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TEKNIKAN JA LIIKENTEEN ALA

THERMOGRAPHIC AND VIBRATION CONTROL MAINTENANCE IN A CHP POWER PLANT

Final thesis

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<p>Abstract</p> <p>Nowadays global economy faces more demand for energy and plants must meet the demand in the most efficient way. Energy industry in Russia has an extreme need for development and change of old-fashioned way of maintenance and management. In the nearest future with its new technologies and inventions that way may cause big problems and losses in the whole energy system all over the Russian Federation and also in the nearest countries.</p> <p>Owners of such plants can't afford costly shutdowns and also it is a question of safety for workers and citizens nearby. Right and efficient maintenance is key component in every factory or power plant to produce cheap and safe energy and provide it for customers.</p> <p>In the Thesis maintenance problems in a CHP power plant are reviewed. The plant in question is located in Petrozavodsk, Russia where the author was working during his practical training. Vibration and Thermography control is a modern and effective method which is commonly used in Europe.</p>			
<p>Keywords Thermography, Vibration, Maintenance, Power plant</p>			

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LIST OF ABBREVIATIONS AND SYMBOLS

CHP - Combined heat and power, a power plant using an heat engine to generate electricity and useful heat simultaneously

IMECO - an electro-mechanical contracting company established in 1977 in Abu Dhabi

RPM – Rotations per minute

IPS – Inch per Second variation

Absolute zero – (-273.15 °C)

ϵ – emissivity value

IR-infrared

VdB- Velocity Decibels

in./s peak-Inch per second peak

V - Velocity

1 INTRODUCTION

Nowadays the most actual and important problem of industry is how to increase quality and reliability of equipment in every field of industry. The problem is caused by continuous increase of installed power at any factory, power plant or industrial complex. Also it is caused by equipping them by modern, complicated and innovative systems of maintenance and management.

Certainly traditional ways of increasing reliability are known widely such as upgrading different units, optimization of processes or half-power equipment usage. Those methods can only be applied to low-power systems.

However in most industrial areas it has not been possible to apply the methods due to restrictions caused by dimensions and mass. Consequently this leads to search of new ways for solving problems with reliability and resource.

One of such development options can be preventive maintenance system that already gets high positions all over the world. Nondestructive testing and modern equipment gives the engineer opportunity to look inside the equipment without disassembling it and get all the data at the same time. Infrared camera and vibration analyzer are the most usable and common tools for such important job as Power plant maintenance. Professional and certified uses are the key point to efficient and safe maintenance. In such a huge and dangerous industry every fault can cause serious damage, human casualties or losses of millions of dollar.

In the thesis advantages of preventive maintenance and its main features are presented.

2 MAINTENANCE

Until recently machinery and equipment were used either until breakdown or there was scheduled repairing called preventing maintenance. In the first case of using equipment until breakdown only cheap equipment can be used and at observance of existing backup systems. Second case of preventive maintenance got wide distribution all over the world. That caused impossibility of backup system usage, expensive equipment and big losses in case of unpredicted breakdowns.

Certain interval of time is the only thing that determines this method. Interval of maintenance can be measured by statistics of usage of the same equipment, its history and its load. But for most of equipment preventing maintenance does not prevent unexpected breakdowns. Reliability of machinery can be lowered after scheduled maintenance because of assembly defects made by workers. It's obvious that increase of performance, stability and resources and also safe usage of machinery are tightly connected with right and timely evaluation of its technical condition.

That was the key to foundation of new scientific direction – technical diagnostics.

2.1 Technical diagnostics

Technical diagnostics is a branch of science studying and inventing methods that help to evaluate and predict technical condition of equipment without its disassembly. It's worth mentioning that some methods of evaluating technical condition already existed but the information about mechanisms it was limited and in very small cases was possible to find out damage caused.

Invention of automatic systems of monitoring, control and diagnostics brought technical diagnostics to higher level. That helps to prevent difficult and expensive repairing, lowers laboriousness and time of maintenance. Eventually that leads to decrease of operational costs.

Usually in complicated machines and aggregates operational costs exceed manufacturing costs several times. For example in car industry that will be 7 times more and in industrial machinery that number will be always more than 8.

According to IMECO, laboriousness and repairing time can be decreased by up to 40% and fuel by consumption up to 4% only because of diagnostics tools implementation?

Those things help the industry in many aspects:

- Increase of durability and reliability of machines and equipment
- Preventing emergency situations
- Increase of performance and production output
- Forecasting equipment resources
- Decrease of time and money consumption for maintenance
- Decrease of needed staff
- Optimizing spare parts quantity

Thus safety usage, reliability increase and cost reduction are impossible nowadays without a wide use of technical diagnostics. That method gives an opportunity to get significant economic benefits and ability to use preventive maintenance.

3 VIBRATION DIGNOSTICS

Every CHP power plant has plenty of rotating equipment, engines, turbines and bearings. The most efficient and common way to check the condition of those aggregates is to analyze the vibration level. So it can be said that vibration diagnostics are used to identify the root reason of vibration or noise problems.

3.1 Vibration theory

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. Vibration can be classified into two types: desirable or undesirable. Desirable vibration means type of vibration that humans use in their lives. Most common vibration produces loudspeaker: sound that we hear is also kind of vibration in different frequencies. It is also known that everything around us has its own frequency and vibrates even if it's not possible to feel it. The example of how the frequencies spread into spectrum can be seen in the Figure 1.

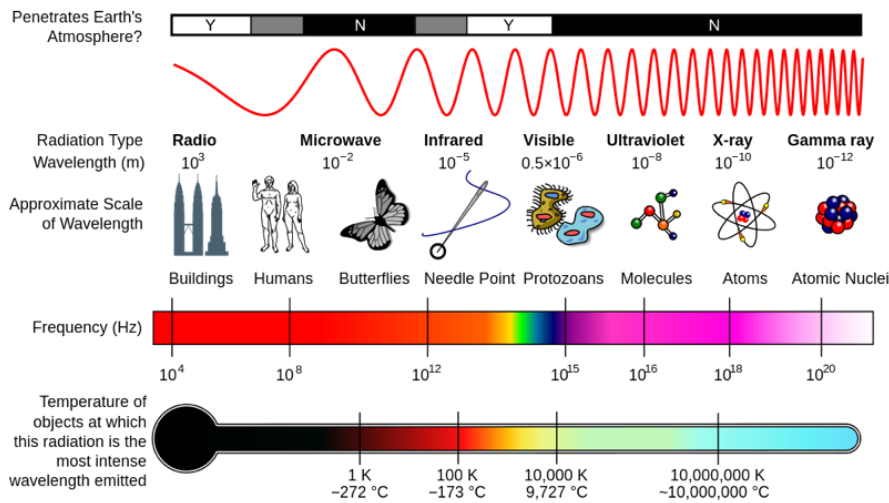


FIGURE 1. The electromagnetic spectrum. (SoundTherapy, 2016)

On the other hand there are many types of harmful vibrations such as imbalanced motor vibration. They all waste energy, create unwanted sound or even destroy parts or mechanisms. For all rotating parts all kind of vibration is harmful and dangerous. Only careful design, perfect manufacturing and qualified maintenance may cause long-life of equipment like shown in Figure 2.

Vibration Effects

Bearing Wear

Vibration causes increased maintenance

- Accelerated component failure
- Engine / motor failure

Bearing life reduced by third power
10x increase in load = 1000x decrease in life



$$L_d = L_c \left(\frac{C_d}{P_l} \right)^k$$

k = 3 for ball bearings
k = 3.3 for roller bearings

Lundberg and Patengren

Sliding Wear

Generally varies linear with load

@1 IPS (Inch per Second variation), 7800 RPM, engine experiences 2G oscillation, variation of .001 in.

Industry standard is vibration less than 0.1 IPS; 10x reduction in vibration is 10x reduction in wear rate.

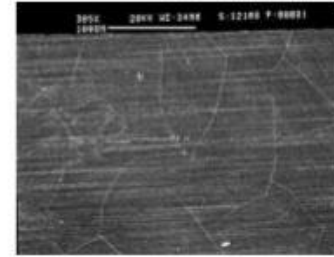


FIGURE 2. Vibration effects. (Top 3 vibration causes, 2015)

3.2 Equipment for vibration control

Vibration monitoring of a regular machine is a cost-effective method of predictive maintenance to increase machine life and prevent unexpected shutdowns.

Nowadays there are plenty of ready monitoring solutions on market for different customers and different needs. If industrial use is taken as an example it can be said that systems are divided into two types:

- Portable data collectors, analyzers, scanners and balancers
- stationary online condition monitoring systems

3.2.1 Portable tools

There are plenty of different types, shapes and sizes on market right now. Prices for the devices can be also variable: 80 € for a cheaper one and up to 10000 € for professional solutions. In the Thesis two examples of portable vibration meter are shown: one which is commonly used in Europe and one from Russian industry.

Russian market has its own version that is commonly used by most plants or industrial centers. That product is well known on Russian market by the name “SD-21”.



FIGURE 3. Russian portable vibration meter “SD-21” with original software. (VAST, 2016)



FIGURE 4. Russian portable vibration meter “SD-21” in original case. (VAST 2016)

In pictures 3 and 4 is shown ready vibration analyzer that is right now used in CHP plant in Petrozavodsk. That fully digital device that can collect data has its own memory and battery and at the same time it can analyze the data. Also it works as field balancer. Easily connected to computer with the help of software “DREAM” can give wide and exact information about rotation part you have tested before. That program has its own algorithms for automatic problem detection and all the equipment and bearing types are pre-installed. Nowadays price varies for 7000 € to 10000 € depending on seller, delivery options and software.

As for European market the choice of such equipment is so wide that you hardly can understand the difference between companies. For a long time and still nowadays German engineering companies were well known all over the world by their perfect quality.

Here is represented one German company named “PROFTECHNIK”. They have a perfect product: vibration analyzer “VIBXPERT II”



FIGURE 5. European portable vibration analyser “VIBEXPERT II”. (Proftechnik, 2016)

This device is designed and produced in Germany but it has same features as its Russian analog.

Usage of such device is not as difficult as it looks. Most of them automatically recognize the problem and help engineers to understand the root of the problem. The operator of such device needs to put sensor or sensors to the right position in the equipment that needs to be inspected.



FIGURE 6. European portable vibration analyser “VIBEXPERT II”, example of use. (Proftechnic, 2016)

3.3 Methods of vibration control

Most important thing in every measurement or research task is correctly collected data. If we take as an example motor it is important to collect full-spectrum vibration data in three axes (horizontal, vertical and axial) on both ends of the shaft. It is also important to take a few measurements with different loads if possible. Some problems can be shown only in some specific modes and may cause unexpected machinery failure. For example mechanical problems tend to appear at 2000 rpm but rotor unbalance can be detected at rotation speed.

All the bearings have different number of rolling elements and it causes different specific frequencies. Actual speed of the motor is also key factor in detecting problems of rotating parts. There is one more phenomenon in the rotating equipment. It's called resonance speed or critical speed. When the theoretical angular velocity excites the natural frequency of rotating object resonance appears. That resonance causes huge growth of vibration in that rotation speed.

Equipment software plays an important role in analyzing data. All modern programs have their own database with bearing information and this helps to analyze data in

automatic mode, and to give ready repair report. It is also important to inspect the whole assembly (motor – driven equipment) because of resonance problems. They are usually typical for such assemblies in which vibration frequency of one part is close to the natural frequency of the entire system.

In case the engineers don't have previous data for certain type of a machine they may use an absolute level of vibration summarized in the table:

TABLE 1. The IRD General Machinery Vibration Severity Chart (ReliablePlant, 2016)

Machinery Condition	Velocity (in./speak)	Velocity (VdB)
Very Rough	$V > 0.628$	$VdB > 121$
Rough	$0.314 < V < 0.628$	$115 < VdB < 121$
Slightly Rough	$0.157 < V < 0.314$	$109 < VdB < 115$
Fair	$0.0785 < V < 0.157$	$103 < VdB < 109$
Good	$0.0392 < V < 0.0785$	$97 < VdB < 103$
Very Good	$0.0196 < V < 0.0392$	$91 < VdB < 97$
Smooth	$0.0098 < V < 0.0196$	$85 < VdB < 91$
Very Smooth	$0.0049 < V < 0.0098$	$79 < VdB < 85$
Extremely Smooth	$V < 0.0049$	$VdB < 79$

That table gives an opportunity to make fail/pass exam and gives graduation scale of machine condition. That criteria is applicable for almost all rotation machinery in frequencies between 1.6 and 1667 hertz.

Anyway, a sensitive criteria is needed for predictive maintenance program.

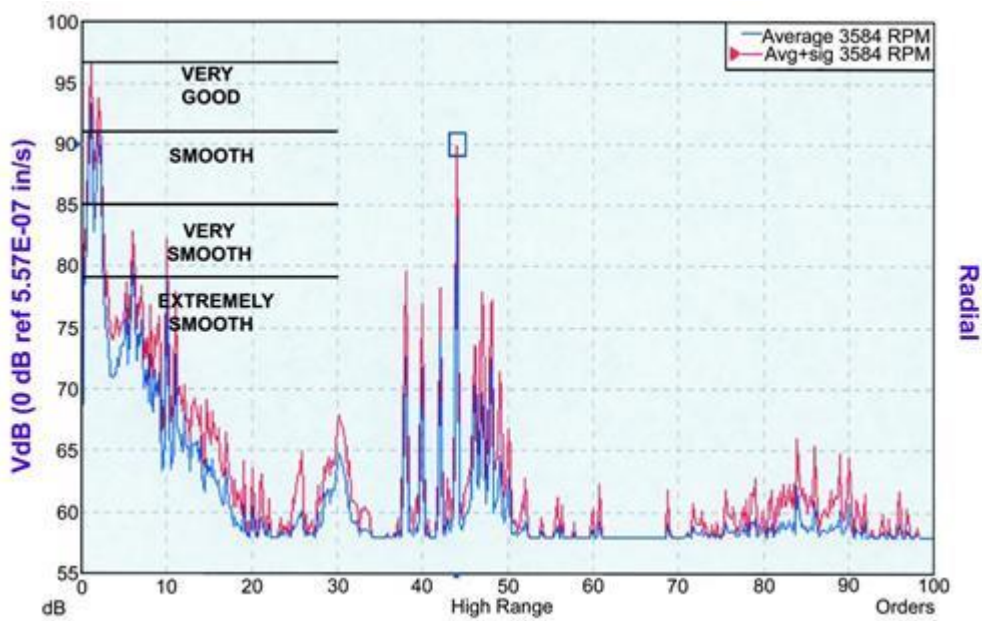


FIGURE 7. Spectrum diagram and acceptance criteria. (ReliablePlant, 2016)

That Figure presents common spectrum picture that gives the program from the data. Nowadays with the help of modern software technicians can easily define the problem with the help of program. If the bearing specifications are known, program will give automatic report about problems with machine and list of needed repairs. Anyway, there are methods to define frequency of some specific problems and here are some of them:

TABLE 2. Rules for determining approximate values of bearing tone frequencies. (ReliablePlant, 2016)

Ball Pass Frequency Outer Race (BPFO) $= \text{No of rollers} \times \text{shaft speed} \times 0.4$
Ball Pass Frequency Inner Race (BPFI) $= \text{No of rollers} \times \text{shaft speed} \times 0.6$
Fundamental Train Frequency (FTF) $= \text{speed} \times 0.4$

Of course it is not necessary for the engineer to do routine operation that computer can do in seconds but he must understand the root of the problem and must handle data very carefully to prevent mistakes.

3.4 Online condition monitoring systems

In this chapter another product of the same German company “PROFTECHNIK” is presented. Online condition monitoring system is equipment that stationary placed in working aggregates and controls its condition all the time to prevent unexpected breakdowns. “VIBGUARD” is an automatic complex solution for big industry.

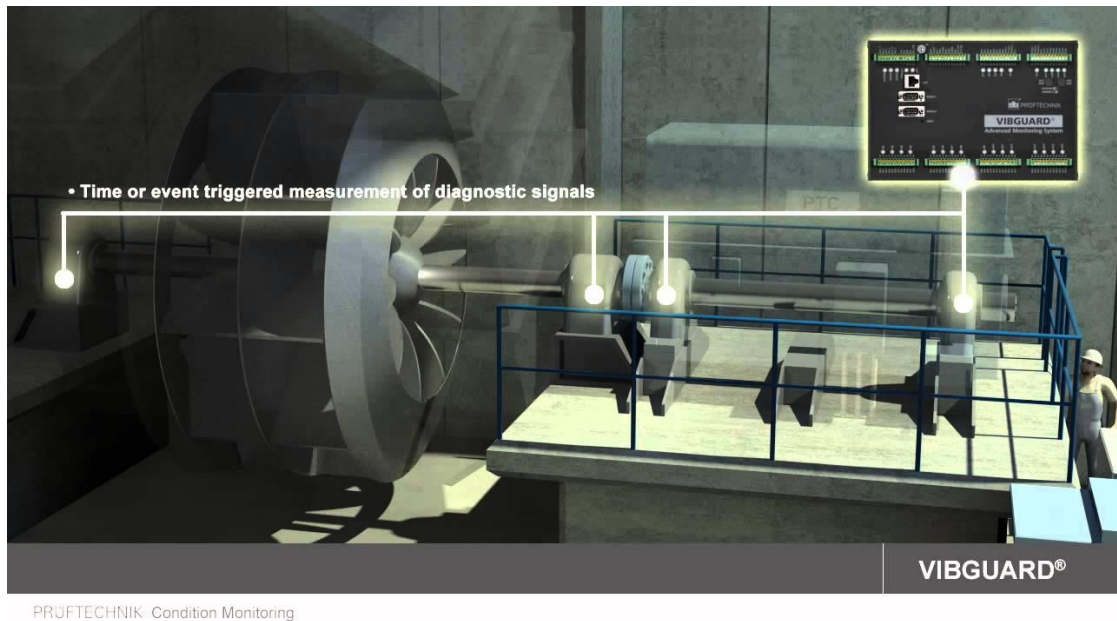


FIGURE 8. Condition monitoring system “VIBGUARD” application. (Proftechnik)

That system offers online control and protection of the equipment all the time. It has 20 parallel channels for all kind of signal inputs and can analyze any data at the same time. It has its own advanced alarm system which can automatically make correction in equipment in seconds to prevent unexpected shutdowns and save company’s money or even lives of its workers. Fast data processing allows the company to apply that system even to machines with highly dynamical processes such as testing stands, wind turbines or drag lines.

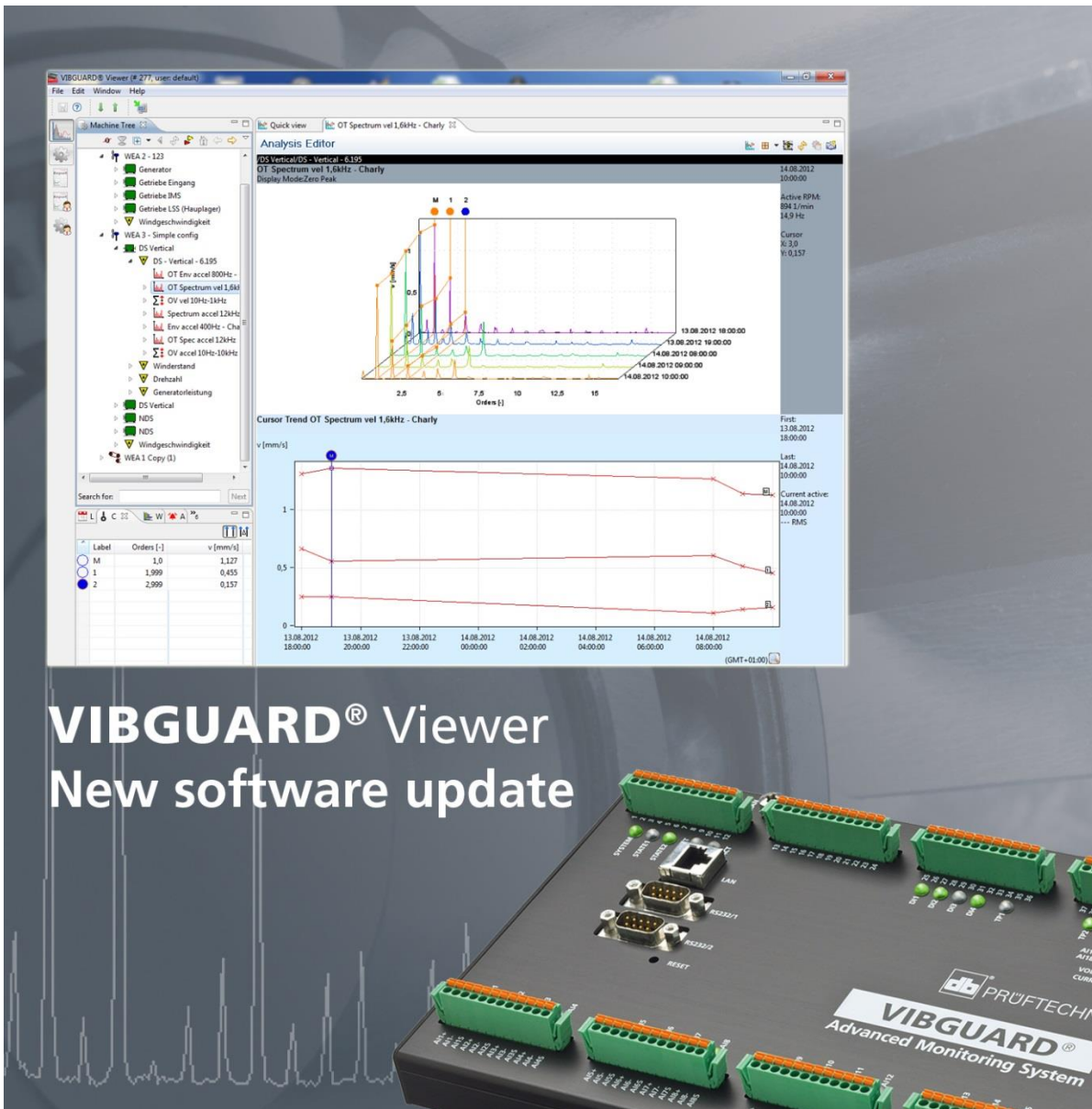


FIGURE 9. Online condition monitoring system “VIBGUARD” and its software. (Proftechnic)

In FIGURE 9 is presented original software that can work with such systems. It allows engineers to follow in real time every parameter and vibration level in working equipment. The main feature is that it can be connected to all sensors at the same time and give opportunity to analyze the situation on big equipment such as turbine on CHP plant. Any needed adjustments can be made at the same time in working equipment with the specialist control.

4 THERMOGRAPHIC DIAGNOSTICS

Another very important part of CHP power plant is electrical distribution system. There are hundreds types of switchgear, transformers, breaker panels, cabinets and equipment connectors on every typical power plant in every place on earth?. Each unit can have potential risk of accident or breakdown. To minimize the risks and control equipment quality in plant maintenance engineers use special tool - thermographic scanner or IR scanner.

4.1 Theory

In the base of IR thermography lays a physical phenomenon that all the bodies emit electromagnetic radiation in its temperature more than absolute zero. Every surface has its own emissivity depending on material it's made of and helps to identify its temperature in non-contact way. Emissivity is its effectiveness in emitting energy as thermal radiation. That ratio varies from 0 to 1 and means that surface with value 1 has 100%, 0.8 has 80% emissivity.

ε – Means emissivity value.

Value of emissivity can be easily measured by special device as Leslie's Cube. Special device called bolometer compares the thermal radiation from tested surface to ideal black sample as you can see in the FIGURE 10.

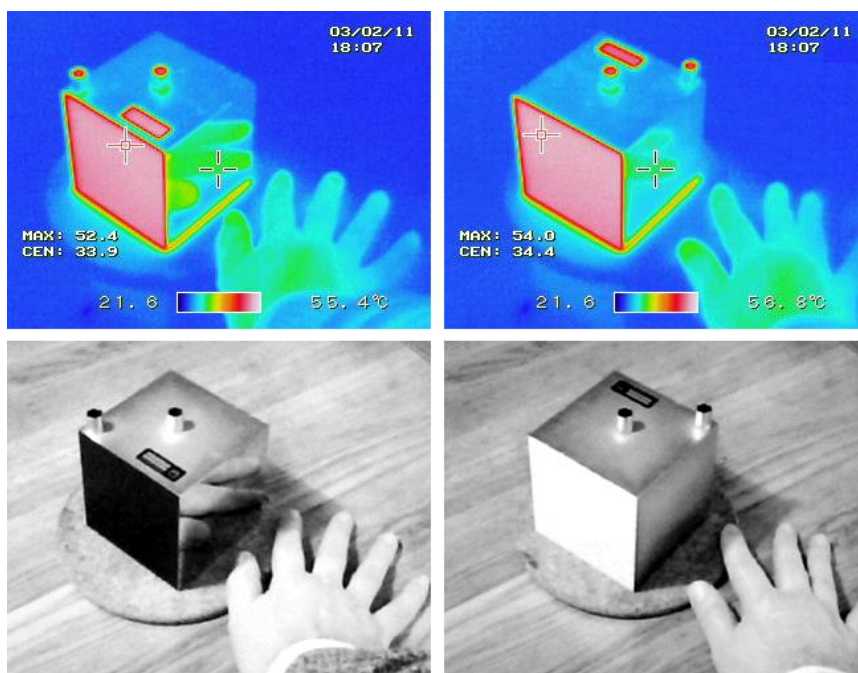


FIGURE 10. Leslie's cube. (Wikipedia, 2016)

Nowadays the value of almost all surfaces is determined in many books and you can easily find the needed number without difficult experiments. Here in the table some of them are presented:

TABLE 3. Short table of emissivity. (Wikipedia, 2016)

Metal	Emissivity	Non-metal	Emissivity
Bare aluminum	0.02–0.4	Concrete (rough)	0.93–0.96
Gold	0.02–0.37	Glass	0.76–0.94
Copper	0.02–0.74	Wood	0.8–0.95
Lead	0.06–0.63	Carbon	0.96
Brass	0.03–0.61	Human skin	0.98
Nickel	0.05–0.46	Paper	0.7–0.95
Steel	0.07–0.85	Plastic	0.8–0.95
Tin	0.04–0.08	Rubber	0.86–0.94
Silver	0.01–0.07	Water	0.67–0.96
Zinc	0.02–0.28	Sand	0.76–0.9

4.2 IR camera usage

Infrared camera is a complicated and technological device and its usage is not just like “point and shoot”. First and most common misconception is that IR camera can “see” through the objects. It is totally not true because it can only detect radiation coming from the surface of the object and it does not working even through grass.

Secondly it's very important to have perfect environment in working scene because any rain, sun, wind can have an effect on result or accuracy of measurements. Also if you are measuring surface inside the plant, the influence of hot object nearby should be minimized: camera will register reflected radiation from hot object and measurement will fail.

The operator of the camera should be engineer with theoretical knowledge. He should take into account all the factors influencing the camera and pass the certification for knowledge of the camera itself.

On the FIGURE 11 below you can see the simple principle of IR camera:

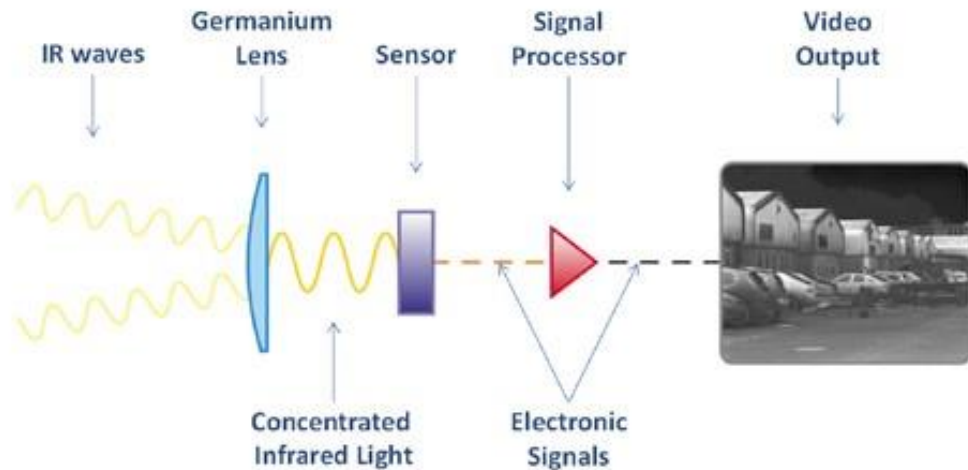


FIGURE 11. Infrared camera system. (Silent Sentinel, 2016)

Nowadays those thermal images are easy to use and much more affordable than even a few years ago. That's why it seems to be a realistic solution for every company. In power plants there is plenty of equipment that is under the load of thousands of volts every second and the only way to control its condition can be picture from IR scanner. Here below is an example of scanner with thermal image.



FIGURE 12. Thermal imager by FLUKE company. (FLUKE)

That equipment is easy to use: qualified person points the device at the equipment and searches for places with unexpected overheating. That scanner can produce live image of the heated equipment and measure the temperature on surface and hottest point. After the inspection all the pictures can be uploaded to the computer for analysis and reporting.

There are three main points of such equipment use:

- **Safety**

Even such equipment usage is safe; operator should follow safety standards and use personal protective equipment to avoid high-voltage risk.

- **Equipment load**

For correct inspection equipment should be loaded at least 30% to 40% of nominal load. Ideal condition for testing is maximum load.

- **Emissivity**

Different objects have their own ability to emit infrared energy or heat. That effects measurement accuracy and the higher emissivity the better measurement will be done. However for electrical inspection there is usually no need to specify exact temperature of object, only temperature difference is important.

By the temperature difference with the same loaded objects it is possible to find the broken equipment.

In figure 13 there is an example of equipment that has been just repaired. One of the wires was weakly connected and it heats under the load. That picture shows that its temperature difference was only 12.2 C more than the normal one. This difference cannot be found by another method but in the future may cause serious problems with electrical part or even cause fire and equipment damage.



FIGURE 13. Example of thermal diagram showing problem with wire (overheating).
(Lumen Electronics, 2016)

5 INSPECTIONS AND MAINTENANCE

Two main methods of technical diagnostics mentioned above can't live without highly qualified engineers and well-designed inspection system. Also they should have close integration and cooperation with all existing maintenance systems.

Most CHP plants in Russia have now scheduled maintenance system and are just trying to apply technical diagnostics in that system.

Scheduled maintenance consists of three parts according to the repairing volume:

- **Actual maintenance**

That type of maintenance includes solving of actual problems and repairing after breakdowns

- **Middle maintenance**

Consists of solving actual problems but with parts changing and all needed part recovery

- **Capital maintenance**

Total resource recovery and repairing all attached equipment to reach factory characteristics (can be done in factory with equipment transportation)



FIGURE 14. Capital repairing of turbine CHP-2 Ufa. (CHP Ufa, 2012)

6 ECONOMICAL POINT

It's obvious that preventive system of maintenance saves a huge amount of money by preventing shutdowns and serious accidents but another side of the coin is that the equipment for such maintenance is very expensive and highly-qualified workers are needed to operate it. Company needs to set totally new department of qualified engineer and buy them modern equipment. Also all the inspections are conducted very often need big amount of human and economic resources.

But anyway it is obvious that improvement of preventive maintenance is the main key to well-balanced and effective maintenance system. It gives many features to power plant and saves a lot of money.

Here are direct advantage by the preventive maintenance and how it helps from economical view point:

- Lifetime of expensive and complicated equipment can be increased by up to 5-10 extra years of use.
- Maintenance period can be increased by up to 15-30%
- Reduction of reserve equipment

Total savings from the right maintenance system can be between 2-10% depending on equipment type. Moreover there are indirect cost-cutting measures such as expenses from unexpected shutdowns, repairing and recovery after emergencies. For some reason it is hard to evaluate such costs but some specialists think that they can be up to 6% of total annual production volume.

Preventive system of maintenance is the future for all plants and innovations come every day but it's not the only factor. The thing is that maintenance strategy should be well-balanced to reduce expenses and have efficient financial management. Preventive maintenance should correlate with old system that uses equipment until breakdown. As you can see in Figure 15 there is optimal operating range in which costs and quality of maintenance stay in balance. In such case you won't get bad working equipment and it won't be over-maintained so no extra losses are caused. As it was said before high economic efficiency can be reached only with the help of great maintenance strategy. Figure 16 shows the balance between different types of maintenance and the role they have. That is the only way for plant to keep everything in condition, prevent accidents and spend less money.

Maintenance strategy involves trade-offs between preventive maintenance costs and total breakdown costs

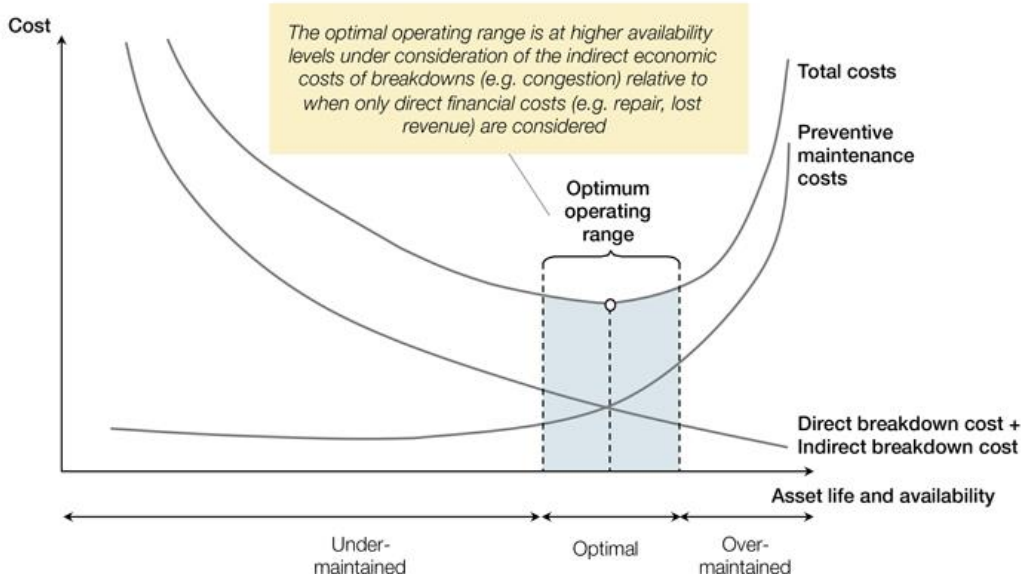


FIGURE 15. Optimization of maintenance spending. (World Economic Forum, 2016)

Maintenance strategy needs to be customized for each asset

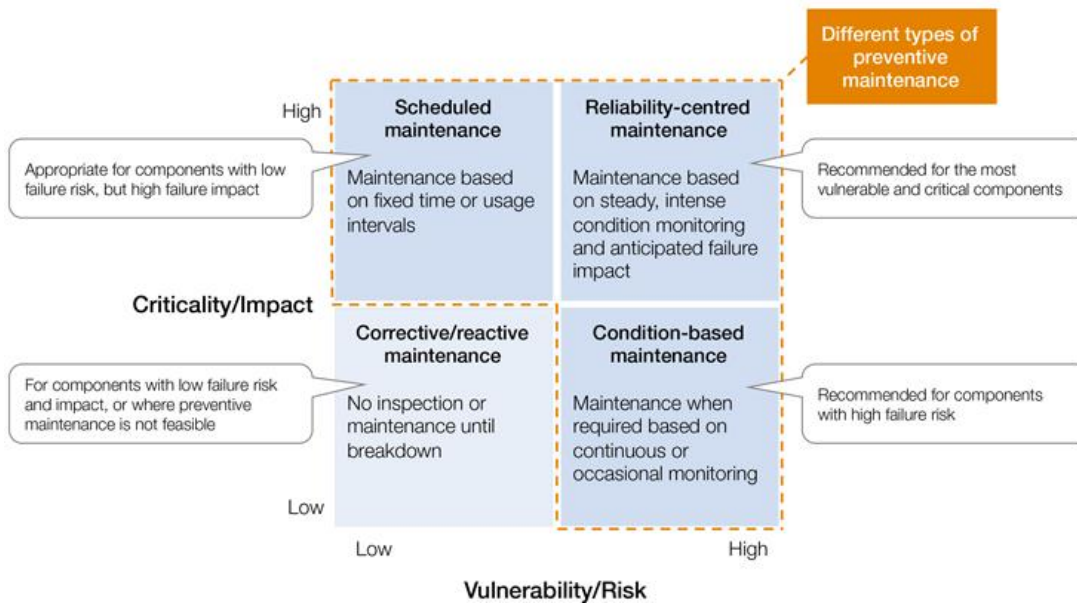


FIGURE 16. Assets regulation in maintenance strategy. (World Economic Forum, 2016)

7 IMPLEMENTATION AND EXISTING SYSTEM

Nowadays Russian industry faces many problems because of its old-fashioned way of engineering and old equipment. All the power plants are under the governments control and renovation goes very slowly. For example most of the equipment at CHP plant in Petrozavodsk was produced and designed 20-40 years ago. In the same way most of the engineers working there are 50 years of old. That's why modernization and innovation goes very slow. People use old-fashioned ways of maintenance.

Here comes a problem, when they get some new system, aggregate of equipment, the faces new technology and old methods are applied. But that equipment is modern and can be only operated with new knowledge. Sometimes because of scheduled maintenance equipment can be working even worse than before. It is caused by human factor. Also if somebody will test the equipment before planned maintenance they will see that it doesn't need maintenance yet and that schedule can be corrected.

Nowadays such departments exist where two engineers carry out all the tasks and measurements by themselves. They usually face such problems as mistrust from other departments but already many times they saved expensive equipment.

7.1 Equipment that was saved

As an example a real situation in CHP plant in December 2015 can be given.

On 11.12.2015 an engineering team was doing scheduled measurements and faced the rise of vibration in one of the exhausters. The level of that vibration was not critical but anyway engineers decided to plant additional inspections of that element. In Figure 17 it is shown a measured level of vibration in a CHP plant in Petrozavodsk. Measurement on 22.12.2015 showed critical situation in that equipment.

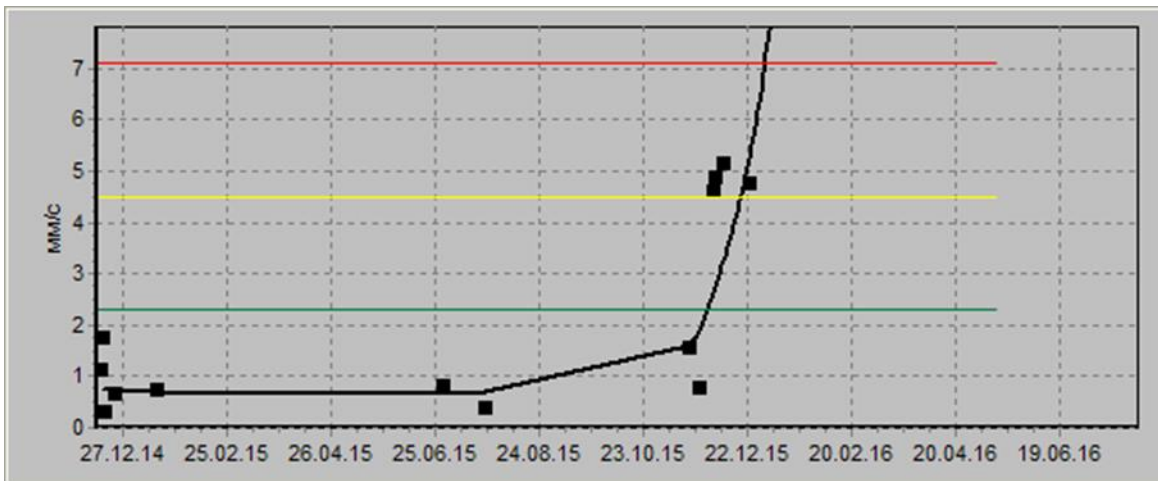


FIGURE 17. Graphic made by the measurements from vibration meter "SD-21" (Vladislav Goncharov, 2016)

Those measurements from vibration meter "SD-21" were treated and analyzed with the use of original software that gives that graphic. It shows that increasing of vibration will grow exponentially and cause shutdown of the equipment. The situation was critical because measuring team had clear vision of the situation development but main engineers did not agree with them.

There is still huge influence of old school of maintenance and most of the workers don't trust modern equipment. They were thinking that there was no danger and don't give permit for maintenance. Afterwards when the vibration level started to grow very fast they proved that situation was extremely dangerous and could cause big losses.

The right decision was made to make planned repair of the motor. Dissection show that equipment was in bad condition despite it was renewed some time ago. On 02.01.2016 all the repairing was done when the load of plant was minimum because of the holiday in country so the losses were minimized. Shutdown was prevented and financial losses minimized.

That case shows importance of the measurement department and necessity of modern technologies.

8 CONCLUSION

In conclusion it can be said that vibration and thermal control is the main part of preventive maintenance system in every power plant. These two methods of maintenance control can't live separately from well-designed maintenance system. In every plant or other factory the maintenance system itself needs to be well managed. Reactive maintenance and preventive system should be included.

As a matter of fact it can be said that a perfect maintenance system can't be without modern technology and equipment. There should be team of engineers that will invent the maintenance system for certain place or some it can be ordered from some sided company as well. Also the most important part of every maintenance system is human resources. It should be a highly qualified group of people with experience of working on such big objects.

In fact it's obvious that condition monitoring system comes now to every plant and will become part of maintenance system. They have a huge role, cost a lot of money but in the future that gives great advantage.

It follows from above that there are three main factors of good factory life: balanced maintenance system, qualified human resources and modern technologies.

REFERENCES

- Azima DLI.** Using vibration analysis to test for bearing wear. Retrieved May 10, 2016, from <http://www.reliableplant.com/Read/27324/Vibration-analysis-bearing-wear>
- Barkova N.A. (2013).** Introduction to vibration diagnostics.
- Chuck Yung (2006).** Vibration analysis: what does it mean? <http://www.plantservices.com/articles/2006/154/>
- Circuit Cellar (2014).** What Is Emissivity? Retrieved May 7, 2016, from <http://circuitcellar.com/ee-tips/what-is-emissivity-ee-tip-133/>
- Decentralized energy.** (2007). Strategies for CHP plant maintenance. Retrieved April 27, 2016, from <http://www.decentralized-energy.com/articles/print/volume-8/issue-5/features/strategies-for-chp-plant-maintenance-sampm-costs-are-generally-equal-to-power-plant-capital-cost-over-10-15-years.html>
- DynaVibe (2015).** Top 3 causes of aircraft vibration. Retrieved May 5, 2016, from <http://www.slideshare.net/DynaVibe/top-3-causes-of-aircraft-vibration>
- Imeco.** Electro-mechanical contracting company. Available from <http://www.imeco.com/>
- Plant maintenance (2014).** Quality Assured Maintenance Management For Coal Handling Plant. Retrieved May 5, 2016, from http://www.plant-maintenance.com/articles/Maintenance_Management_QA.pdf
- Plant Maintenance Resource Center.** (2015). *Quality Assured Maintenance Management For Coal Handling Plant*. Retrieved April 23, 2016, from http://www.plant-maintenance.com/articles/Maintenance_Management_QA.pdf
- VAST.** (2016). Retrieved April 20, 2016, from VAST: <http://www.vibrotek.ru/>
- Wikipedia.** Emissivity. Retrieved May 5, 2016, from <https://en.wikipedia.org/wiki/Emissivity>
- World economic forum (2014).** Strategic infrastructure. Retrieved May 17, 2016, from <http://reports.weforum.org/strategic-infrastructure-2014/1-implementing-om-best-practices/1-5-extend-asset-life/>
- Zavodfoto (2013).** Factory life journal. Retrieved May 5, 2016, from <http://zavodfoto.livejournal.com/1423267.html>