轴轴承上可以安装多个加速度传感器。

在发电机高速轴上安装一个速度传感器，每转一个脉冲。重采样的应用并进行必要的阶次分析，这是足够准确的。

直驱风力发电机组：

速度传感器以外，通常还需要三个加速度传感器。

风力发电机组 – *Wind turbine generators*

Wind Turbine Generators

Wind turbines are developed for an operating time of 20 years. Nevertheless, they are subject to specific loads, which are the reason, why some components of the drive train do not reach their life expectancy without any maintenance works. However, to generate good returns, it is important to implement a predictive maintenance.

That´s why, condition monitoring systems are already a standard feature in wind turbines. So, it is possible to detect irregularities, in time:

– bearing damages and imbalance on the main bearing,

– damages on gears and bearings of the gearbox,

– damages on bearings and imbalance of the generator, and

– all alignment faults.

By Condition Monitoring, it is possible to detect damages even several months before reaching a critical state. In particular:

➔ *Maintenance works, personnel and tools could be planned and organized in the long-term.*

➔ *Spare parts could be ordered in time.*

➔ *Repair times are kept very short and could be shifted to the low wind period.*

安装的加速度传感器 – *Installed acceleration sensor*

The typical wind turbine configuration:

Typically, two acceleration sensors are installed at the generator and five sensors are installed at the gearbox. Further sensors are installed at each rotor bearing.

At the high-speed shaft, the generator shaft, a speed sensor is installed, which supplies one impulse per revolution. For the application of the essentially required order analysis by resampling, this is sufficiently accurate.

Gearless WTG:

In addition to the speed sensor, three acceleration sensors are typically applied.

风力发电机组叶片轴承诊断

叶片轴承将转子叶片的根部与轮毂连接在风力涡轮机上。它们承载非常大的交变载荷，而滚动元件和轴承环之间的滚动运动相对较低。叶片轴承的轴承表面的磨损通常不明显，并且不能通过传统的振动诊断方法检测到。

在实践中，叶片轴承的状态大多通过油脂样品分析或拆卸后检查。GfM 开发了低速传动的诊断方法用于评估叶片轴承。利用叶片轴承附近的传感器进行数据采集。为了测量，叶片旋转到最大可能的偏转角度。只要振动发生，测量结果允许评估内圈，外圈和滚动元件的局部轴承损坏。

离线叶片轴承诊断过程：

➜ 多个位移传感器和一个速度传感器安装于轮毂。

➜ 为了测量，叶片变桨角度在 90°，风轮处于静止状态并有一个叶片垂直地面。

➜ 采用 PeakStore 进行数据采集。

➜ 仪器安装在轮毂中，并通过带应用程序的智能手机进行远程控制。测量过程大约需要 4 个小时。

è 在办公室完成评估工作。

在线叶片轴承诊断过程:

➜ 多个位移传感器和一个速度传感器安装于轮毂。

è 为了测量，叶片变桨角度正常运行。

➜ 采用 Peakanalyzer 进行数据采集和分析。

Blade Bearings of Wind Turbines

Blade bearings connect the root of the rotor blades of wind turbines connected to the hub. They carry very large alternating loads while rolling movements between the rolling elements and bearing rings is comparatively low. Often the wear of the running surfaces of blade bearings is not noticed immediately and cannot be detected by classical vibration diagnostic methods.

In practice, the state of blade bearings is determined mostly by grease samples or after dismantling. GfM has developed a method of diagnosis of slow-speed drives which also permits the evaluation of the blade bearings. The data acquisition is performed with sensors in the vicinity of the blade bearings. For the measurement, the rotor blade is rotated to the maximum possible deflection. The measurement results allow the assessment of local bearing damage on the inner ring, outer ring and rolling elements, as far as vibrations arise.
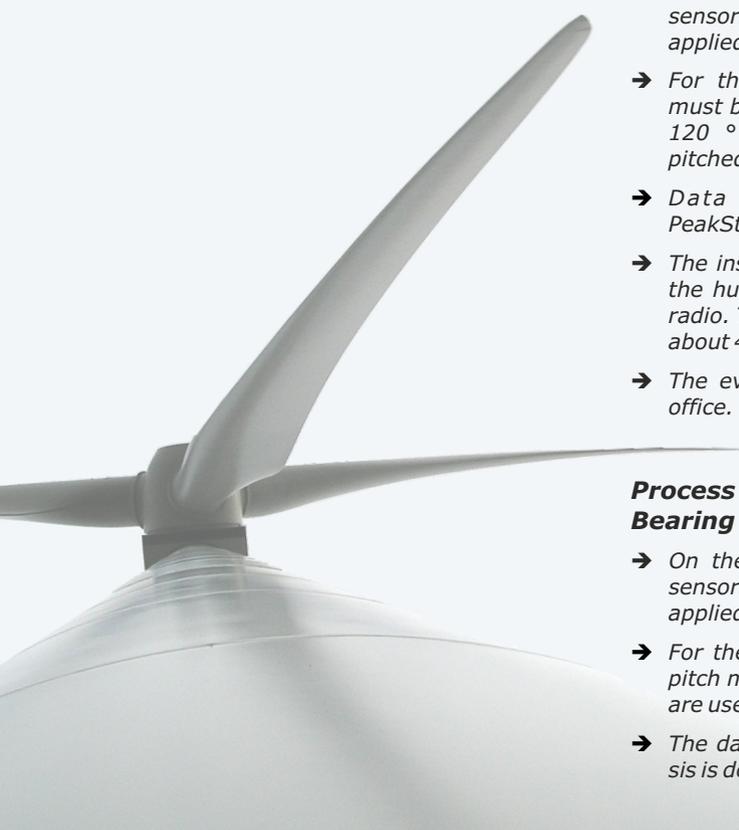
Process of the Offline Blade Bearing Diagnosis:

➔ On the hub several displacement sensors and a speed sensor are applied.

➔ For the measurement, the blade must be at a standstill in the 0 ° -, 120 ° - and 240 ° position are pitched at 90 °.

➔ Data are collected with the PeakStore5.

➔ The instrumentation is mounted in the hub and remote controlled via radio. The measuring process takes about 4 hours.

➔ The evaluation takes place in the office.

Process of the Online Blade Bearing Diagnosis:

➔ On the hub several displacement sensors and a speed sensor are applied.

➔ For the measurement, the normal pitch movements of the rotor blade are used .

➔ The data measurement and analysis is done by the Peakanalyzer.

风力发电机组基础监测

近年来，越来越多地报道了风力发电机组的基础问题。每项具体评估都要对各风力发电机组进行必要的调查。除了由专家对基础本身进行广泛的直接评估之外，还要证实具体的初始怀疑的间接测量方法，这些方法不描述基础本身，而是基础组件的运动。

基础安装部件的移动是载荷影响的结果。载荷可以在比如系统急停或正常停机时产生。

为了分析由于正常运行负载而导致的基础安装部件的运动，Baseanalyzer 将永久安装在风力发电机组上，并全天候在线测量所有运行情况。使用位移传感器和应变传感器。

Baseanalyzer 可作为独立系统，也可以作为 Peakanalyzer 的一部分提供。

监测过程：

位移和应变传感器安装在基础安装部分的区域中。这通常在几个小时内完成。通常在主风向和横向风向上进行测量。

监控的是塔筒的运动。警报阈值可以随时自由更改。位移传感器和应变传感器的组合用于区分允许的弹性应变和临界的塔筒运动。

作为应变传感器，可以应用应变仪测量点。

Foundations of Wind Turbines

In recent years, was reported increasingly about problems of foundations of wind turbines. The concrete assessment of each makes investigations on the individual turbines necessary. In addition to the extensive direct assessment of the foundation itself by specialists can be uses for hardening of a concrete initial suspicion indirect measurement methods in question, which describe not the foundation itself, but the movement of the foundation installation part.

Movements of foundation installation part are the result of loads. Loads can be either provoked, for example by an emergency stop of the system, or you can use loads from the normal system operation, which is much gentler on the wind turbine.

To analyze the movements of the foundation installation part as a result of normal operational loads, the Baseanalyzer at the wind turbine is permanently installed and measures online around the clock all operating situations. As sensors displacement sensors and strain sensors are used.

The Baseanalyzer is available as an independent system or as part of the Peakanalyzer.

Process of Monitoring:

The displacement and strain sensors are installed in the area of the foundation installation part. This is usually done in a few hours. Often it is sufficient to measure in the prevailing wind direction and transversely to this.

Monitored is the movement of the tower. An alarm threshold can be entered freely and naturally changed at any time. The combination of displacement and strain sensors allows for the distinction between admissible elastic elongation and critical tower movement.

As a strain sensor, a strain gauge measuring point is applied.

Peakanalyzer Manager

Peakanalyzer Manager 是一个支持多种任务的通用软件：

– 配置在线系统 Peakanalyzer 和 Baseanalyzer

– 配置离线系统 PeakStore5xx

– Peakanalyzer 和 Baseanalyzer 的监控服务和报警管理

– 其他来源数据的全自动频率选择性在线监测

– PeakStore 测量数据的全自动化离线诊断

– 其他来源数据的全自动化离线诊断

– 人工数据分析。

Peakanalyzer Manager 将数据存储在同一台计算机或网络上的 SQL 数据库中。SQL 数据库可以在网络中由多个用户同时使用。

Peakanalyzer 自身完成了深度诊断监测。测量的时间序列信号采用速度信息的频谱，阶谱和包络线谱的组合。这些频谱分析基于重要的频谱分量，然后检查其是否符合运动损伤模型。

使用其他来源的数据时也会发生相同的过程，但分析必须在安装了 Peakanalyzer Manager 的计算机上运行。为此必须有时间序列数据的接口，并且定期将时间序列数据传送到 Peakanalyzer Manager。

然后根据频谱、阶谱和包络线谱组合的重要频谱分量分析，检查其是否符合运动损伤模型。

同样适用于离线测量的数据。诊断工作在 Peakanalyzer Manager 中完成。

此外，Peakanalyzer Manager 还有一个报告生成器，它支持生成状态和诊断报告。
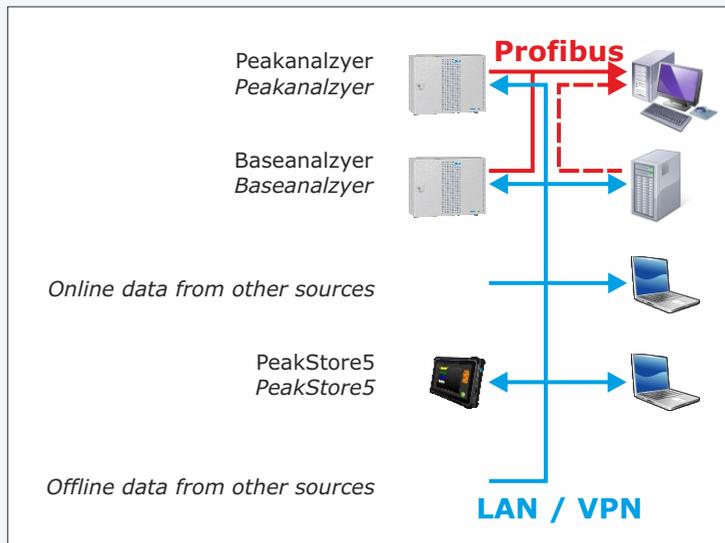
Peakanalyzer Manager

The Peakanalyzer Manager is an universal software supports different tasks:

– configure the online systems Peakanalyzer and Baseanalyzer

– configure the offline system PeakStore5

– monitoring service and alarm management for Peakanalyzer and Baseanalyzer

– fully automated frequency selective online monitoring of data from other sources

– fully automated offline diagnosis of PeakStore data

– fully automated offline diagnosis of data from other sources

– manual analysis of data.
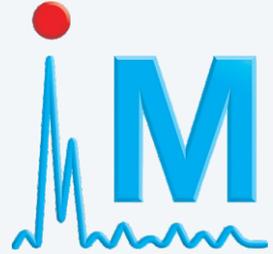
The Peakanalyzer Manager stores data in an SQL database, that has to be located on the same computer or in the network. In the network, the SQL database can then be used by multiple users simultaneously.

In the Peakanalyzer the deep diagnostic monitoring is done in the Peakanalyzer itself. Of the measured time signals using the speed information spectra, order spectra and envelope curve order spectra are composed. These spectra will be analyzed regarding significant spectral components, which in turn are checked for compliance with kinematic damage patterns.

The same process takes place if data from other sources are used, although with the difference, that the analysis will be performed on the computer, on which the Peakanalyzer Manager is installed. So there has to exist an interface to the time data and the time data have to be supplied regularly to the Peakanalyzer Manager.

And then spectra, order spectra and envelope curve order spectra are composed, which are analyzed regarding significant spectral components, which in turn will be checked for compliance with kinematic damage patterns.

The same scenario is applied to data from offline measurements. The diagnostic work is done in the Peakanalyzer again.

In addition, the Peakanalyzer Manager has a report generator, which supports the generation of status and diagnostic reports.

control station

, SQL-Server
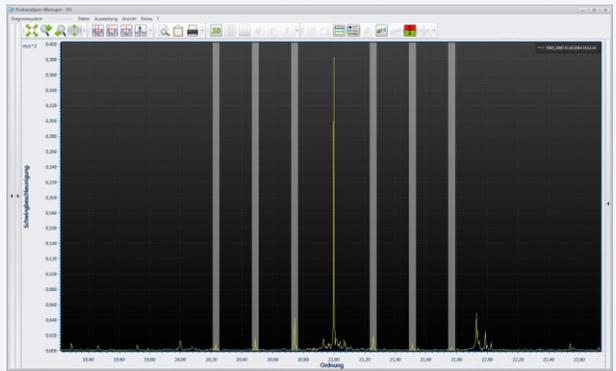Data gateway, SQL Server

Diagnostician, internally or externally

service staff

Peakanalyzer Manager

Peakanalyzer Manager 包括许多便捷的分析工具：

– 时间序列信号、频谱和阶谱图

– 瀑布图和其他图谱

– 测量光标、谐波光标、边带光标和标记光标

– 时间序列特征图

– 时间序列参数图

此外，可以比较不同机器之间的频谱和趋势。

报告生成器简化报告。可以自动的生成标准报告。

阶谱 – *Order spectrum*

通过振动描述的现象可以在阶谱中可视化。阶次是参考速度的倍数。因此，速度变化不会影响解析。

在瀑布图中，许多图谱是连续排列的。因此，可以容易地检测单个频谱分量的变化。 有经验的观察者可以快速检测到异常的运行状态。然而，难以检测各个频谱分量的绝对值。

在频谱图中，许多图谱上下方式排列在一起。结果为二维表示。幅度（第三维）由不同颜色标记。因此，单个值的测量非常简单。

Peakanalyzer Manager

The Peakanalyzer Manager also includes a number of convenient analysis tools:

– *Diagrams of time signals, frequency spectra and order spectra*

– *Waterfall diagrams and spectrograms of all spectra*

– *Measurement cursor, harmonic cursor, sideband cursor and marker cursor*

– *Presentation of characteristics as a time plot*

– *Presentation of parameters as a time plot*

Moreover, the comparison of spectra and trends between different machines is possible.

A report generator simplifies reporting. Standard processes are executed automatically with it.
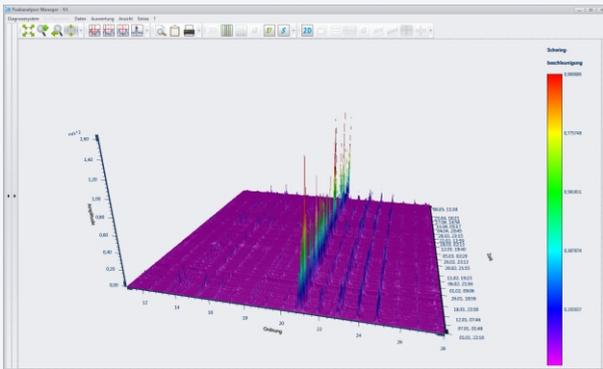
瀑布图 – *Water flow chart*
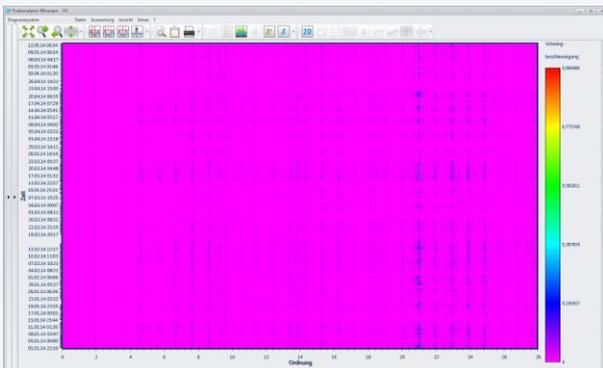
图谱 – *Spectrogram*

Phenomena, that could be described by vibrations, are visuable in the order spectra. Orders are the multiples of a reference speed. Thus, speed variations do not affect the interpretation.

At the water flow chart, many spectra are arranged behind one another. So, it is possible, to detect changes of single spectral components, easily. The experienced viewer could quickly detect abnormal operating conditions. However, it is difficult to detect the absolute level of individual spectral components.

In the spectrogram, many spectra are arranged, one above the other. The result is a two-dimensional representation. The amplitude – the third dimension – is marked by different colours. So, the measuring of single values is quite simple.

Peakanalyzer – 全自动化在线状态监测系统

系统Peakanalyzer 全自动化地监测传动装置的振动。根据测量的时间序列信号，形成频谱、包络谱、阶谱和包络线谱。这些频谱将根据传动典型损伤模型进行分析。如果检测出损伤，则会产生报警。所有这些都完全自动运行，无需人工干预。
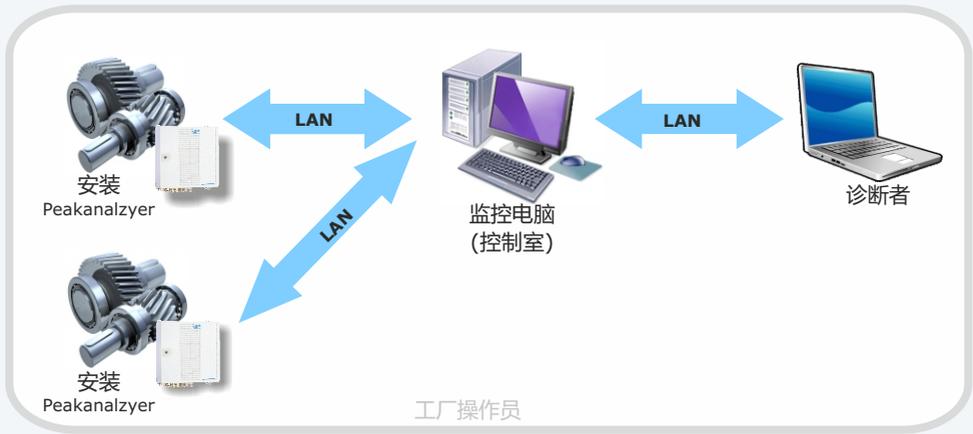
警报包含一条纯文本消息，以易于理解的方式描述检测到的异常。现在首次需要人工进行报警确认。

在大多数情况下，在第一次检测到损伤并报警到传动装置的损坏停工之间仍可运行很长时间。通常，你可以持续地观察损伤的"增长"，同时组织安排维修工作。

除了非常有意义的纯文本消息之外，当然还有可以查看导致警报的所有数据。这些可以是频谱和包络谱，瀑布图和图谱，或者甚至是某个频率线随时间变化的幅值。这使诊断专家能够贡献自己的特定经验。

Peakanalyzer 可以由工厂的操作员来监控。或者也可委托GfM 或独立的第三方来监控。

Peakanalyzer – the Fully Automated Online Condition Monitoring System

The Peakanalyzer monitors the vibrations of a drive, fully autonomously. Spectra and envelope spectra are composed of the measured time signals. These spectra will be analyzed regarding to pattern, that are typical for damages on drives. And if this is the case, the system generates an alarm. So far, no action is required.

The alarm includes a plaintext, that describes the detected irregularity in a simple way. This is the first time, a human action is required to confirm the alarm.

If the Peakanalyzer has detected a typical damage pattern and has generated an alarm, then there is still enough time until the actual breakdown of the drive. In general, you will observe the "growth" of a damage, while organizing the maintenance works, simultaneously.

Except for the very meaningful plaintext, there is also the opportunity to see all the data, that led to the alarm. These are spectra and envelope spectra, waterfall displays and spectrograms or just the profile of the amplitude of a particular frequency line as a time plot. So diagnosis experts can contribute their specific experiences.

The plant operator can supervise the Peakanalyzer, himself. Alternatively, GfM can be mandated with the supervision or also a independent third company.

Peakanalyzer – 全自动化在线状态监测系统

典型损伤:

➜ 滚动轴承缺陷

è 齿轮不规则

è 轴上的故障

è 不平衡

è 不对中

è 其他异常
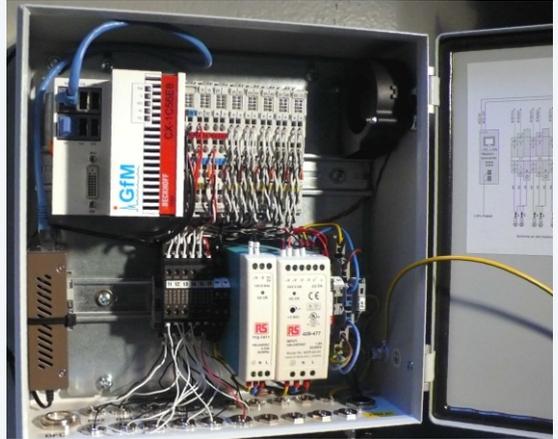
Peakanalyzer 具有防雷保护 –
Peakanalyzer with overvoltage protection

通过创新算法实现高可靠性诊断:
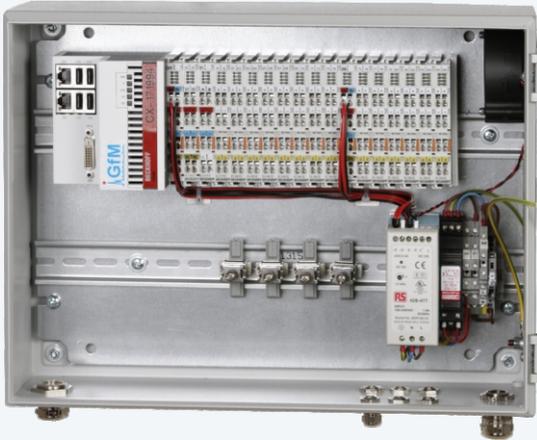
一方面,不能忽视齿轮的损坏。另一方面,系统不能太过敏感并频繁报警。因此,需要非常智能的算法来完善诊断:

➜ 通过一致使用阶次分析,在速度变化的情况下可靠的诊断

➜ 形成具有32,768线的高分辨率频谱,以避免由于低分辨率导致的诊断错误

➜ 通过使用DVS分析,即使在未知负载条件下也能可靠地进行诊断

è 利用损伤频率的交叉检查进行巧合匹配时的可靠诊断

è 通过自动验证有效诊断条件,对未定义的操作条件进行可靠的诊断

è 通过连续测量中验证报警条件,即使在意外振动进入的情况下也可靠地进行诊断

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Peakanalyzer – the Fully Automated Online Condition Monitoring System

Peakanalyzer 具有 26 通道的版本 –
Peakanalyzer in a 26-channel version

Systems

High diagnostic reliability through innovative algorithms:

On the one hand, no damages on gears have to be overlooked. On the other hand, the system should not be too sensitive, that false alarms are generated, permanently. Therefore, very intelligent algorithms are applied to perfect the diagnosis:

➔ *Reliable diagnosis in case of speed variations by the consistent use of order analysis*

➔ *Formation of high-resolution spectra with 32,768 lines to avoid diagnostic errors due to low spectral resolution*

➔ *Reliable diagnosis in case of unknown machine load by the use of DVS-analysis of all spectra*

➔ *Reliable diagnosis in case of coincidental match by the use of cross-checking of symptoms of damage frequencies*

➔ *Reliable diagnosis in case of undefined operating conditions by automatic verification of valid diagnostic conditions*

➔ *Reliable diagnosis in case of coincidental transmitted vibrations by verification of alarms in subsequent measurements coincidental transmitted vibrations*
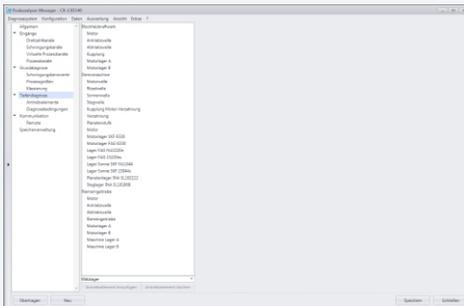
Peakanalyzer – 安装、配置和调试

加速度传感器的安装非常简单。每个传感器通过一个小的安装底座粘在机器上。传感器本身已拧紧。然后将传感器电缆连接到 Peakanalyzer。连接电源线和网线。

必须为 Peakanalyzer 提供一些基本信息。包含传动部件的的运动学数据和一些基本定义。

如有必要，再次检查所有传感器的正确连接。相应的菜单设置完成。然后 Peakanalyzer 即可投入运行。系统立即开始监测。
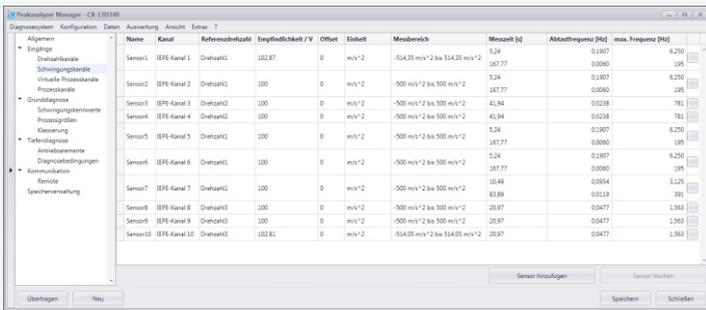
传感器输入数据 – *Input of the sensor data*

传动部件输入数据 – *Input of the drive elements*

诊断条件输入数据 – *Input of the diagnostic conditions*

Peakanalyzer – Installation, Configuration and Commissioning

The installation of the accelerometers is very easy. For each sensor, a small mounting base is glued on the machine. The sensor itself is screwed. Now, the sensor cables are connected to the Peakanalyzer. The power supply and a network cable is connected, too.

The Peakanalyzer has to be supplied with some basic information. These are the kinematic data of the drive and a few fundamental definitions.

The correct connection of all sensors can be checked again. The relevant menus are available. Thereafter, the Peakanalyzer can be put into operation, immediately. Now, the system starts the monitoring.

加速度传感器的推荐位置：
- 电机轴承 B：径向
- 电机轴承 A：径向和轴向
- 行星齿轮级：驱动端和输出侧，径向
- 圆柱齿轮级：驱动端和输出侧，径向

Recommended positioning of accelerometers:
- *Motor B-bearing: radial*
- *Motor A-bearing: radial and axial*
- *Planetary gear stage: drive end and output side, radial*
- *Cylindrical gear stage: drive end and output side, radial*

外形尺寸： *- Housing options:*
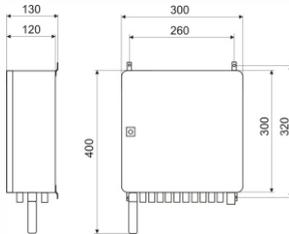
宽度 300 mm – *300 mm wide*
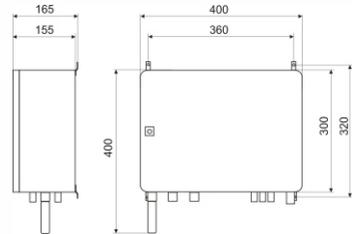
宽度 400 mm – *400 mm wide*

检查传感器 – *Check the sensors*

Peakanalyzer – 报警的呈现

Peakanalyzer Manager 中会显示警报，如果需要，还可显示在控制室监控平台上。

异常和相关显著值以表格形式显示。用户不需要具备任何诊断知识，但仍然可以从深入的诊断结果中受益。

诊断专家可以通过阶谱和包络线谱检查探测到的异常。

报警信息 *– Alarm table*

Peakanalyzer – How an Alarm Looks Like

An alarm is displayed at the Peakanalyzer and if necessary also at external platforms, like a control centre.

Abnormalities and the associated significance values are shown in an alarm overview in tabular form. The user does not need any diagnostical experiences to get valuable diagnosis results.

A diagnosis expert can check the detected irregularities in the order spectra and in the envelope curve spectra.

探测到滚动轴承内圈损坏的阶谱和包络谱 –
Order spectrum and envelope order spectrum of a detected roller bearing inner race damage
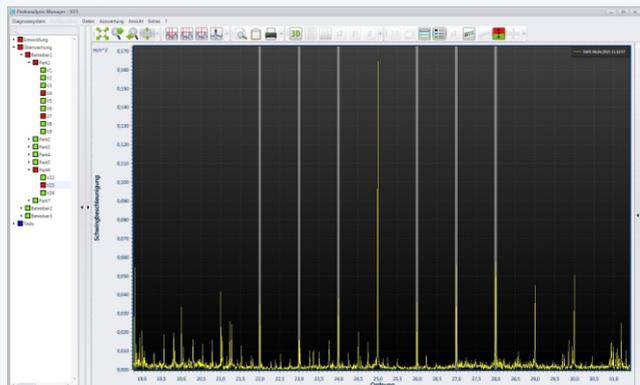
探测到局部齿轮损坏的阶谱 –
Order spectrum of a detected local tooth damage

Peakanalyzer 用于参数自动监视

特征值和参数的监测具有悠久的历史。早在20世纪60年代，就已经制定了 VDI 2056 指南，该指南现已被撤销。它最初用于评估电机振动对其基础的影响。因此，监视参数是在 10 到 1000 赫兹范围内振动速度的有效值。

提醒：在六十年代，主要使用模拟技术识别特征值，直到使用指针仪器或可以在纸幅上绘制测量值的测量划线器。

即使在今天，特征值和参数对机器监视也具有一定的意义。尽管频率选择性机器诊断更加准确和可靠。但是这需要更多计算时间。而特征值监测能够在极短的反应时间内实现。

对于机器诊断，可以考虑以下特征值：

– 振动速度的有效值

– 振动加速度的有效值

– 振动加速度包络线的有效值.

通常，先存储参考值，用于比较后面的度量值。这样，振动行为的变化可以非常迅速地被识别。异常的具体原因通常不能从特征中得出。然而，这可以通过随后的频率选择性诊断来得到。

特征值监测的典型应用：

➜ 机床监测

è 试验台上急停测试

è 批量产品最终测试。
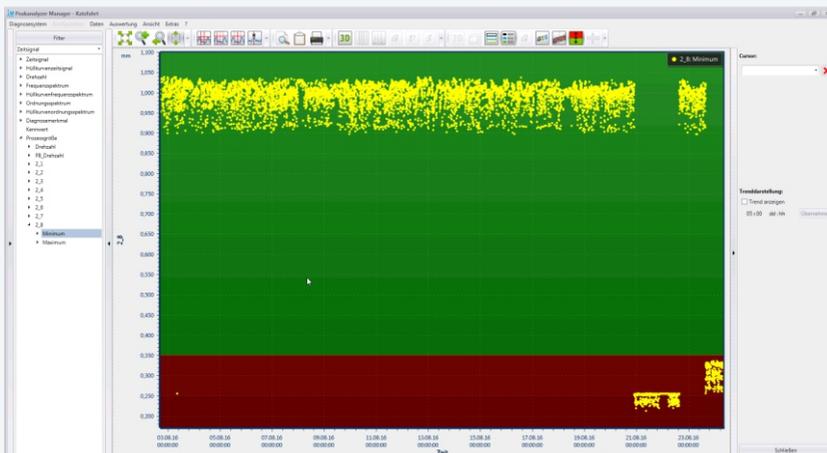
距离信号的平均值 – *Average value of an distance signal*

Peakanalyzer
for Automatic Parameter Monitoring

The monitoring of characteristic values and parameters has a long tradition. Already in the 60s the VDI guideline 2056 was created, which now was withdrawn. It served originally the assessment of the influence of vibrations of electrical machines on their foundations. Consequently the effective value of vibration velocity in the range of 10 up to 1000 Hertz is the supervised parameter.

Reminder: In the 60s, the detection of characteristic values was carried out mainly with analog technology up to visualization with hand instruments or measurement scribes which could draw a measured value to a paper web.

Today, characteristic values and parameters have still a certain importance for the machine monitoring. Although the frequency selective machine diagnosis is much more accurate and reliable. But it requires computation time. In contrast, the parameter monitoring enables extremely short reaction times.

For machine diagnostics the following characteristic values come into question:

– Effective value of vibration velocity

– Effective value of vibration acceleration

– Effective value of the envelope curve of the vibration acceleration.

Typically, one first stores reference values with which the later measurement values are compared. In this way, changes in the vibrational behavior can be extremely quickly recognize. Normally, the specific cause of anomalies cannot be derived from characteristics. However, this may be clarified by a subsequent frequency-selective diagnosis.

Typical applications for the monitoring of characteristic values are:

➔ Monitoring machine tools

➔ Test runs on test stands for the purpose of emergency shutdown

➔ End-of-line testing of serial products.

Systems
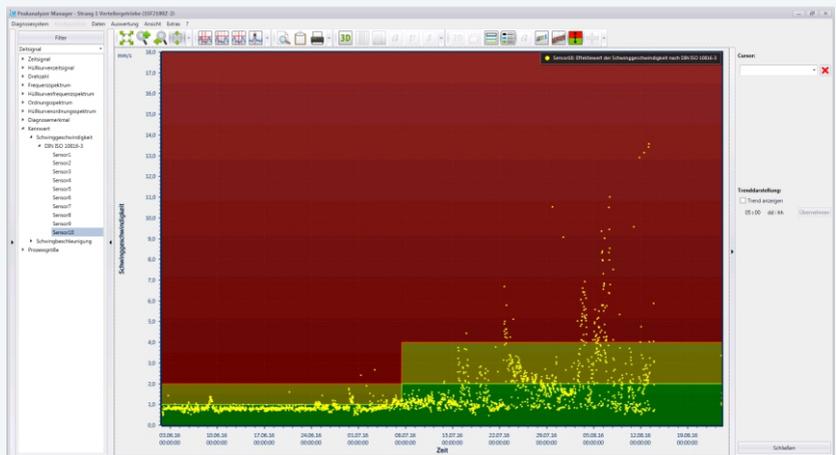
振动速度的有效值 – *RMS value of vibration velocity*

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Peakanalyzer – 技术参数

输入信号：

– 多达 32 通道的快速输入范围 ±5 V 加速度传感器 (IEPE)，采样频率 50 kHz，带宽 20 kHz，振幅分辨率可选 24 Bit 或 16 Bit；可选感应位移传感器 (± 10 V)，采样频率 10 kHz，带宽 4 kHz，振幅分辨率 24 Bit；可选电压信号 (±10 V)，采样频率 100 kHz，带宽 30 kHz，振幅分辨率 16 Bit
– 连接的加速度传感器的自动断线检测
– 最多 32 个输入通道，用于测量其他数据（如功率，温度，扭矩）
　- ± 10 V，幅值分辨率 24 Bit 或 16 Bit
　- 0 … 20 mA，幅值分辨率 16 Bit
　- Pt100，幅值分辨率 16 Bit
　- 应变片，幅值分辨率 24 Bit
　- Profibus
　- 采样频率可调节 1 Hz … 1 kHz
　- 统计值的存储 (例如最小值、最大或平均值)，可设置按分钟或小时。
– 最多 4 通道速度输入，脉冲时间点测量，精度 1ns。可选择通过 A/B 通道测量旋转方向的速度。或通过 Profibus 输入速度
– 可通过 LAN（最长100 m）或光纤（最长 2 km）在现场分布式采集输入信号

自动化监视：

– 面向事件的诊断，适用于每台机器两种速度和两种功率范围
– 可通过数字输入，速度通道或可控制的过程通道启动测量
– 生成 32,768 线的频谱和包络频谱，可调至20 kHz，10 kHz，5 kHz，2,5 kHz，1,25 kHz，625 Hz，312,5 Hz 和156 Hz
– 32,768 线阶谱和包络谱，速度相关的分辨率
– 通过 DVS（传动振动有效识别）分析自动检测频谱有效峰值，包络频谱、阶谱和包络谱
– 特征值依据 DIN ISO 10816-3
– 特征值依据 VDI 3834 0,1 Hz … 10 Hz, 10 Hz … 1 kHz, 10 Hz … 2 kHz, 10 Hz … 5 kHz
– 具有可调滤波频率的振动速度，振动加速度和振动加速度包络线的在线有效值
– 监视已配置参数和过程变量的阈值超限
– 根据峰值（幅度和显著性，频率/阶次）生成诊断属性
– 报警时存储特征值
– 报警时存储频谱，包络谱，阶谱和包络阶谱
– 报警时存储时间序列信号
– Peakanalyzer 上的测量数据最多可存储 3 个月
– 通过以太网读取报警状态
– 通过 Profibus 输出特征值和过程变量报警或通过数字量输出发送信号

报警处理：

– 报警可以通过软件进行确认。这可确保仅在较高振动值下再次生成相同的警报（间接趋势监控）。

机器寿命文档编制：

– 诊断特征和特征值的循环存储
– 频谱的循环存储，包括包络谱、阶谱和包络阶谱
– 循环存储时间序列信号

其他功能：

– Peakanalyzer 的个人访问权利
– 监控配置存储在 Peakanalyzer 中，电源启动后自动运行
– 短时 UPS，用于在发生电源故障时存储重要数据
– 电源 230 V，通常 <40 W，最大 80 W
– 控制箱，IP 65
　- 常规尺寸 300 mm x 300 mm x 120 mm, 可按需加大尺寸
　- 重量约 7 kg
　- 电缆夹套
– 工作温度范围 5 °C … 40 °C
– 存储温度范围 -20 °C … 70 °C

Peakanalyzer – Technical Data

Signal inputs:

– up to 32 fast inputs for **accelerometers** (IEPE) in the range ± 5 V, sampling frequency 50 kHz, bandwidth 20 kHz, amplitude resolution optional 24 Bit or 16 Bit; alternatively **inductive displacement sensors** (± 10 V), sampling frequency 10 kHz, bandwidth 4 kHz, amplitude resolution 24 Bit; alternatively **voltage** (± 10 V), sampling frequency 100 kHz, bandwidth 30 kHz, amplitude resolution 16 Bit

– automatic detection of broken wires of connected accelerometers

– up to 32 inputs for collecting of further measured values (e.g. drive power, temperature, torque)
  - ± 10 V, amplitude resolution 24 Bit or 16 Bit
  - 0 ... 20 mA, amplitude resolution 16 Bit
  - Pt100, amplitude resolution 16 Bit
  - strain gauge, amplitude resolution 24 Bit
  - Profibus
  - sampling frequency adjustable 1 Hz ... 1 kHz,
  - storage of statistical sizes, e.g. minimum, maximum or average value, is adjustable between multiple values per minute and one value per hour

– up to 4 speed inputs, measurement of impulse time point, accuracy 1 ns. Optionally speed input via A/B-Lane with measurement of rotating direction. Alternatively speed input via Profibus

– distributed mounting of signal inputs in the field via LAN (up to 100 m) or fibre optical cable (up to 2 km) possible

Automatic monitoring:

– event based diagnosis for two speed ranges and two power ranges per machine

– start of measurements can be controlled via digital inputs, speed input or process input

– calculation of spectra and envelope curve spectra with 32,768 lines, adjustable to 20 kHz, 10 kHz, 5 kHz, 2.5 kHz, 1.25 kHz, 625 Hz, 312.5 Hz and 156 Hz

– order spectra and envelope curve order spectra with 32,768 lines with a speed depending resolution

– automatic detection of significant peaks in spectra, envelope curve spectra, order spectra and envelope curve order spectra by DVS (Drive Vibration Significance analysis)

– characteristic values according to DIN ISO 10816-3

– characteristic values according to VDI-3834 0.1 Hz ... 10 Hz, 10 Hz ... 1 kHz, 10 Hz ... 2 kHz, 10 Hz .. 5 kHz

– online RMS of vibration velocity, vibration acceleration and vibration acceleration of envelope with adjustable filter frequency

– monitoring of threshold exceeding of configured characteristic values and process factors

– generation of found peaks (amplitude and significance, frequency/ order) as diagnostic attributes

– storage of characteristic values in case of an alarm

– storage of spectra, envelope curve spectra, order spectra and envelope curve order spectra in case of an alarm

– storage of time signals in case of an alarm

– measurement data can be saved up to 3 months (adjustable) on the Peakanalyzer

– querying of alarm states over Ethernet

– output of characteristic value alarms and process factor alarms via Profibus or signalling via digital outputs

Alarm dealing:

– Alarms can be acknowledged by software. This ensures that the same alarm will only be generated again if there are higher vibration values (indirect tendency monitoring).

Documentation of machine life:

– cyclic storage of diagnostic attributes and characteristic values

– cyclic storage of spectra, envelope curve spectra, order spectra and envelope curve order spectra

– cyclic storage of time signals

Other features:

– individual rights for accessing the Peakanalyzer

– the monitoring configuration is stored on the Peakanalyzer, automatic start by connection of the supply voltage

– short-time-UPS for saving important data on power failure

– voltage supply range 230 V, typical < 40 W, maximum 80 W

– steel plate box, IP 65
  - gauges typical 300 mm x 300 mm x 120 mm, larger boxes if required
  - weight about 7 kg
  - cable glands

– operating temperature range 5 °C ... 40 °C

– storage temperature -20 °C ... 70 °C

Systems

Peakanalyzer SE

Peakanalyzer SE 是由 GfM 公司开发的在线状态监测系统的特殊版本，该版本使得专业客户可以使用他们自己开发的诊断工具。系统计算时间序列信号、频谱、包络线谱、阶谱和包络线阶谱。这些数据可以直接通过 Peakanalyzer Manager 进行可视化，也可以不受限制的导出到客户自有的分析工具中。

此外，Peakanalyzer SE 可以根据 DIN ISO 10816、VDI 3834 准则和其他（如包络曲线信号或测量值的有效值）计算出特征值。这些特征值用于监视预先定义的极限值，并用于产生报警。

如果后续希望升级到完整版本的 Peakanalyzer，可以通过激活码方便的实现。需要购买一年或无限制的许可证。完整的版本包括通过 DVS 分析和运动损伤模型搜寻的方法对复杂传动的全自动化监测，。

除了最大的 32 个振动传感器通道以外，Peakanalyzer SE 提供多达 32 个采用统计特征值的过程值监视。

	Peakanalyzer SE	Peakanalyzer
数据采集:		
- 振动, 采样频率 50 kHz	max. 32	max. 32
- 速度	max. 4	max. 4
- 过程数据, 采样频率 max. 1 kHz	max. 32	max. 32
存储计算:		
- 时间序列信号和包络线	✓	✓
- 频谱和包络线频谱	✓	✓
- 阶谱和包络线阶谱	✓	✓
- 依据 DIN ISO 10816、VDI 3834 准则和其他来自振动的特征值	✓	✓
- 过程数据的统计值	✓	✓
全自动化诊断:		
- DVS-分析法		✓
- 运动损伤模型搜寻和产生报警		✓
特征值监视:		
- 依据 DIN ISO 10816、VDI 3834 准则和其他来自振动的特征值	✓	✓
- 过程数据的统计值	✓	✓
可视化:		
- 时间序列信号、频谱和过程特征值	✓	✓
- 瀑布图和图谱	✓	✓
- 过程数据时间序列图	✓	✓
- 诊断特征图谱显示		✓

Peakanalyzer SE

The Peakanalyzer SE of GfM is an inexpensive special edition for experts using their own diagnosis tools. Time signals, spectra, envelope curve spectra, order spectra and envelope curve order spectra are calculated. Those can be visualized directly by means of the Peakanalyzer Manager, but can also be exported unrestricted into customer-owned analysis tools.

Furthermore the Peakanalyzer SE can calculate characteristic values according to DIN ISO 10816 and VDI guideline 3834 and others, such as the effective value from the envelope curve signal, from measurement values. These characteristic values are monitored for previously defined limit values and are used for alarm generation.

Who wants to upgrade to the full version of the Peakanalyzer later on, can do this uncomplicated for all or a part of the hardware-sided installed canals by activation codes. Therefore a one-year or unlim-ited license has to be purchased. The full version includes a fully automated monitoring of complex drives by DVS-analysis and searching for kinematic damage patterns – as it is known from the Peakanalyzer.

In addition to the maximum of 32 vibration canals up to 32 canals for monitoring of process values are available for the Peakanalyzer SE by using statistical characteristic values.

	Peakanalyzer SE	Peakanalyzer
Data acquisition:		
- Vibration channels, sampling frequency 50 kHz	max. 32	max. 32
- Speed channels	max. 4	max. 4
- Process values channels, sampling frequency max. 1 kHz	max. 32	max. 32
Storage resp. calculation:		
- Time signal and envelope curve	✓	✓
- Spectrum and envelope curve spectrum	✓	✓
- Order spectrum and envelope curve order spectrum	✓	✓
- Characteristic values according to DIN ISO 10816 and VDI guideline 3834 and others from vibration channels	✓	✓
- Statistic values from process values	✓	✓
Fully automatic diagnosis:		
- DVS-analysis		✓
- Search for kinematic damage patterns and alarm generation		✓
Monitoring of characteristic values:		
- Characteristic values according to DIN ISO 10816 and VDI guideline 3834 and others from vibration channels	✓	✓
- Statistic values from process values	✓	✓
Visualization:		
- Display of time signals, spectra and process of characteristic values	✓	✓
- Water flow charts and spectrograms	✓	✓
- Process values as a time plot	✓	✓
- Display of diagnostic features into spectra		✓

集成化 Peakanalyzer

集成化Peakanalyzer 状态监测系统软件授权，基于现有或用户安装的硬件实现高效、频率选择的状态监测系统。

使用集成化Peakanalyzer，可以可靠且早期地检测传动链中的不规则性，比如轴、联轴器、齿轮和滚动轴承上的异常。通过高频振动检测，形成阶次谱和包络阶谱，并且对应于损伤模式的显著频谱分量的自动检测来实现分析。

先决条件是必须有 Beckhoff TwinCAT 3 环境，并包括必要的模拟输入模块和传感器。与独立系统相比，具有直接的成本优势，因为用于控制的工业 PC 也可用于 Peakanalyzer。同样，现有的通信基础设施可用于配置Peakanalyzer 或下载数据。

控制单元中已有的信息 ，如转速、风速或功率，可以直接进入集成化 Peakanalyzer。这些测量不需要额外的传感器。此外，控制器也可以直接访问诊断结果。

集成化 Peakanalyzer 在 TwinCAT 3 环境中执行单独的任务，仅访问分配给 Peakanalyzer 的信号输入模块。不影响为控制单元提供服务的任务。

硬件配置通过附加插件实现，该插件完全集成在 TwinCAT 3 开发环境中，只需几步即可将信号输入端子分配给Peakanalyzer。使用Peakanalyzer Manager 软件进行传感器和传动链的进一步配置。

系统

Windows PC
TwinCAT 3 XAE
 PLC Programming
 TcCom Programming
 Peakanalyzer AddIn

Windows PC
Peakanalyzer Manager

LAN / TCP

Configuration

Beckhoff CX-System

BECKHOFF

Other Windows Applications

Windows Service
Peakanalyzer

ADS

TwinCAT 3 XAR

PLC
Control

TcCom
Control

TcCom
Peakanalyzer

I/O Terminals | Control | CMS
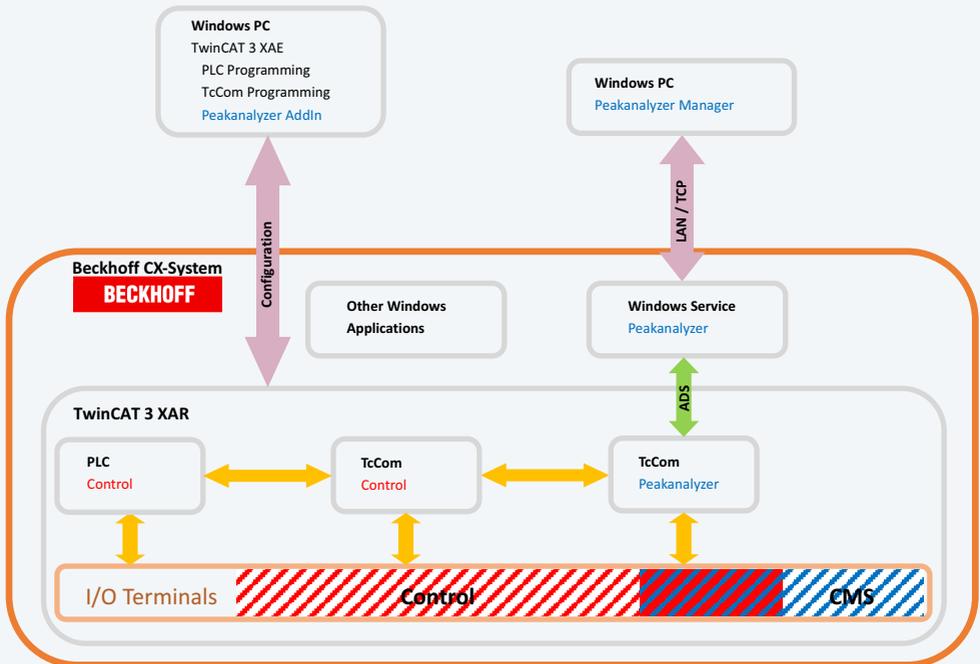
Integrated Peakanalyzer

The Integrated Peakanalyzer is a software license for a high-efficiency, frequency-selective condition monitoring system based on existing or user-installable hardware.

With the Integrated Peakanalyzer, irregularities in the drive train, i.e. anomalies on shafts, couplings, gears and rolling bearings can be detected reliably and early. The analysis is realized by high-frequency detection of the vibrations, formation of order spectra and envelope order spectra and the automatic detection of significant spectral components corresponding to damage patterns.

The prerequisite is the presence of a Beckhoff TwinCAT 3 environment including the necessary analog input terminals and sensors. Compared to a autarkic system, there is a direct cost advantage, since the industrial PC used for the control can also be used for the Peakanalyzer. Likewise, the existing communication infrastructure can be used to configure the Peakanalyzer or to download the data.

Information already present in the control unit, such as speed, wind speed or electrical power are usually taken directly into the Integrated Peakanalyzer. No additional sensors need to be planned for these measurements. In addition, diagnostic results can be made directly accessible to the controller.

The Integrated Peakanalyzer runs in a separate task on the TwinCAT 3 environment and only accesses signal input terminals that are assigned to the Peakanalyzer. The tasks serving the control unit remain unaffected.

The hardware configuration is carried out via an additional plug-in, which is fully integrated in the TwinCAT 3 development environment and in a few steps enables an assignment of the signal input terminals to the Peakanalyzer. The further configuration of the sensors and of the drive train is carried out with the Peakanalyzer Manager software.

Systems

集成化 Peakanalyzer

风电机组集成化Peakanalyzer共有两个版本:

➔ PAI-W04 最多 4 个振动信号通道,
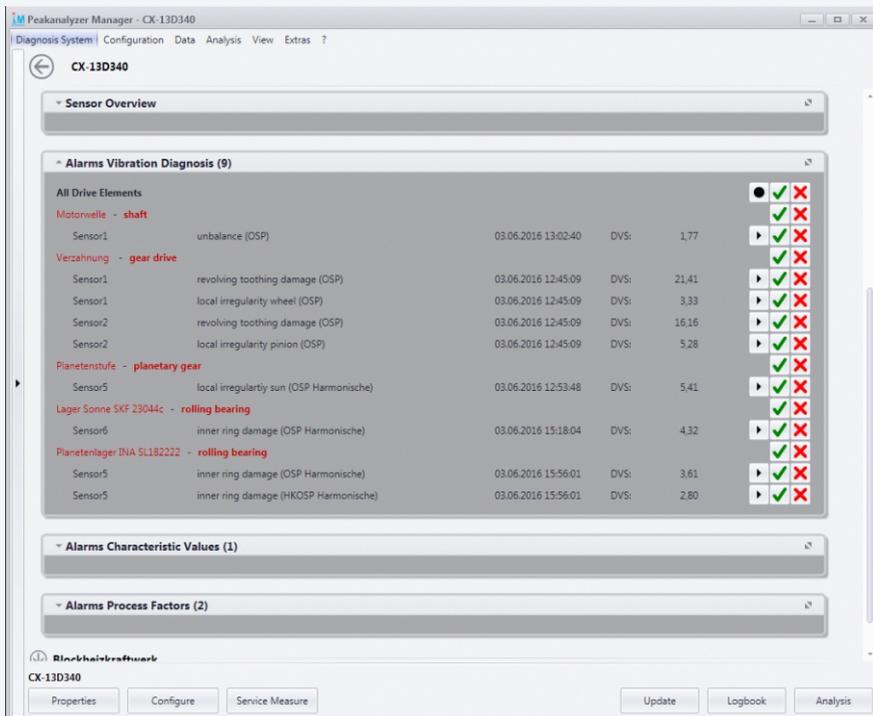 适用于直驱型风电机组

➔ PAI-W10 最多 10 个振动信号通道,
  适用于齿轮箱风电机组

在集成化Peakanalyzer中,用户必须确保安装并运行所需的硬件。

直驱型风电机组:

– 每个滚动轴承至少有一个加速度计,灵敏度500 mV/g,符合 IEPE 标准
  (例如,PCB 601A02)

– Beckhoff 双通道模拟量输入模块 ELM3602。每两个加速度计使用一个电缆夹。

齿轮箱风电机组:

– 每个主轴轴承至少一个加速度计, 灵敏度500 mV/g, 符合IEPE 标准
  (例如,PCB 601A02)

– 齿轮箱轴承上配置多个加速度计, 灵敏度100 mV/g, 符合 IEPE 标准
  (例如,PCB 608A11)

系统

Integrated Peakanalyzer

The Integrated Peakanalyzer for wind turbines is available in two versions:

➜ · PAI-W04 up to four channels for vibration signals,
   suitable for gearless wind turbines

➜ · PAI-W10 up to ten channels for vibration signals,
   suitable for wind turbines with gearbox

At the Integrated Peakanalyzer, the user must ensure that the required hardware is installed and operational.

Gearless wind turbine:

– at least one accelerometer per rolling bearing with a sensitivity of 500 mV/g with IEPE standard (e.g., PCB 601A02)

– Beckhoff dual-channel analog input terminal ELM3602. One clamp is required for every two accelerometers.

Wind turbine with gearbox:

– at least one accelerometer per rotor bearing with a sensitivity of 500 mV/g with IEPE standard (e.g., PCB 601A02)

– several accelerometers at the gearbox bearings with a sensitivity of 100 mV/g with IEPE standard (e.g., PCB 608A11)

– at least one accelerometer per generator bearing with a sensitivity of 100 mV/g with IEPE standard (e.g., PCB 608A11)

– Beckhoff dual-channel analog input terminal ELM3602. One clamp is required for every two acceleration sensors.

In the case that the speed is not available from the control unit, the installation of a speed sensor (e.g., Turck Ni12U-M18-AP6X-H1141) and a Beckhoff EL5151 single-channel incremental encoder interface are required.

The Beckhoff controller must have a TwinCAT 3 environment and an IO/C++ runtime license. There must be two free CPU cores, 512 MB of RAM and 2 GB of free hard disk space available.

<div style="writing-mode: vertical">Systems</div>

– 每个发电机轴承至少有一个加速度计，灵敏度100 mV/g，符合IEPE标准
  (例如，PCB 608A11)

– Beckhoff 双通道模拟量输入模块 ELM3602。每两个加速度计使用一个电缆夹。

如果控制单元无法提供转速，则需要安装速度传感器 (例如Turck Ni12U-M18-AP6X-H1141) 和Beckhoff EL5151 单通道增量编码器接口模块。

Beckhoff 控制器必须具有TwinCAT 3 环境和IO/C++运行时授权。必须具有两个可用的CPU内核，51 2 M B 的RA M 和2 GB 的可用硬盘空间。

集成化 BladeBearingAnalyzer

集成化BladeBearingAnalyzer 是一个软件授权。它允许将BladeBearingAnalyzer 应用于叶片轴承进行 集成化状态监测。非常有效的诊断算法可以搜索与各个叶片轴承的损伤频率相匹配的频率模式。当叶片变桨时，对每个叶片轴承执行诊断。如果在叶片轴承上检测到不规则，则产生警报。

此外，测量每个叶片轴承的轴承间隙，并且如果间隙超过设定值，则产生警报消息。

集成化 BladeBearingAnalyzer 使用条件：风电机组配置 Beckhoff 系统，EtherCAT 连接轮毂以及相应 的传感器和模拟输入模块。在这种情况下，BladeBearingAnalyzer 可以集成到现有的控制单元中。具 有直接的成本优势，因为用于控制的工业 PC 也用于 BladeBearingAnalyzer。同样，现有的通信基础设施可用于配置BladeBearingAnalyzer 或下载数据。诊断结果可以直接由控制单元访问。

集成化 BladeBearingAnalyzer 在 TwinCAT 3 环境中执行单独任务，仅访问分配给 BladeBearingAnalyzer 的信号输入模块。不影响为控制单元提供服务的任务。

系统

Integrated BladeBearingAnalyzer

The Integrated BladeBearingAnalyzer is a software license. It allows to use the BladeBearingAnalyzer as an integrated system to perform condition monitoring on rotor blade bearings on a wind turbine. Very efficient diagnostic algorithms search for frequency patterns that match the damage frequencies of the individual blade bearings. The diagnosis is executed for each blade bearing when the blade is pitched. If irregularities are detected on a blade bearing, an alarm is generated. An alarm is generated if irregularities are detected on a blade bearing.

Furthermore, the bearing clearance of each blade bearing is measured and an alarm message is generated if the clearance exceeds the tolerance.

The Integrated BladeBearingAnalyzer requires a Beckhoff system on the wind turbine and an EtherCAT connection to the hub and corresponding sensor technology there as well as analog input terminals. Under this condition, the BladeBearingAnalyzer can be integrated into the existing control unit. This results in a direct cost advantage, since the industrial PC used for the control can also be used for the BladeBearingAnalyzer. Likewise, the existing communication infrastructure can be used to configure the BladeBearingAnalyzer or to download the data. Diagnostic results can be made directly accessible to the control unit.

The Integrated BladeBearingAnalyzer runs in a separate task on the TwinCAT 3 environment and only accesses signal input terminals that are assigned to the BladeBearingAnalyzer. The tasks serving the control unit remain unaffected.

Systems

集成化 **BladeBearingAnalyzer**

技术要求

必须通过EtherCAT 提供以下信号：

- 每个叶片的变桨角度，分辨率至少为 0.1°

- 每个叶片轴承的速度，每转至少 3,600 个脉冲

- 叶轮的速度

- 叶片轴承与轴承环的轴向位移，50 kHz / 24位
  (为了检测此信号，我们推荐使用电感式传感器例如 Turck BI4-M12-LIU-H1141和 Beckhoff输入模块 ELM3004)

Beckhoff IPC 具有TwinCAT 3 和IO/C++ 运行时授权

- 2 个可用的 CPU 内核，512 MB RAM，用于测量和分析软件

- 2 GB 可用硬盘空间，用于测量数据

叶片经常完全变桨也是先决条件之一。

Integrated BladeBearingAnalyzer

Technical requirement

The following signals must be available via EtherCAT:

– *Pitch angle signal from each rotor blade with a resolution of at least 0.1°*

– *Speed signal from each blade bearing with at least 3,600 pulses per revolution*

– *Speed signal of the rotor*

– *the axial displacement signal of the bearing ring connected to the rotor blade of all rotor blade bearings with 50 kHz/24 bit*
  (For the detection of this signal we recommend the inductive sensor Turck BI4-M12-LIU-H1141 or comparable and the Beckhoff input terminal ELM3004)

Beckhoff IPC with TwinCAT3 and IO/C++ runtime license

– *2 free CPU cores 512 MB RAM for the measurement and analysis software*

– *2 GB free hard disk space for measurement data*

It is also a prerequisite that the rotor blade is regularly pitched with full deflection.

Software installation

The following steps are required:

– *Installation of the Peakanalyzer background service on the IPC*

– *Installation of the Peakanalyzer Configurator on a PC that is used for the TwinCAT configuration*

– *Installation of the Peakanalyzer Manager that is used for monitoring the BladeBearingAnalyzer to show alarm information and measurement data*

软件安装

需要执行以下步骤:

– 在 Beckhoff IPC 上安装 Peakanalyzer 后台服务

– 在用于 TwinCAT 配置的 PC 上安装 Peakanalyzer Configurator 配置器

– 安装用于监控的 Peakanalyzer Manager，显示 BladeBearingAnalyzer 报警信息和测量数据

集成化 **BladeBearingAnalyzer**

软件配置

首先必须将硬件通道分配给 Peakanalyzer。通过作为 TwinCAT XAE 插件提供的 Peakanalyzer Configurator 来完成。

配置以下通道和模块：

– 一个完整的 ELM3004 模块分配给 BladeBearingAnalyzer，并由 Peakanalyzer Configurator 自动参数化。

– 配置三个自定义通道用于叶片变桨速度。

– 配置三个自定义通道用于叶片变桨角度。

– 配置一个自定义通道用于叶轮转速。

自定义通道必须手动将控制单元相应变量链接到 BladeBearingAnalyzer 的 TcCom 模块。然后可以通过 Peakanalyzer Configurator 将配置上传到BladeBearingAnalyzer 。经过该过程 BladeBearingAnalyzer 的 TwinCAT 配置已完成，Beckhoff IPC 上的后台服务等待必须通过 Peakanalyzer Manager上传的其他配置。
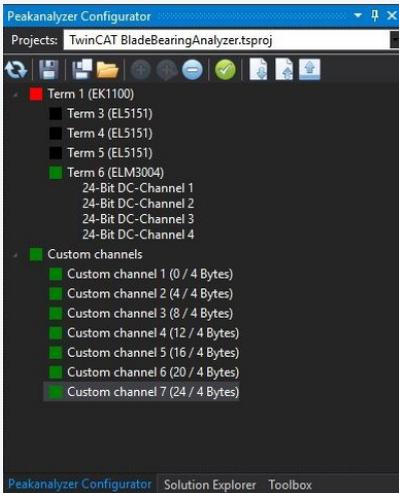
Peakanalyzer Configurator – *Peakanalyzer Configurator*

Integrated BladeBearingAnalyzer

Software configuration

At first the hardware channels must be assigned to the Peakanalyzer. This is done via the Peakanalyzer Configurator that is delivered as TwinCAT XAE Plugin.

Whereas following channels and terminals are configured:

– One complete terminal ELM3004 is assigned to the BladeBearingAnalyzer and is automatically parametrized by the Peakanalyzer Configurator.

*– Three custom channels are configured for the speed values of each blade.*

– Three custom channels are configured for the pitch angle of each blade.

– One custom channel is configured for the speed of the rotor.

The custom channels must be manually linked from the correct value of the control to the TcCom module of the BladeBearingAnalyzer. Afterwards the hardware description can be uploaded to the BladeBearingAnalyzer via the Peakanalyzer Configurator. At this stage the TwinCAT configuration of the BladeBearingAnalyzer is finished and the background service on the IPC waits for an additional configuration that must be uploaded via the Peakanalyzer Manager.

Systems
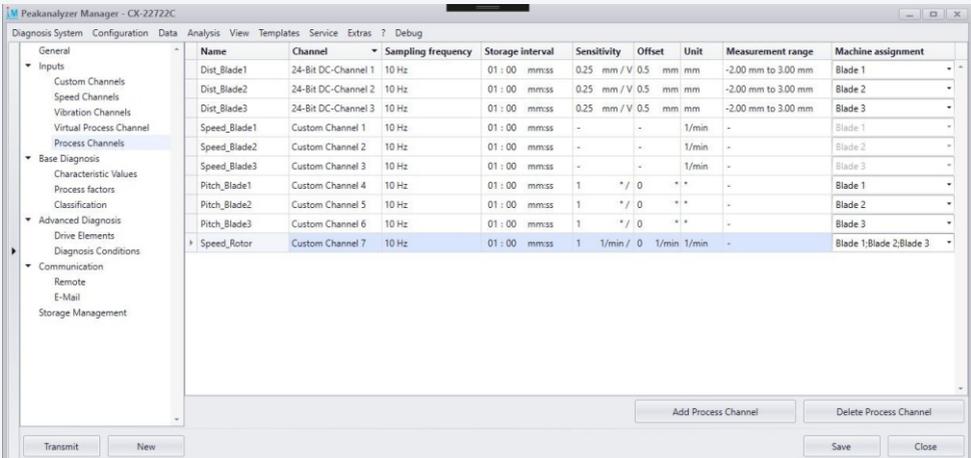
BladeBearingAnalyzer 通 道配置 –
Channel Configuration of BladeBearingAnalyzer

PeakStore5 – 最大12 通道的离线诊断系统

PeakStore 可以轻松地进行振动测量。传感器通过磁铁连接到机器上，并启动 PeakStore5，整个过程仅需几分钟。然后打包传感器，记录测量结果，您就完成了测量。

数据采集最多可以有 12 个振动通道和一个速度通道。对于大部分传动，无需更多传感器用于所有需要的测量位置。此外，PeakStore5 可通过智能手机上的应用程序进行远程控制，因此在测量过程中，人员无需待在机器附近。

诊断优先通过阶次分析进行。因此，不受速度波动影响，测量结果绝对可靠。

操作通过完全集成的平板电脑和 PAM 软件实现。您可以直接查看测量数据并在现场进行分析。但您也可以保存其他信息，如照片和测量日志。或者，您可以将所有数据直接发送给服务提供商进行分析。系统你可以设置 1.5 秒至 164 秒的测量时间或无限的时间。对于不限时间的测量，可以记录12 个通道大约 4 小时的测量数据，每个通道的采样率为51.2 kHz。

采样频率为 50 kHz 似乎很高。利用该理论，可以检测到高达25kHz 频率的正弦振动。在实践中，由于不可避免的抗混叠滤波器的特性，该值将更低。

对于轴承诊断，使用包络分析。这能够提取由滚动轴承损坏产生的冲击脉冲序列，其通过卷积与任何系统振荡相关联。

这些自然振动是从受损区域到加速度传感器的诊断信息的实际传送。这些自然振动的质量对诊断本身的质量具有决定性影响。

尽管这些自然振荡的频率是可确定的，但它们通常因机器而异。在实践中，通过尽可能宽带地测量，您可以获得最佳诊断结果。这就是 PeakStore5 采用相对高的 50kHz 采样频率的原因。

A sampling frequency of more than 50 kHz seems to be rather high. However, sinusoidal vibrations are detectable up to a frequency of 25 kHz. In practice, this value will be lower, because of the characteristic of the antialiasing filter.

Envelope analysis is used for the bearing diagnosis. Envelope analysis is capable to extract the force pulses, which are generated through bearing damages. These force pulses are linked with the natural vibrations of the whole system via convolution.

This natural vibrations of the system are the really carriers of the diagnostic information from the damage to the acceleration sensor. The quality of this natural vibrations has a significant influence on the quality of the diagnosis, itself.

The frequencies of these natural vibrations are determinable, but usually different from machine to machine. In practice, the best diagnosis results are achieved, through broadband measurements. This results in the relatively high sampling frequency of 50 kHz of the PeakStore5.

PeakStore5 – Offline Diagnosis on up to 12 Channels

Vibration measurements can easily be performed by the PeakStore5. The sensors have to be attached with magnets at the engine. Now, the PeakStore5 has to be started. The whole process just takes a few minutes. Then, you simply put back the sensors in the case again and log the measurements and is done.

The data collection is carried out with up to 12 vibration channels and one speed channel. At many drives, it is no longer necessary to implement sensors, to operate all necessary measuring positions. Furthermore, the PeakStore5 can be remote controlled via an app on a smartphone, so that no staff needs to be directly near the machine during the measurement.

Diagnosis is done preferably by order analysis. So, speed ripples have no influence, and the measuring results are absolutely reliable.

The operation is realized by a full-fledged integrated tablet PC and the software PAM. There you can look at the data directly and analyze it locally. But you can also store additional information such as photographs and measurement protocols. Or you ship all data directly to a service provider for analysis.

Measurement times of 1.5 seconds up to 164 seconds and indefinite measurement times as well can be set. In case of the indefinite measurement time you can record with 12 channels, each with 51.2 kHz sampling rate, about 4 hours of measurement data.

PeakStore5 – 离线诊断系统最大 **12** 通道

当前的振动特征值可以在传感器概览中读取。

The current vibration characteristics can already be read in the sensor overview.

振动通道必须配置一次。通道名称以及传感器的重要参数存储在 PeakStore5 中。

The vibration channels must be configured once. Channel names as well as important data of the sensor are stored in the PeakStore5.
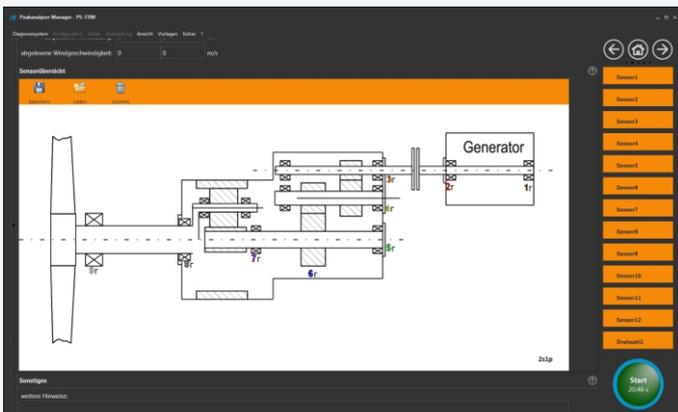
然后可以在测量任务中记录传感器位置。测量数据将永久的绑定测量任务。

The sensor positions can then be noted in the electronic measurement protocol. The measurement protocol is permanently assigned to the measurement data.

PeakStore5 – Offline Diagnosis on up to 12 Channels

即使在测量期间，时间序列信号也可以单独显示或以群组显示。

Already during the measurement, time signals can be displayed individually or in any groups.
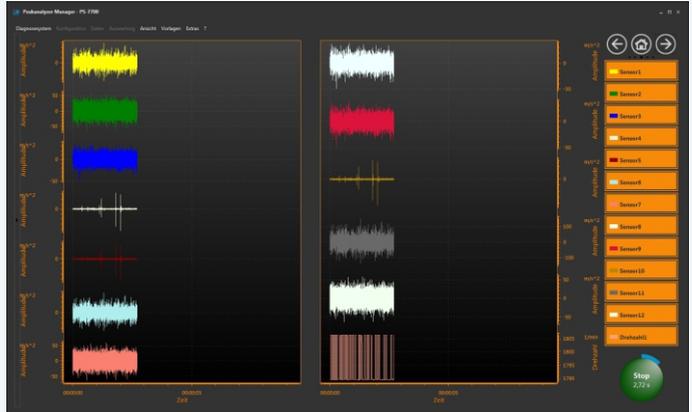
测量期间同时计算频谱、阶谱、包络谱和包络阶谱。

Spectra, order spectra, envelope spectra and envelope order spectra are also calculated during the measurement.
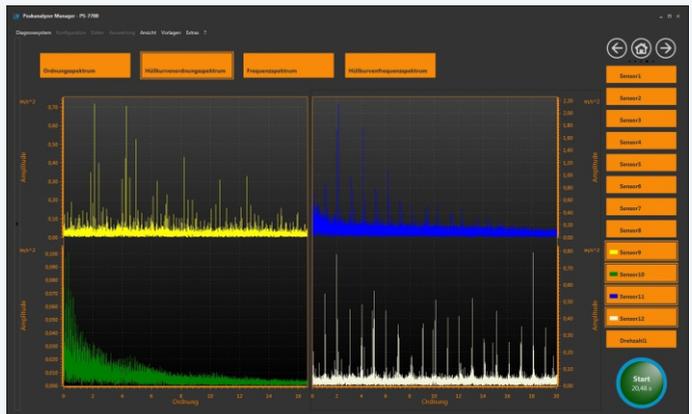
如果有可用的接入点，则可以在测量结束后立即将全部数据导出到 FTP 服务器。

If an access point is available, the entire data can be exported to an FTP server immediately after the measurement.
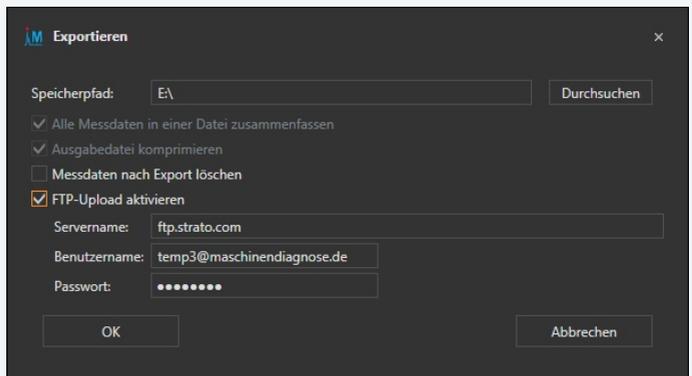
PeakStore5 – 技术参数

运行中的 PeakStore5 – *PeakStore5 in practice*

输入信号：
– 加速度（IEPE）或电压输出（±10 V）的传感器输入通道：12路，8路或4路，每个通道的采样频率可单独调节，最高可达51.2 kHz，带宽0.1 Hz ... 20 kHz（-3 dB）@ 51.2 kHz，24位幅值分辨率，带自动锁定和解锁功能的四针LEMO连接器。
– 2路速度输入，5 kHz采样频率，16 MHz计数频率，3针LEMO连接器

数据采集：
– 所有通道同时记录
– 8个不同的测量时间，可分别设置1.5秒到164秒或不限时间
– 通过独立的功能键或触摸操作启动和停止
– 速度显示
– 所有通道的每秒有效振动速度的显示
– 显示测量时间和测量配置
– 测量期间显示时间序列信号和阶谱
– 智能手机应用程序，用于远程操作和显示振动有效值和速度

存储介质：
– 内置SSD硬盘，30GB 可用空间，可在41秒内进行300次测量

数据交换：
– 使用Peakanalyzer Manager软件直接在平板电脑上读取和显示测量数据
– 将测量数据导出到优盘，网络驱动器或FTP服务器

电源：
– 12...19 V DC
– 内置锂离子电池，运行时间长达5.5小时
– 外部传感器电源连接1个，例如用于位移传感器的 24V DC电源，双针LEMO连接器

尺寸：
– PeakStore5: H/W/L: 198/272/45 mm, ~2,5 kg

温度：
– 运行温度: 5 °C ... 40 °C
– 存储温度: -20 °C ... 70 °C

软件：
– Peakanalyzer Manager (已包含)

PeakStore5 – Technical Data

齿轮箱上带有磁耦合的传感器 –
Sensors with magnetic coupling on a gearbox

Signal inputs:
– *12 or 8 or 4 inputs for accelerometers (ICP) or sensors with voltage output (± 10 V), sampling frequency for each channel separate up to 51.2 kHz, bandwidth 0.1 Hz ... 20 kHz (-3 dB) @ 51.2 kHz, 24-bit amplitude resolution, four-pole LEMO connector with automatic locking and unlocking*
– *2 speed inputs, sampling frequency 5 kHz, count frequency 16 MHz, three-pole LEMO connector*

Data acquisition:
– *Simultaneous recording of all channels*
– *8 different measurement times of 1.5 s to 164 s or unlimited*
– *Start and stop via separate function key or touch control*
– *Display of the speed*
– *Display of r.m.s. of vibration velocity of all channels in a second interval*
– *Display of the measurement time and the measurement configuration*
– *Display of time signals and order spectra during the measurement*
– *Smartphone App for remote control of the measurement and display of r.m.s. of vibration velocity and speed*

Storage medium:
– *Internal SSD hard disk with 30 GB free space, for 300 measurements with 41 s*

Data exchange:
– *Reading and displaying of the measurement data is done with the software Peakanalyzer Manager directly on the tablet*
– *Export of measurement data to an USB stick, a network drive or a FTP-Server.*

Power supply:
– *12...19 V DC*
– *Internal lithium-ion battery with up to 5.5 hours run time*
– *1 connector for external sensor supply, e.g. 24 V DC battery for distance sensors, two-pole LEMO connector*

Dimensions:
– *PeakStore5: H/W/L: 198/272/45 mm, ~2.5 kg*

Temperatures:
– *Operating temperature: 5 °C ... 40 °C*
– *Storage temperature: -20 °C ... 70 °C*

Software:
– *Peakanalyzer Manager (included)*

PeakStore5 – 附件

这款坚固的手提箱用于打包PeakStore5、传感器、电源和远程控制附件等。[PSZ- case]

This sturdy carrying case offers space for the PeakStore5, the sensors, the power supply and the remote control. [PSZ-case]

带有快速释放锁紧螺栓的带子，可用于连接到 PeakStore5 的底部或顶部。 [PSZ-strap]

The carrying strap with quick-release fastening bolts is optionally attached to the bottom or top of the PeakStore5. [PSZ-strap]

我们建议使用集成触摸板并电池供电的外置蓝牙键盘（QWERTZ），用于直接在 PeakStore5 上评估测量数据。 工作时间可长达90小时；包含USB充电线。[PSZ-keyboard]

此外，我们建议使用电池供电的外置蓝牙鼠标。[PSZ-Mouse]

The rechargeable, external Bluetooth keyboard (QWERTZ) with integrated touchpad is recommended for analyze measurement data directly on the PeakStore5. Up to 90 hours operational readiness; including USB charging cable. [PSZ-keyboard]

In addition, the rechargeable external Bluetooth mouse is recommended. [PSZ-mouse]

PeakStore5 – Equipment

用于将 BNC电缆连接到 LEMO 传感器输入端的适配器。 [PSZ-BNC]

Adapter for connecting BNC cables to the LEMO sensor inputs. [PSZ-BNC]

用于将 PeakStore5 连接到 USB 3.0 端口的适配器。因此，PeakStore5 可以在普通 PC 上操作而无需在平板电脑操作。[PSZ-USB]

Adapter for connecting the PeakStore5 to a USB 3.0 port. Thus, the PeakStore5 can be operated without a tablet on a normal PC. [PSZ USB]

Systems适配器电缆，通过 USB 端口为传感器提供 24V 额外电源。可选择直接通过平板电脑的 USB 端口或移动电源。

通过平板电脑供电时最大电流：200 mA

通过移动电源供电时最大电流：420 mA

当连接到移动电源时，适配器可以提供多达12个位移传感器的供电。 [PSZ-DC]

Adapter cable for providing 24 V for sensors with additional power supply via a USB port. Optionally directly via the USB port of the tablet or an additional battery.
max. power when supplied via tablet: 200 mA
max. power when supplied by battery: 420 mA
The adapter can supply up to 12 displacement sensors when connected to a battery. [PSZ-DC]

电池供电的 WLAN 接入点，用于远程控制 PeakStore5。先决条件是智能手机上的安装 Android 或 iPhone 版本的 PeakStore Remote 应用程序。PeakStore5 和智能手机之间的距离可达 200 米。电池寿命长达 4 小时; 包括 USB 充电线。[PSZ-RemoteControl]

Battery-powered WLAN access point for the remote control of the PeakStore5. Prerequisite is the PeakStore Remote App for Android or iPhone on a smartphone. Increases the range between PeakStore5 and Smartphone up to 200 m. Up to 4 hours of battery life; including USB charging cable. [PSZ-RemoteControl]

Systems

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加速度传感器
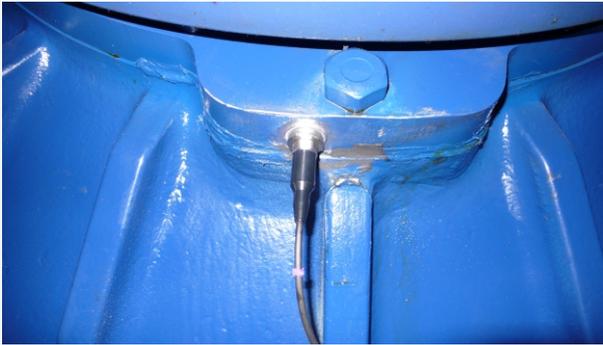
压电加速度传感器的功能基于1880年由J.和P. Curie发现的石英晶体的效应，即石英晶体在机械应力下相互充电。压电晶体将振动质量传递到变送器壳体。如果这种晶体起作用，那么由于振动质量的惯性，力会影响压电晶体。晶体产生的电荷与力成比例。在现代传感器中，该电荷直接转换为电压。

加速度传感器坚固耐用，成本经济，适用于非常宽的频率范围。它们非常适合状态监测。

对于离线测量，传感器通过磁铁连接。在线状态监测系统则使用螺钉或粘合剂连接。

齿轮箱上的加速度传感器，拧紧在胶合安装底座上 –
Acceleration sensor at gear box, screwed onto glued mounting base

齿轮箱上的加速度传感器，磁耦合连接 –
Acceleration sensor at gear box with magnetic coupling

Accelerometers

The functionality of the piezoelectric acceleration sensor is based on the 1880 by J. and P. Curie discovered effect of quartz crystals, which charge each other under mechanical load. A seismic mass is mechanically coupled by the piezoelectric crystal to the transducer housing. If this crystal is set into action, then forces affect the piezoelectric crystal, because of the inertia of the seismic mass. Then, the crystal generates electrical charge, which is proportional to the force. In modern sensors, this electrical charge is directly converted into an electrical voltage.

Acceleration sensors are robust, inexpensive and suitable for a very wide frequency range. For Condition Monitoring, they are perfectly suitable.

Sensors with magnets are used for the offline measurements. In Online Condition Monitoring systems, screw or adhesive bonds are used.

Order number	S-608A11	S-607A11	S-607A61	S-601A02
Type	-PA, -PS, -PSL, -PS5	-PA	-PA	-PA, -PS, -PSL, -PS5
Sensitivity	100 mV/g; 10.2 mV/m/s²	100 mV/g; 10.2 mV/m/s²	100 mV/g; 10.2 mV/m/s²	500 mV/g; 51 mV/m/s²
Measurement range	490 m/s²	490 m/s²	490 m/s²	98 m/s²
Frequency range ± 3 dB	0.5 ... 10,000 Hz	0.5 ... 10,000 Hz	0.5 ... 10,000 Hz	0.17 ... 10,000 Hz
Resonance Frequency	22 kHz	25 kHz	25 kHz	16 kHz
Connection cable	integrated, on top	integrated, lateral	integrated armored, lateral	separate, on top
Cable length	9.1 m	3 m	3 m	10 m
Volatage suply	IEPE	IEPE	IEPE	IEPE
Temperature Sensors	-54 ... 121 °C	-54 ... 121 °C	-54 ... 121 °C	-54 ... 121 °C
Temperature Standard cable from PU elastomere	-20 ... 80 °C	-0 ... 80 °C	-0 ... 80 °C	-0 ... 80 °C
Protection class	IP 68	IP 68	IP 68	IP 68

-PA   These sensors are used for the Peakanalyzer and delivered pre-fabricated. An assembly aid will be delivered. This aid will be bonded at the machine housing. The sensor is bolted on it by an assembly bolt M6x1.

-PS   These sensors are used for the PeakStore and delivered pre-fabricated with contact magnet and BNC connectors.

-PSL These sensors are used for the PeakStore and delivered pre-fabricated with contact magnet and LEMO-1B connectors.
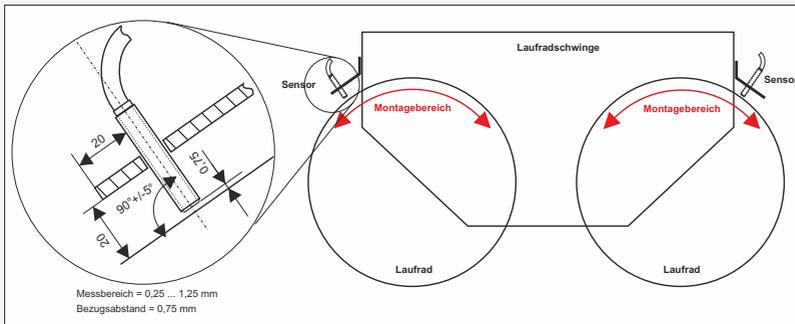
-PS5 These sensors are used for the PeakStore5 and delivered pre-fabricated with contact magnet and LEMO-0B connectors.

位移传感器

在机器诊断领域中，位移传感器通常用于低速旋转传动部件的同心度。 除了这种不平衡和不对准之外，还可以可靠地检测到各个轴承上的不规则性。

此外，波速也可以通过位移传感器确定。

传感器的安装通常需要一个小的辅助结构，根据传动独立设计。

位移传感器的安装 - *Mounting of displacement sensors*

Distance Sensors

In the field of machine diagnostics displacement sensors are commonly used for detection of concentricity of rotating drive elements with very low speeds. Besides unbalance and mis-alignment in this way irregularities located on the respective shaft bearings are reliably detectable.

In addition, also the speed of waves can be defined by distance sensors.

In general, to mount the sensor a small auxiliary construction is required, that has to be made individually for the drive.

Order number	S-IWRM 18U9501	S-Bi1,5-EG08-LU/S100-10M	S-BI4-M12-LIU-H1141
Type	-PA, -PS, -PSL, -PS5	-PA, -PS5, -PSL, -PS5	-PA, -PS, -PSL, -PS5
Description	inductive linear sensor	inductive distance sensor	inductive distance sensor
	reference distance 3.25 ± 0.25 mm	nominal range 0.25 … 1.25 mm	nominal range 0.5 … 3 mm
	sensitivity 2.67 V/mm	referance distance 0.75 mm	referance distance 0.75 mm
	slew rate 1 mm/ms	increase 10 V/mm	increase 4 V/mm
	linearity ± 0.1 mm	sensitivity 0.1 mm/V	sensitivity 0.25 mm/V
	repeatability ± 0.01 mm	measurement repetition rate 200 Hz	measurement repetition rate 200 Hz
		measurement speed 0.02 mm/ms	measurement speed 0.2 mm/ms
		linearity deviation ± 0.03 mm	linearity deviation < 0.025 mm
		repeatability ± 0.01 mm	repeatability ± 0.025 mm
Temperature Sensors	0 … 60 °C	-25 … 100 °C	-25 … 70 °C
Temperature Standard cable from PU elastomere	-20 … 80 °C	-20 … 90 °C	-20 … 80 °C
Housing	brass nickel plated, threaded barrel, M18x1	stainless steel, threaded barrel, M8x1, length 42 mm	brass chrome plated, threaded barrel, M12x1, length 62 mm
Protection class	IP 67	IP 67	IP 67
Volatage suply	14 … 30 VDC, < 20 mA	10 … 30 VDC, ≤ 10 mA	10 … 30 VDC, ≤ 10 mA
Connection	integrated connection cable, on top	integrated connecting cable, axial, 4-wire, length 10 m	connector and separate cable, length 10 m

-PA   These sensors are used for the Peakanalyzer and delivered pre-fabricated.

-PS   These sensors are used for the PeakStore and delivered pre-fabricated with BNC connector.

-PSL These sensors are used for the PeakStore and delivered pre-fabricated with LEMO-1B connector.

-PS5 These sensors are used for the PeakStore5 and delivered pre-fabricated with LEMO-0B connector.

速度传感器

速度传感器可以光学或电感方式运行。 光学传感器通常用于离线测量。 通常需要在轴上有一个反射标记，传感器记录通过的反射标记。电感式传感器记录通过的金属物体，这也可以是联轴器的螺钉。

通常，人们使用传动的高速轴进行速度检测。对于阶次分析，在大多数情况下，每转一个脉冲的速度检测就够了。因此，旋转轴上的一个测量点就足够。

为了安装速度传感器，通常需要一个小的辅助结构，根据传动独立设计。

联轴器上的速度传感器，通过金属支架固定 –
Speed sensor on the coupling of a drive, attached by means of metal angle

光学速度传感器，磁性三脚架的离线测量–
Optical speed sensor with magnetic stand

Speed Sensors

Speed sensors either operate optically or inductively. Optical sensors are commonly used for offline measurements. Then, you usually need a reflection mark on the shaft. The passing of the reflection mark is registered by the sensor. Inductive sensors register the passing of metallic objects. This may be the screws of a coupling.

In general, the high-speed shaft is used for the speed detection of the drive. For order analysis, it is enough to detect the speed at least once per revolution. Therefore, one measurement point on the rotating shaft is sufficient.

A construction aid is needed to attach the speed sensor. This has to be customized for the drive.

Order number	S-Ni12U-M18-AP6X-H1141	S-M12PLPQ8
Type	-PA	-PS, -PSL, -PS5
Description	inductive speed sensor	optical speed sensor
	switching frequency 1.5 kHz	operating range limit 1.5 m
	sensing distance 12 mm	max. switching frequency 1 kHz
	status display LED red	status display LED yellow
Temperature Sensors	-30 ... 85 °C	-20 ... 60 °C
Temperature Standard cable from PU elastomere	-20 ... 80 °C	-20 ... 80 °C
Housing material	brass nickel plated	brass nickel plated, threaded barrel, M12x1, length 74 mm
Protection class	IP 67	IP 67
Volatage suply	10 ... 30 VDC, < 15 mA	10 ... 30 VDC, < 100 mA
Connection	connector and separate connection cable	connector and separate connection cable

-PA   These sensors are used for the Peakanalyzer and delivered pre-fabricated. The mounting thread is M18x1.

-PS   These sensors are used for the PeakStore and delivered pre-fabricated with BNC connector. The mounting thread is M18x1.

-PSL These sensors are used for the PeakStore and delivered pre-fabricated with LEMO-1B connector. The mounting thread is M18x1.

-PS5 These sensors are used for the PeakStore5 and delivered pre-fabricated with LEMO-0B connector. The mounting thread is M18x1.

诊断工具 – 外部数据分析

使用诊断工具，可以计算和分析来自 PeakStore5 以及其他测量系统的测量数据。在这种情况下，根据配置，可以根据现有速度形成频谱和包络频谱以及阶谱和包络阶谱。 此外，计算所有传感器的振动速度和振动加速度的有效值。在完全许可版本中，可实现与 Peakanalyzer 同样的运动学模型自动化诊断。在没有操作员干预的情况下自动报告发现的传动部件异常。在后续版本中，还将使用报告生成器自动创建完整的诊断报告。

除了 PeakStore5 的测量数据外，完全许可版本的诊断工具还可以读取以下数据格式：

– PeakStore200, PeakStore400, PeakStore410

– DasyLab

– Famos

– Diadem

– 通用格式文件

信号调理工具:

– 定义恒定速度

– 从方波生成速度

– 从啮合生成速度

– 修正脉冲

– 消除速度异常值

– 平滑速度

– 削减信号

– 变换单位

– 更改采样频率

– 更改包络滤波器

– 更改 FFT 参数

– 更改传感器分配

Signal conditioning tools:

– Define fixed speed

– Generate speed from rectangular pulse

– Generate speed from meshing

– Pulse correction

– Eliminate speed outlier

– Smooth the speed

– Cut signals

– Change unit

– Change the sampling frequency

– Change the envelope shaping filter

– Change FFT parameters

– Change sensor assignment

Diagnostic Tool – Analysis of External Data

With the Diagnostic Tool, measured data can be calculated and analyzed by the PeakStore5 as well as by other measuring systems. In this case, according to configuration, frequency and envelope frequency spectra as well as order and envelope order spectra are formed at existing speed. In addition, the RMS values of the vibration velocity and vibration acceleration are calculated by all sensors. In the fully licensed version, the fully automatic diagnosis is performed on the basis of the kinematic data as with the Peakanalyzer. Found abnormalities of drive elements are reported without the intervention of an operator. In a later release, a report generator will also be available to create a complete diagnostic report.

The fully licensed Diagnostic Tool can read in addition to the measured data of the PeakStore5 the following data formats:

– PeakStore200, PeakStore400, PeakStore410

– DasyLab

– Famos

– Diadem

– Universal File Format

Systems
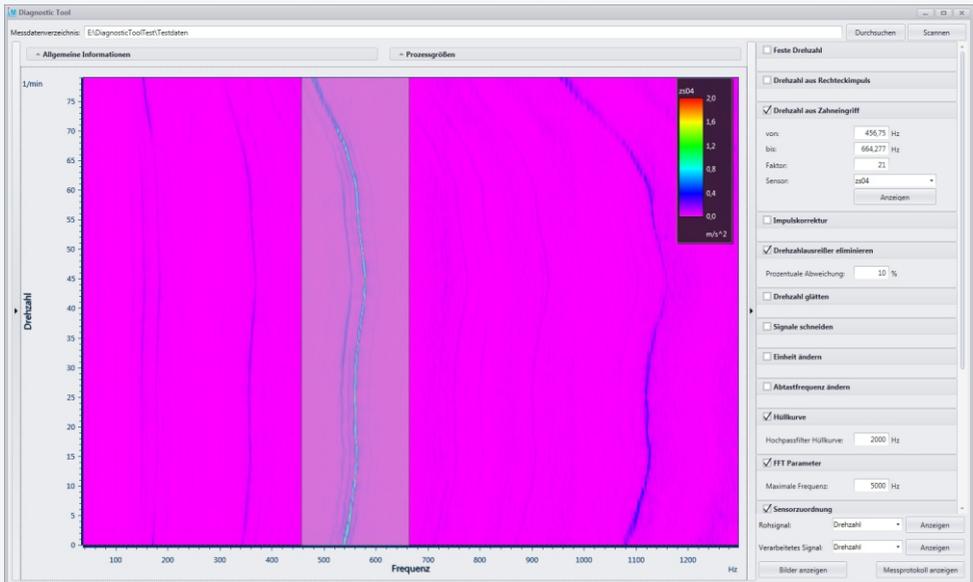
从啮合中计算用于阶次分析的速度 –
Calculation of the speed for the order analysis from the meshing

在线状态监测系统监测服务

除了定制在线状态监测系统外，GfM 还提供监测服务。这包括定期地：

– 配置系统

– 报警监视

– 报警确认并通知操作人员

– 报警文档

– 定量观察振动造成的已知损坏并向操作人员提供建议

– 修复后重置报警阈值

– 传动变更后的参数配置

– 创建状态报告，通常每季度一次，记录所有活动。

提供监控服务：

➜ 对于 Peakanalyzer：
Peakanalyzer 会自动完成每 10 分钟一次的高级诊断。 这是在 Peakanalyzer 中直接完成的，无需监控中心的参与。如果通过全自动监控发出报警，GfM 将对其进行验证。验证后将通知操作人员。

➜ 对于其他系统：
在 Peakanalyzer Manager 中，根据传动的运动学自动检查时间序列数据和速度信息是否存在异常。如果检测到异常，GfM 将对其进行验证。验证后将通知操作员。

服务

Monitoring Service for Online Condition Monitoring Systems

Besides customize online condition monitoring systems, GfM offers the monitoring service. This includes regularly

– Configuration of the systems

– Monitoring for alarms

– Verification of alarms and alerting the operating personnel

– Documentation of alarms

– Quantitative observation of known damage on the basis of vibrations and making recommendations to the operator staff

– Resetting of alarm thresholds after repair

– Adaptation of the configuration in case of modifications to the drive

– Creation of a status report, usually once every quarter, in which all activities are documented.

The monitoring service is offered:

➜ For the Peakanalyzer:
The Peakanalyzer automatically performs about every 10 minutes an advanced diagnosis. This is done directly in the Peakanalyzer without participation of the monitoring center. If an alarm is reported by the fully automated monitoring, it will be verified or falsified by GfM. In case of verification, the operating personnel is informed .

➜ For other systems:
In Peakanalyzer Manager time data and speed information are automatically checked for anomalies based on the kinematics of the drive. If an anomaly is detected, this is verified or falsified by GfM. In case of verification, the operator personnel informed.

Services

传动链离线振动诊断

这很简单：我们在需要检查的传动上安装一些传感器并开始数据采集。保存采集的信号并形成频谱和包络谱。分析传动动单元不规则的频谱。结果总结在一份报告中。

当然，您也可以自己进行数据采集。为此，您需要最多12通道的数据采集系统PeakStore。

传动应在正常的工作温度和典型条件下运行。在数据收集期间，测量的速度可能会波动。不稳定的速度没有问题，因为它们可以通过使用阶次分析进行补偿。

离线振动诊断的步骤：

➔ 通过磁铁将加速度传感器安装在轴承附近

è 在高速轴上安装速度传感器服

è 开始数据采集

➔ GfM 办公室中分析数据并创建诊断报告务

如果滚动轴承滚道上存在损坏，例如点蚀，则滚动元件会反复超支。每一次过度滚动都会产生力的尖峰。

对于非常小的损害- 在其形成的早期阶段- 所释放的能量非常小，以至于人类用耳朵感知它们。但是使用加速度传感器，可以可靠地测量产生的振动。

这种低能量撞击序列的检测可在包络谱中实现。在个别情况下，滚动轴承的损坏可在最终失效前十二个月内清楚地识别出来。

如果齿在一个齿轮级没有满负荷，则后面的齿必须吸收传递的能量。产生力脉冲。这是齿轮的局部损坏。它可以在振动信号的频谱中检测出来。

此外，可以可靠地检测整个齿轮的损坏。

Offline Vibration Diagnosis of Drive Trains

It´s very simple: We come to you, install a few sensors at the drive and start data collection. The recorded signals were stored and afterwards, spectra and envelope spectra were formed. These spectra were analyzed with respect to irregularities. The results are summarized in a report.

Of course, you can also perform the data collection by yourself. For this, you need the up tp 12-channel data collector PeakStore5.

The drive should have it´s normal operating temperature and run under representative conditions. During the data collection, the speed may vary, but it has to be measured. Instable speeds are no problem, because they are compensated by using the order analysis.

Process of Offline Vibration Diagnosis:

→ mounting of acceleration sensors nearby the bearings by means of permanent magnets

→ installation of a speed sensor at the high speed shaft

→ start data collection

→ data analysis in the GfM office and preparation of a diagnosis report

Services
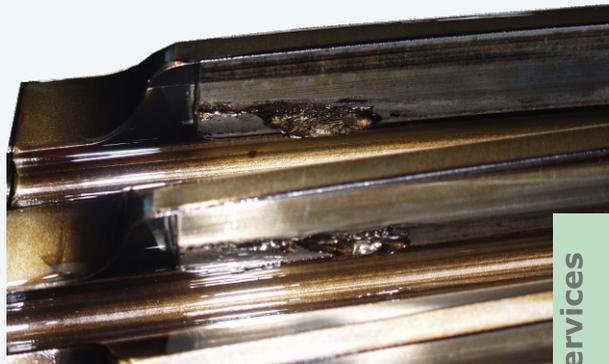
If a tooth is not fully loaded at one gear stage, the following tooth has to absorb the transmitted energy. A force pulse is generated. This is a local damage of the gearing. It can be detected in the spectra of the vibration signal.

Also damages of the entire pinion or of the entire wheel are detectable, reliably.

If there is a damage on the bearing race, for example pitting, it will be overrun by the rolling elements over and over again. Every single overrolling produces a force peak.

In case of very little damages, which are in the early stage of their development, the emitted energy is low. It is not possible to identify them by hearing. Using acceleration sensors, it is possible to measure the emitted vibrations, reliably.

The proof of these low-energy force peaks is possible in the envelope spectra. In some cases, bearing damages could be identified more than twelve months before their final breakdown.

诊断报告

诊断报告列出了测量的所有结果，如果需要，还可列出所有边界条件。一方面，诊断报告为客户提供诊断结果的概述，另一方面，该报告足够详细，成为进一步分析问题的基础。

在诊断报告中，我们提供了诊断结果的摘要，并以表格以及图表的形式展示诊断结果。因此，我们的客户能够理解解释所依据的背景。

当然，我们为所有客户提供数字形式的原始数据，因为透明度是任何诚实业务关系的基础。

诊断报告的内容:

➔ 管理信息

è 简短描述便于理解的初始情况

➔ 制定的整体评价

è 表格形式的诊断结果以及行动建议

è 便于理解报告的重要频谱

è 运动学数据表

Contents of the Diagnosis Report:

➔ *administrative information*

➔ *a short description of the initial situation, if it is relevant for understanding*

➔ *a formulated overall rating*

➔ *the diagnostic results in tabular form with recommendations for action*

➔ *spectra, that are relevant for understanding the results*

➔ *kinematic data in tabular form*

Diagnosis Report

The diagnosis report contains all measurement results and all boundary conditions, as long as they are relevant for understanding. On the one hand, the diagnosis report gives an overview about the diagnosis results. On the other hand, the report is detailed enough, to form the basis for further questions.

The results are summarized in a table. We provide charts for every diagnosis result. So our customer is able to understand the background of the interpretation.

Of course, we also provide the digital raw data, because transparency is the basis of every honest business relationship.
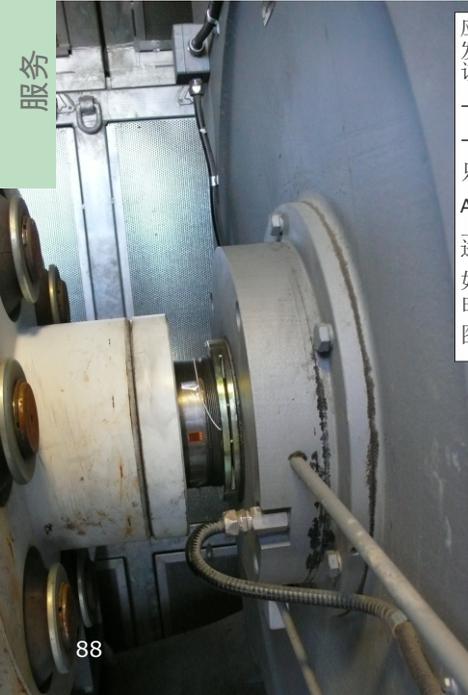
扭矩测量

轴传递扭矩。有时需要精确检查这些扭矩。例如因为：

– 传动部件屡次损坏，原因不明。

– 传动部件振动和噪音，没有合理的解释。

– 产品质量不理想。

– 传动部件产生大量热量。

通过扭矩的测量和分析，尤其是动态部件的精确描述，可以有意想不到的发现。这些发现是理解机械和控制工程背景的先决条件。然后，技术解决方案也就近在咫尺了。

扭矩测量的步骤：

➔ 将应变计粘在轴的清洁点上

➔ 安装遥测发射器，电池和天线

è 校准测量点

è 根据定义的任务采集数据

è 根据需要分析数据，形成频谱和图谱

è 在报告中总结所有测量结果

服务

应变计是由 Arthur Claude Ruge 于 1938 年在美国马萨诸塞州发明的。它们基于简单的物理原理。每个电导体都具有电阻。该电阻取决于其材料和温度，尤其是几何尺寸：

– 随着导体长度的增加，电阻增加。

– 随着导体横截面的增加，电阻减小。

只要在弹性范围内可以反向工作。

Arthur Claude Ruge 将一跟细长的电阻丝粘在一块薄薄的纸上。他将纸张固定在柔性弯杆上。他将阻力的变化与实际应变进行了比较，并且得到了很好的匹配。

如今，采用晶片薄导体附在支撑膜例如聚酰亚胺上。导体通常由康铜制成，这样具有高温稳定性。

图中，应变计安装在传动轴上。

Torque Measurement

Shafts transmit torque. Sometimes it is necessary to examine these torques precisely. For example because:

– Drive elements are damaged again and again and the cause is unknown.

– Drive elements emit vibrations and noises, which can´t be explained plausibly.

– The product quality isn´t satisfactory.

– A drive produces a lot of heat.

The measurement and analysis of torque and especially the exact description of the dynamic components can provide unexpected findings. Such findings are required to understand the mechanical and the control engineering contexts. Then, the technical solution is often not far away.

The single steps of the Torque Measurement:

➔ gluing the strain gauges on a cleaned point on the shaft

➔ installing a telemetry sender, a battery and an antenna

➔ calibrating the measuring point

➔ data collection according to the defined task

➔ analysis of data, pictures of spectra and spectrograms, as required

➔ summarizing all measurement results in a report

Strain gauges were invented in 1938 in Massachusetts, USA, by Arthur Claude Ruge. The physical principle is very simple. Each electrical conductor has a electrical resistor. This resistor depends on its material and temperature and especially on the geometric dimensions:

– With increasing length of the conductor, the electrical resistance increases.

– With increasing cross-section of the conductor, the electrical resistance decreases.

As long as this is done in the elastic range, it also works in reverse.

Arthur Claude Ruge glued a thin resistance wire like a meander on a thin piece of paper. He fixed the paper on a flexible bending rod. He compared the change in resistance with the actual strain and registered a good match.

Today there is a very thin conductor on a support film, for example polyimide. The conductor is mostly made of constantan. This has a high thermal stability.

In the picture a strain gauges pair was applied on a transmission shaft.

疑难杂症

– 为何总是相同的轴承损坏？

– 为何机器会振动？

– 为何工件会有图案？

– 为何基础会损坏？

– 为何扭力臂会损坏？

– 为何逆变器会过载

这些问题经常出现在生产设备的调试或技术变更之后。通常这样的问题不容易回答。但是在不同测量的帮助下，首先可以描述这些烦人的现象，然后通常可在与系统设计人员的对话中快速找到解决方案。

振动诊断通常是第一步。 检查是否存在运动学上可描述的振动激励，简而言之，检查轴、齿轮或滚动轴承是否是问题的根源。

然后，检查振动以获得与运动学无关的激励。这可能是外部激发或固有频率。

如果所有这些都不能达到目标，那么通常可以采用扭转振动分析。 为此，将代表性运行点作为扭矩测量点进行数据采集。也许现在能够看到那些意料之外的振动。

所有这些步骤将有助于问题的可视化。通常只能与客户一起对不利情况进行详细分析，最后形成真正的解决方案。

Troubleshooting

– *Why is always the same bearing damaged?*

– *Why does the machine vibrate?*

– *Why does the workpiece obtain a pattern?*

– *Why is the foundation destroyed?*

– *Why is a torque arm damaged ?*

– *Why does the inverter signal overload?*

Such questions often appear after the commissioning of production equipment or technological changes. Normally, such questions can not be so easy answered. But with the help of different measurements annoying phenomena can once be described. And then a solution is quickly found in dialogue with the plant constructors, usually.

A Vibration analysis is often the first step. It is checked whether kinematic recordable vibrational excitations are present, or briefly if a shaft, a gear or a roller bearing is the troublemaker.

Next, the vibrations are examined for excitations that have nothing to do with the kinematics. This may be extern excitation or eigenfrequencies.

If all this doesn't lead to the goal often the analysis of the torsional vibrations is helpful. For this, a torque measuring point is applied, and measurement data are collected in representative operating points. Perhaps vibrations are now visible that were not expected.

All these steps will help to visualize problems. The detailed analysis of adverse situations and above all a real solution will be generally possible only together with the customer.

Services

测量设备的应用 – *Application of measurement equipment*

齿轮箱检查和视频内窥镜

生产工厂的所有者和操作人员不可能具备所有系统组件深入的技术知识。因此必要时需要专家参与。对于机械动力传动链也是如此，尤其是齿轮箱。其中需求量很大的服务内容之一，就是齿轮损坏的检测和评估以及对进一步运行和维护的具体建议的推导。

齿轮箱检查包括评估：

→ 齿轮箱的外部条件，泄漏的检测，与基础和热异常有关的问题，

→ 润滑油的功能，

→ 基于可见齿面和

→ 可触及轴承的齿啮合。

检查前必须停止传动并防止其运动。然后打开检查盖。现在，我们的专家可以直接或通过视频内窥镜仔细查看可见部件。齿轮箱检查必须与振动诊断相结合，因为：

– 虽然检查在评估齿面损伤类型方面具有优势，但通常仅限于可见齿。相比之下，振动诊断提供所有齿的信息，但是关于损伤程度的可靠性较低。

– 即使使用滚动轴承，检查也可以直接或使用工具查看可见部分的损坏类型和损坏程度。通过振动诊断，则可以分析所有轴承座圈以及滚动体。

服务
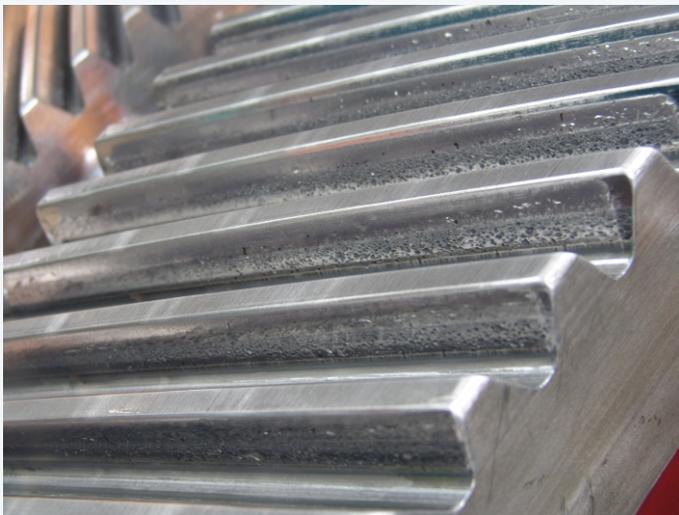
齿轮评估 – *Gearing assessment*

Gearbox Inspection and Video Endoscopy

You would neither expect the owner nor the operator of a production plant to have that deep technical knowledge of all system components. Therefore, it is absolutely normal to involve specialists. So it is also with mechanical power trains, especially with gearboxes. The detection and evaluation of damages on gears as well as the derivation of specific recommendations for further operation and maintenance is part of a major service in great demand.

The gearbox inspection consists of the evaluation of

➜ the external condition of a gearbox, the detection of leaks, problems related to the fundament and thermal anomalies,

➜ the function of the lubricant,

➜ the tooth mesh on the basis of the visible tooth flanks and

➜ the accessible bearings.

For the inspection, the drive must be switched off and secured against movement. Then the inspection covers are opened. Now our specialist has a close look on viewable parts directly or by means of a video endoscope. The gearbox inspection should be combined with the vibration diagnosis, because:

– Although the inspection offers advantages in the evaluation of damage type and damage size on tooth flanks, it is limited to the currently visible teeth. In contrast to this, the vibration diagnosis provides statements to all teeth, but with less resilient results according to the damage size.

– The inspection provides definitive statements about the type and the size of damages, if they can be viewed directly or with tools. With the vibration diagnosis all race ways and rolling elements are necessarily analysed.
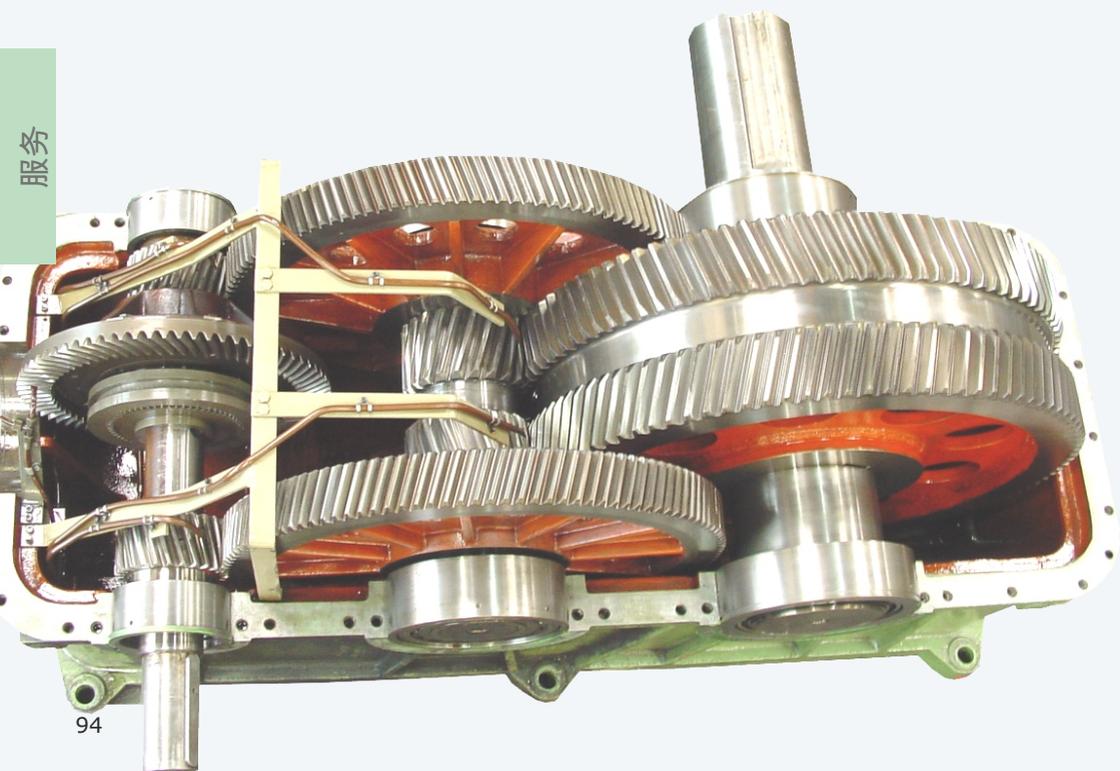

检查润滑 – *Check the lubricant*

改造 / 维修 / 监督

维护齿轮箱需要专业技能，并执行以下步骤：
– 制定维修计划
– 打开和拆卸齿轮箱
– 确定必须更换的零件
– 采购备件
– 如有必要，翻新其他部件
– 安装齿轮箱
– 进行调整
– 调试和试运行

此外，如果存在任何结构缺陷，则提供有意义的改进建议。

GfM 可直接提供部分服务，或推荐合格的服务提供商。确保高质量的服务工作。

服务

Revision / Repair / Supervising

If it is necessary to maintain a gearbox, then expertise is in demand. The following steps are required:

– developing a maintenance plan,

– opening and disassembling the gearbox,

– determination of parts, which have to be replaced,

– procurement of spare parts,

– overhaul of the other parts, if required

– assembly of the gearbox,

– performing adjustments, and

– commissioning and test run.

In addition, it is useful to provide improvements, if there were any constructive deficits.

GfM can offer a part of these services directly or recommend competent service provider. Thus, a high quality of work is assured.

監督 – *Supervising*

传动部件损坏原因

除了快速断裂造成的损害外，还有许多最初未被注意到的有害影响：

– 结构条件和不良材料

– 安装错误

– 过多、过少或错误的润滑剂

– 不利的操作和负载条件

这些影响将导致

➜ 疲劳损伤，如点蚀或灰斑

➜ 磨损，如刮伤，污损或压痕等

➜ 腐蚀

➜ 老化

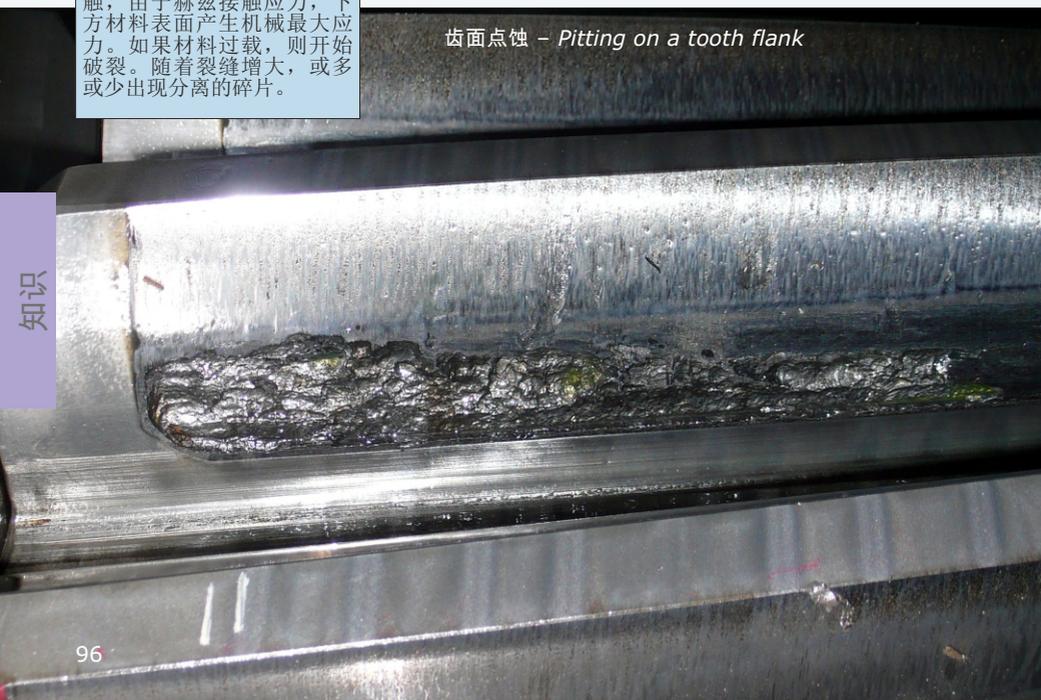一旦达到一定程度的损坏，通常在出现肉眼可见损坏的很久以前，就会产生可测量的振动。

点蚀 – *pitting*

疲劳：

如果存在弯曲表面之间的接触，由于赫兹接触应力，下方材料表面产生机械最大应力。如果材料过载，则开始破裂。随着裂缝增大，或多或少出现分离的碎片。

齿面点蚀 – *Pitting on a tooth flank*

知识

Cause of Damages at Drive Elements

Besides the damages caused by fast fracture, there is a number of harmful effects, which are initially unnoticed. They are

– constructive conditions and unfavourable material characteristics,

– installation errors,

– too much, too little or the wrong lubricant and

– unfavourable operating and loading conditions.

These influences lead to

➔ damages of fatigue such as pitting or grey staining,

➔ wear damages such as scoring, scuffing, smearing or false brinelling,

➔ corrosion or

➔ aging.

These damages lead to measurable vibrations as soon as a certain damage size is reached. This is usually long before they are visible to the naked eye.

Fatigue:

If contact between curved surfaces exists a mechanical stress maximum builds up because of the Hertzian contact stress on below the material surface. If the material is overloaded, it begins to crack. The crack grows and more or less fragments are separating.

滚动轴承点蚀 – *Pitting on roller bearing*
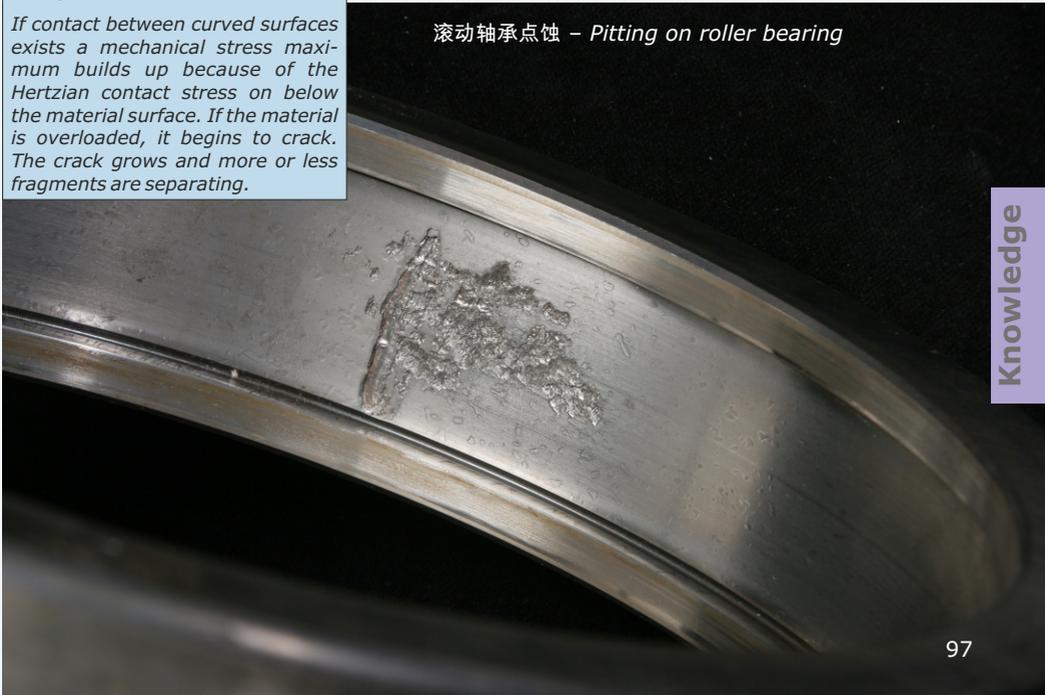
传动部件损坏原因

Wear:

Insufficent lubrication leads to insufficient separation of the contact surfaces. Because of high pressure and frictional heat, metallic compounds occur, which are immediately broken again. This process is favored by surface roughness and foreign particles.

磨损：

缺乏润滑导致接触表面的分离不充分。由于高压和摩擦热会短暂地引起金属连接，并立即再次分离。粗糙的表面和外来的颗粒更容易发生该现象。

齿面磨损 – *Wear on tooth flanks*
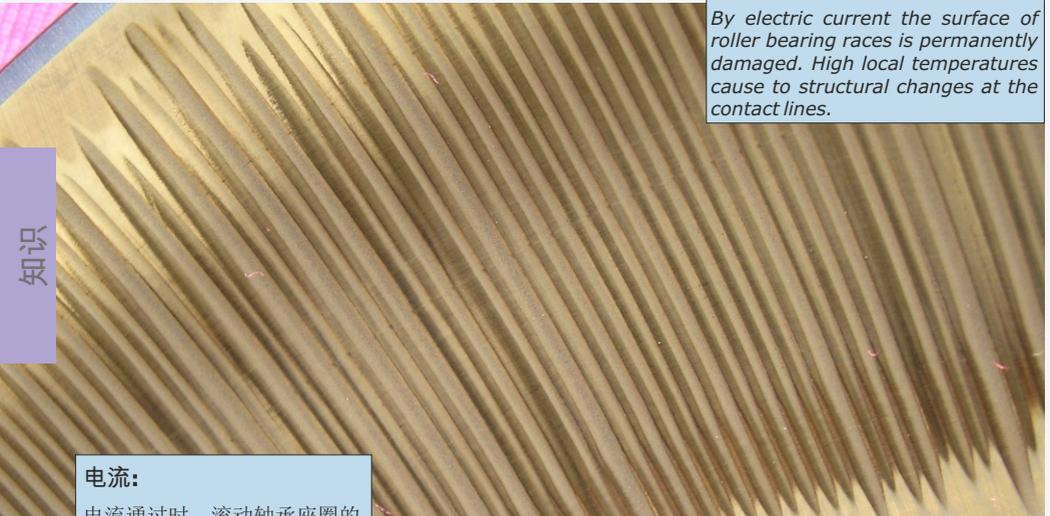
Electric current:

By electric current the surface of roller bearing races is permanently damaged. High local temperatures cause to structural changes at the contact lines.

电流：

电流通过时，滚动轴承座圈的表面永久损坏。局部高温导致接触线处的结构变化。

电流通过滚动轴承产生的损伤 –
Damage caused by electric current at a roller bearing

Cause of Damages at Drive Elements

腐蚀:
通常水的渗透会导致钢与氧气产生腐蚀反应。腐蚀产物有时比钢更硬。然后就变成了破坏滚动轴承的滚道和齿面的工具。

Corrosion:

Water infiltration leads to a reaction of the steel with oxygen. The corrosion products are sometimes stronger than steel. They are like tools, which destroy the bearing raceways and the flanks of the tooth.

滚动轴承腐蚀 – *Corrosion on roller bearing*

白色腐蚀裂纹：

文献中使用的其他术语是白色腐蚀区域，白色结构剥落或脆性剥落。 这种损坏通常与滚动轴承有关。 这些钢的白色区域，显然已经失去了原有的碳原子。这种材料变化可能导致过早失效。目前几个研究项目的主题就是该现象的原因。

White Etching Crack:

Other terms used in the literature are White Etching Area, White Structure Flaking oder Brittle Flaking. This damage is described lately commonly associated with roller bearings. These are white areas of the steel from which apparently the carbon atoms originally contained are lost. This material change can lead to premature failure. The reason for this phenomenon is currently the subject of several research projects.

变速处理

传动中的破坏事件是由周期性振动引起的，这与传动的速度有关。 振动采集和诊断主要与时间有关。

将时域信号变换到频域的信号变换方法可更好地评估振动信号。在最简单的情况下，形成频谱。频谱显示幅度与频率的函数关系。横坐标的单位是赫兹。

对于具有恒定速度的传动，可以直接从测量数据生成所需的频谱。 这不适用于变速传动的情况。首先必须对测量数据进行阶次分析。

在顺序分析中，将时间同步信号归一化为速度，从而产生速度同步信号。 然后可以通常的方式进行进一步的评估。横坐标的单位是阶次。

其中一种易于使用的方法是重采样。仅在数据采集发生后才对振动信号进行计算重采样。因此，需要知道数据采集过程中每个点的准确速度。也就是说，对于时间通道和振动通道，必须记录附加的第三通道，其包含每个采样时刻的转速的瞬时值。然后从时间信号形成速度同步信号。

GfM 所有设备都通过重采样进行阶次分析。

在阶谱中，您可以看到与齿啮合频率相关的边带。这表明可能局部齿损伤。在频谱中，这种区别实际上是不可能的。这是因为在数据采集期间速度变化约为0.7%。

速度数据采集 –
speed during the data collection
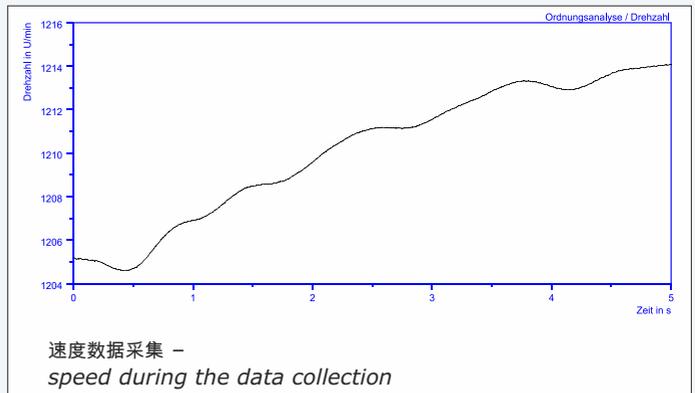
Handling of Speed Variability

Damaging events at drives normally arise by periodical vibrations, which have a relation to the speed of the drive. The vibration collection as well as the vibration diagnosis are mostly time-dependent.

The method of the signal transformation for the compilation into the frequency range is used for a better evaluation of the vibration signals. In the simplest case, the frequency spectrum is created. The spectrum shows the amplitude as a function of the frequency. The unit of the abscissa is Hertz.

At drives with a constant speed the spectra can be created directly from the measuring data. This does not work for drives with variable speed. At first, the measuring data has to undergo an order analysis.

During the order analysis a signal is standardised to the speed with chronological synchronism so that a speed synchronized signal arises. Further analysis occurs in the usual way. The unit of the abscissa is the order.

One of the accepted and easy-to-apply methods is the resampling. Only after data collection the calculative resampling of the vibration signal occurs. Therefore, it is necessary to know the exact speed at every moment of the data collection. That means that for the above mentioned channels, the time channel and the vibration channel, an additional, third channel has to be recorded. This channel contains the momentary value of the speed at every sampling moment. Then, a speed synchronous signal is generated from the time signal.

Every device of GfM executes the order analysis by resampling.

频谱 – *frequency spectrum*
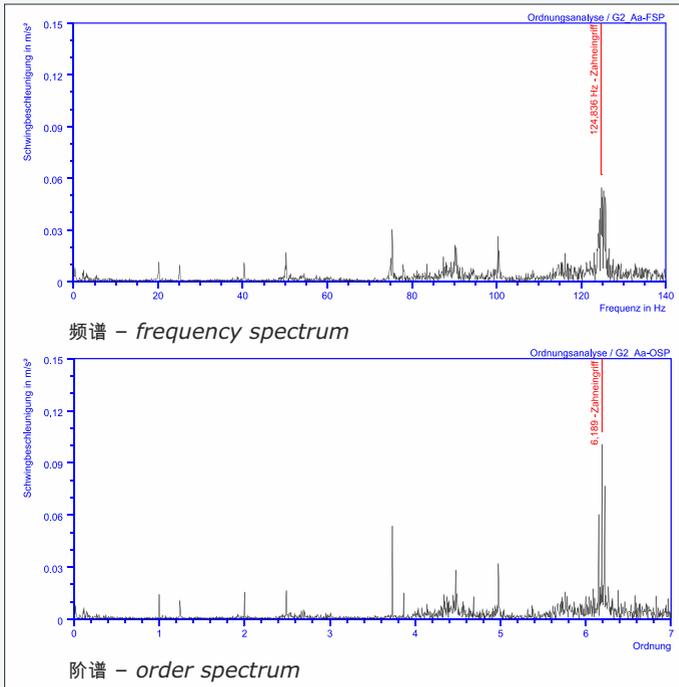

阶谱 – *order spectrum*

In the order spectrum you can see side bands related to the tooth meshing frequency. This could be an indication of a local tooth damage. In the frequency spectrum, this delimination is practically impossible. This is because speed varied during data collection by about 0.7 percent.

Knowledge

自动诊断

对于温度，压力，力或扭矩，通常定义极限值用于验证，该极限值可以根据材料特性或几何参数计算。机器诊断并不存在这样的极限值。我们无法在频谱或包络谱中的峰值与机械可确定的损伤程度之间建立一般相关性。另一方面，必须尽可能减少监控每个状态监测系统所需的工作量。否则，使用状态监测是不值得的。很难想象每天为了发现异常而在频谱中搜索几个小时。

在 GfM 系统中，对形成的所有频谱进行 DVS 分析，一种改进的显著性分析，完全自动地提取显著性的谱线。然后，对于这些显著性的谱线，检查它们的频率是否与运动损伤模型一致。该方法在很大程度上独立于传动上的负载，这意味着它在满负载和部分负载情况下均能工作。可靠的分析结果可以省去人工分析。只有最终的维护决定- 继续或修复- 由人为推荐，而且不一定在诊断工程师检查后。这种意义深远的自动化诊断形式可以最大限度地减少系统的维护工作量，从而降低运行成本。

包络谱 – *envelope spectrum*

显著性阈值 – *significance treshold*

DVS 频谱 – *DVS spectrum*
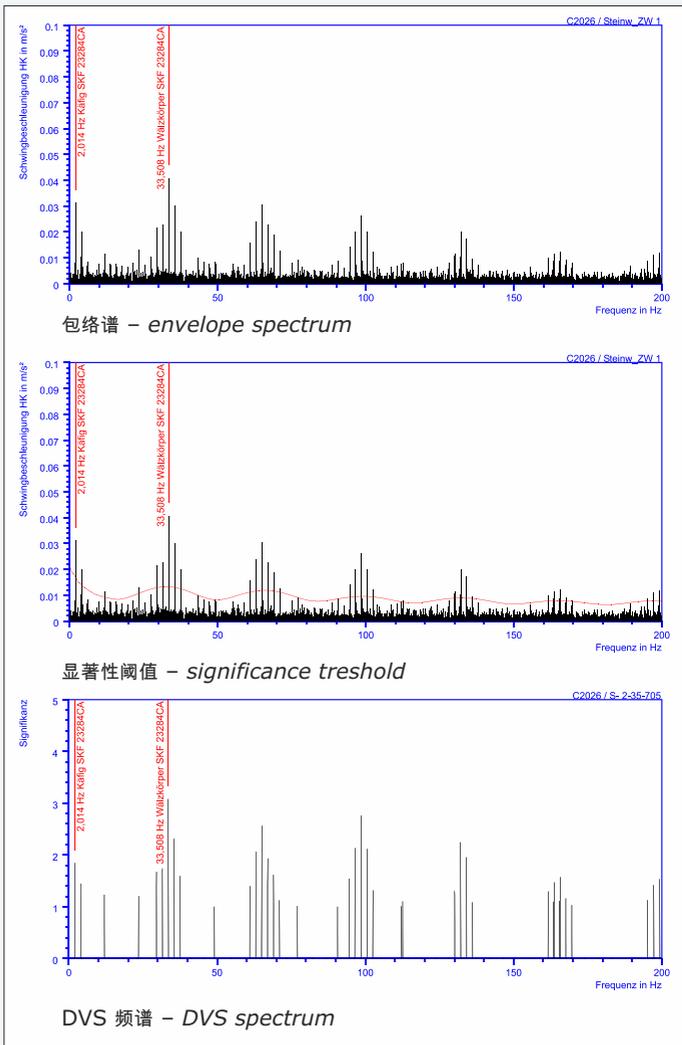
Automation of the Diagnosis

In the case of temperatures, pressures, forces or torques, it is customary to define limit values which can be calculated from material properties or geometric parameters and are easily verifiable. Such limits do not exist for machine diagnostics. It is absolutely illusory to establish a general correlation between the height of a peak in the spectrum or envelope spectrum to a mechanically determinable damage magnitude. On the other hand, the required workload for monitoring each condition monitoring system must be low. Otherwise, the use of condition monitoring is not worthwhile. It is hardly conceivable that one searches several hours daily in spectra for find of anomalies.

In the GfM systems, all spectra formed are subjected to a DVS analysis, a modified significance analysis, in which conspicuous spectral lines are automatically extracted. Then, for these conspicuous spectral lines, it is only checked whether their frequencies coincide with kinematic damage patterns. This method is largely independent from the load on the drive, which means that it operates under full load as well as in partial load operation. The results are so reliable that manual analyzes can initially be dispensed with. Only for the final maintenance decision – continuation or repair – the decision is recommended by a person, if necessary, but not necessarily after a check-up by a diagnostician. This form of very far-reaching automation leads to a minimal maintenance effort for the systems and thus to extremely low running costs.
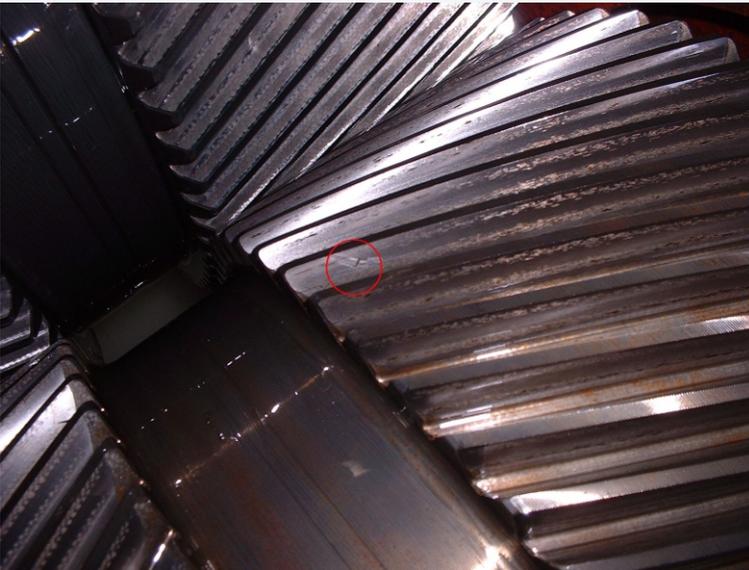
齿轮损坏 – *damage on helical gear*

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