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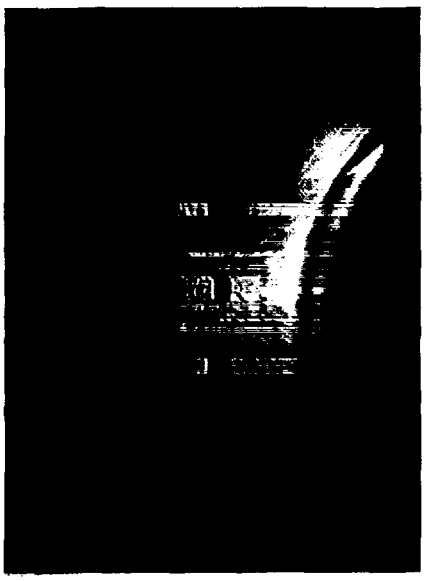

DI

DIAGNOSTIC INSTRUMENTS

VIBRATION

Signal Analysis at Work

SOLUTIONS

UNIDO-Final Report

Project Ref TF/HUN/94/915

"Development of Condition and Diagnostic based Maintenance of Technological equipment"

12.7.97

The project workscope is essentially complete.

The project has been successful in putting in place many of the tools required to improve the state of maintenance in Hungary; University courses devised, modern equipment and software procured, experience of the UK market obtained and customer/supplier assessments made.

However the aims of the project will only be fully satisfied once Hungarian industry can be persuaded that Condition Monitoring is a positive investment.

In order to achieve this, much work is still required by the Hungarian participants. In particular the Government is required to introduce a scheme similar to the DTi one seen in the UK. Service providers such as Stadium must redouble their efforts to spread the message and accept that along the way they will also need to invest and change their approach. Universities are fundamental in providing a steady stream of well qualified engineers with a through understanding of modern maintenance techniques and need to attract students to the new courses devised.

The author takes this opportunity to thank all those who have been involved with this project. It has been a good example of European Co operation.

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2.0 The Hungarian Market

2.1 Update

Since the issuing of the first interim report a number of changes have been noted in the Hungarian Condition Monitoring marketplace. Several other companies not previously made aware of to the author have been noted. At least one of which would have been a candidate for involvement in the program. This is a lost opportunity.

The market survey has also finally been completed and the results are summarised below:-

Other Competitors (see first interim report section 7.0)

In addition to the service companies listed in this earlier report, it has now become clear that a number of these companies also act as outlets for the various equipment manufacturers:-

SKF
Several different groups act on behalf of the Swedish group SKF. They include Malev/LRI and Banki/Szabo. Of the former Malev is the operator of the Hungarian national airline and its airport who also now have a diagnostic group. Szabo is a college lecturer at the Banki Donat Technical College who teaches maintenance and Condition Monitoring.

It would make sense to at least discuss the project with Mr Szabo as he clearly has an influence in this marketplace.

IRD
Originally the major company in this marketplace, IRD has recently been taken over by American based Entek with many of its products and people being finished. In Hungary IRD were apparently represented by AA Stadium although until recently arch rivals DI from the UK also thought that Stadium were their representative.

CSI
Another US based group with European HQ in Belgium, CSI is the second largest supplier in this market after Entek IRD. Its presence in Hungary is limited to representation by Eckelman who do not appear to have made a significant impact.

Others

A number of smaller service companies are also now known to operate in Hungary. Where they operate is not clear but it is felt that they probably only have one or two local customers and as such do not at present represent a significant force.

Their names are:-

Compakt
Dam
Dower
Labor BT.

Industrial/educational spin-offs

A number of education establishments and two major power firms are able to offer a Condition Monitoring service. These are unlikely to ever have enough commercial awareness to make this these organisations a serious threat, but they could have the effect of excluding Stadium from particular market segments or specific industrial sites.

Veiki
The Research Institute of Electrical Energy primarily provide a high level diagnostic service to the vital Paks Nuclear power plant.

Vibroanalizis
Dunamenti Power station has a team of diagnostic engineers who look after this plant and they seem very knowledgeable about their industry. They have an agreement with the station which allows them to use the stations equipment out of working hours for their own use. Although not clear where they work, it is thought to be local industry only.

Miskolc University
The University makes use of a number of different vibration systems for its internal and external use. Because of its location much of its consultancy work is for the mining industry and as such does not represent a true competitor. It is however well equipped with instrumentation in the form of a B&K 2526 and an SKF Microlog.

2.2 Hungarian Market Survey

A detailed study of the potential market for Condition Monitoring in Hungary has been carried out. The actual results are tabulated in an appendix, a summary is given below:-

1000 questionnaires were posted to industry, only 5% responded.

Of this 5% three quarters claimed to be using vibration analysis.

Most users believe that the technique is useful

No economic benefits were provided

Only about 15- 20% of Hungarian industry is actually using this technique

A further study revealed that over 50% of respondents believed that vibration would save money in their plants.

This study also showed that almost one third believed that it had no value to their process.

Between 10-15% used their own staff to carry out this work

Well over 50% used the services of the largest Hungarian supplier-AA Stadium

Of the total installed machinery base less than 5% is monitored

In Hungarian power stations the percentage would appear to be even lower-this contrasts sharply with most industrialised nations since this industry is traditionally one that makes heavy use of the technology.

3.0 Hungarian Site visits

During the author's visit to Hungary, a number of visits were made to both customers of Stadium and general users of Condition Monitoring. Two Steel plants, a Power station and an Oil refinery were visited and a standardised series of questions were raised.

The following is a summary of results of the various meetings:-

3.1. MOL Oil and Gas-Szeged

This plant has been using Vibration analysis for many years and in fact the project's National Expert 1 learnt his trade here in the mid 1980s.

Originally using B&K equipment the introduction of a Japanese designed Rion instrument 4 years ago meant a big improvement in portability and spectral capability. However no software was available for the Rion so long term data storage was a problem. Earlier this year a major step forward was made when MOL purchased a TEC instrument with a low frequency spectrum capability. Unfortunately this instrument is actually at the end of its life and as such support for it may be a problem in the future.

Of approximately 700 machines in the TEC database, some 400 are monitored routinely. The 700 machines utilise some 7-10000 measurement points which was considered excessive by the author of this report. Further investigation revealed that one of the reasons for this was the collection of triaxial measurements at each point, even on relatively small plant items.

This is apparently considered normal in Hungary but is of significant difference compared to the UK where labour costs are a governing factor.

Simpler bearing fault detection methods such as Spike Energy are available but relatively underused at MOL. This particular method, although not 100% useful in all applications, could be used to great effect to reduce workload. Its application must, however be fully explained and understood before it is trusted.

Two other aspects were noted: Firstly despite the fact that MOL is a petrochemical plant with potentially hazardous areas, the instrument does not need to be certified as Intrinsically Safe. In the UK this is a legal requirement due to the high risk of explosion.
Secondly engineers do not appear to be as able or willing to talk in terms of financial benefit in the same way that UK engineers can. This is another reason why Condition Monitoring is not as widely used.

3.2. Dunaferr Steel-Hot Rolling Mill

This Steel plant is one of the largest industrial plants in Hungary and operates a very intensive production schedule. There are some 1500 workers on this side of the site, a total of 4000 elsewhere. The plant itself is some 30 years old and is of Russian origin. Turnover is approximately $1M on 1.2Mtonnes of product each year.

Maintenance is essentially time based and a major operation is currently in hand to introduce a new Computerised Maintenance Management System supplied by a Swedish company.

During the mill's summer shutdown (15th-24th July) a large amount of inspection work is undertaken. Very little Condition Monitoring is carried out which would alleviate much of this work. In particular Gearboxes are routinely overhauled irrespective of their actual condition.

One particular problem which costs the mill a large amount of money each year concerns 5 steel rolling mill stands. Tapered roller bearings are fitted to each roll and during the production cycle these bearings receive a high shock loading as the product passes every 3 minutes. This type of bearing design is not tolerant of high axial forces such as these and as a result a high failure rate is encountered. The bearings themselves are very large and very specialised and as such can cost upto $50000 each,

The bearings are checked visually every quarter but sometimes failure occurs every 4-6 weeks. Production rates run at 300 Tonnes per hour and the average selling price of 1 Tonne of steel is $300.

A bearing failure results in a loss of at least 1 hours production and the cost of loss production plus the replacement bearing of EACH failure amounts to $140000. This is extraordinary and the question must be asked would a UK steel plant put up with this level of failure or would it (a) attempt to design out the failure or (b) monitor the plant to allow failure prediction to be made?

It is disappointing to report that Condition Monitoring is little used in this mill and there does not appear to be any real interest in applying it. Costs have been sought to install a monitoring system on the bearings already discussed but no funds are available. A simple SPM instrument was procured some time ago for monitoring sliding bearings but the SPM technique does not work on this type of bearing. This is a gross misuse of Condition Monitoring and it is no wonder that management is unwilling to allocate further funds.

This is a site where Condition Monitoring could save vast amounts of money for a relatively small investment.

3.3. Dunaferr Cold Rolling Mills (DWA)

This plant does, at least own some fairly up to date Condition Monitoring equipment in the shape of a B&K 2526 data collector and associated software along with an engineer trained to use it.

The mill employs some 800 staff of which 130 are involved with maintenance (a high ratio compared to UK) but this is due to fall to 111 shortly. Turnover is some £0.1B pa and half of the product goes for export to car and domestic appliance manufacturers.

The new maintenance management is young and has some excellent ideas for the future. At present though they have only reached the stage of producing an equipment inventory as a prelude to introducing the Rubin maintenance management software already discussed. An external report has also been commissioned to help plan the way forward. These are all very positive steps and this plant is the first that the author has heard of in Hungary that is actually attempting to model itself on Western lines successfully.

The maintenance engineer however has a big problem with Condition Monitoring. Despite having purchased modern equipment it was being used in such a labour intensive way that it's use has now been virtually halted.

The problem is centred around the time taken to collect and analyse the data. A copy of the Condition Monitoring data collection schedule and timings are included in an appendix but an example is given here of how ridiculous the situation is:-

In one area of the plant there are 5 small pumps each driven by a 150kW motor. There are 2 measurement locations on each; motor non driven end and motor driven end. Each location has 4 measurements taken. A total of 40 points. Due partly to the speed of the B&K instrument but more to do with the way the measurement points have been set up, each of these motors take 32 minutes to measure. A total time of 2 1/2 hours is therefore needed to collect data on just 5 small machines. One hour per machine is then allocated in order to analyse this data.

THIS YIELDS A TOTAL REQUIREMENT OF 7 1/2 HOURS OR 1 MANDAY TO MONITOR THESE 5 SMALL MOTORS.

When similar timings are extrapolated across the whole plant the author has calculated that its takes 3 man months to adequately monitor . Based on a typical schedule of monthly readings there is clearly a huge problem with running the system in this way.

On highly critical machines, where the measurement interval should be greater than monthly, the problem is even worse:- 1 man month to collect and analyse 200 measurements on only 20 machines!

This plant is a good example of Hungarian industry at last using Condition Monitoring but in totally the wrong way. In the UK this sort of situation would not arise at such a ;large and critical plant because there are several good vibration based service

companies that would be able to advise on how to run the system. Most likely the system itself in the UK would have been set-up by one of these companies in the first instance and therefore this situation is unlikely to have arisen.

Recommendations

The Condition Monitoring system at DWA needs a complete and radical overhaul if it is ever to be cost effective. The author recommends the immediate application of:-

1. Remove all CPB and Spectral measurements from the routine schedules and measure only overall vibrations on simple plant-pumps, motors, fans etc.

2. Set alarms on these overall measurements on a group wide basis and allow the computer software to report all the machines that have violated their alarms.

3. Collect spectral and CPB measurements on these points only and provide detailed action report as a result of this analysis.

4. Review the collection interval on critical items and increase if monthly to two weekly.

3.4. Dunamenti Power Station

This station has a highly experienced diagnostic group specialising in a variety of Condition Monitoring techniques. These include Endoscopic inspections in which a large investment had recently been made.

The station provides some 2000MW via a number of different machines and employs 1100 staff. In comparison to a UK station, a similarly sized one would now employ only 250. Traditional time based methods are still used as the core of the maintenance effort with Condition Monitoring only used to solve particular diagnostic problems.

The overhead associated with a group such as this is quite high and in the UK most of these groups have now been disbanded or sold off to private industry.

The diagnostic group has expertise in areas such as vibration, Thermography, endoscopy, alignment, material testing, noise monitoring, balancing and pressure vessel testing going back some 15 years.

Apart from the investment already mentioned, most of the equipment used by the group is hopelessly out of date. Like many Hungarian sites visited by the author it was a little like stepping back in time compared to what is commonly used now in the UK. This lack of investment will eventually open the door to external competitors such as Stadium.

4.0 Differences in approach-UK & Hungary

It is felt by the author that one of the reasons for the lack of large scale uptake of this technology in Hungary is the preoccupation with high level diagnostics rather than routine trend analysis.

This is further borne out by the use of highly qualified Engineers to carry out routine data collection and analysis both by external organisations, such as Stadium, and internally at companies such as MOL.

Labour cost variations between technicians and engineers in Hungary is very low, again in contrast to the UK where it is very unusual to find engineers being used for data collection tasks.

Serious consideration should be given to an alternative approach in Hungary, perhaps based on a central diagnostic group of engineers using technicians or semi skilled staff to collect data. This would undoubtedly result in a lower cost service since the volume of data collection would be much higher. Improved automation of the analysis function is also readily available and for similar plant items, diagnostics is almost automatic.

Hungarian engineers do not appear to be as able or willing to talk in terms of financial benefit in the same way that UK engineers can. This is another reason why Condition Monitoring is not as widely used.

In the UK the demand for Condition Monitoring is driven by economic requirements, in Hungary it is more down to an individual's choice.

In Hungary labour costs are much lower than in the UK allowing service companies to offer Condition Monitoring at very competitive rates.

Capital investment is harder to obtain in Hungary, hence the demand for service work.

In Hungary there does not appear to be enough knowledge of the value of the technique at high management levels. In the UK young engineers are brought up understanding the place of Condition Monitoring and therefore apply it when they get into senior positions.

UK engineers are also brought up to have a higher economic awareness

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Top management in Hungary still view maintenance as a cost and not a cost benefit.

5.0 International Quality system accreditation

5.1 Why does Stadium need a Quality System?

"A Quality System seeks to continuously improve performance at every level of operation, in every area of the business using all human and capital resources. It demands commitment and discipline and ongoing effort."

Without a Quality System and in all walks of life we would find that from 99.9% of suppliers we would get:-

At least 20000 wrong prescriptions each year
Unsafe drinking water for one hour each month
No heating for 9 hours each year
Broken phones for 10 minutes per week
Two major air crashes per day
2000 lost letters per hour.

In the field of Condition Monitoring where AA Stadium operates the lack of quality could result in customers experiencing major breakdowns every week in spite of the monitoring programs put in place to prevent them.

Ultimately of course this leads to customer dissatisfaction followed, very quickly, by the loss of that customer to a competitor. Although currently dominant in Hungary and some neighbouring countries, poor standards and lack of quality will soon lead to a loss of business.

It is for this simple reason that Stadium must prepare to introduce a comprehensive Quality System.

5.2 ISO 9004:- Designing a Quality system for AA Stadium

The project had, as one of its objectives, a limited assessment of Stadium and other companies with a view to them attempting to obtain an internationally recognised Quality accreditation such as ISO 9004. It was decided later by the project co ordinators that since there was no participation from other companies that their assessment was not required.

The first interim report published under this contract has already drawn attention to some of the areas that AA Stadium will need to address before it is worth investing in any International accreditation.

Clearly the scope of the project was never intended to cover its proper planning and implementation but there follows some guidelines to assist AA Stadium in its preparation for a formal audit.

5.3 The cost of quality

In service industries as well as manufacturing costs are very closely linked with quality. From a commercial point of view a service is worth what a customer is prepared to pay for it. If the quality of the service is poor then ultimately its selling price will be low.

In a Western economy such as the UK the days are gone when a supplier could add almost any profit margin to its goods or services:- competition is increasing, customers are more knowledgeable and quality standards are higher. The Hungarian market is not yet so well regulated and at present Stadium are dominant. This will not last forever because the entry cost to provide a Condition Monitoring service is relatively low. US and UK based companies who operate this service in their own countries are, compared to Hungary, relatively cash rich. Hungarian labour costs are about one quarter of those in the UK and so a Hungarian offshoot of a UK based service company can only be a matter of time. Higher salaries can be offered and key personnel bought. With them will come Stadium's customers.

A high quality service is the key to preventing this loss of business since it will take time for a new entrant into the market to gain a quality reputation. In order to provide this high quality of service, Stadium needs a Quality System.

As with any such undertaking there are some basic steps to applying a Quality System:-

5.4 Application of a Quality system

1. What is the service offered?

What formal definition of the service it provides has Stadium carried out?

In the same way that a manufacturing organisation carries out market research prior to developing and launching a product, any service orientated company must start with a survey of the needs of the market.
As an example a specification of operational requirements needs to be drawn up to define areas such as:-

What services do customers want?
What staff levels are required?
Where should staff be based?
What level of business can the organisation cope with?

2. Production of a plan to achieve the agreed service(s)

There are several issues to take account of:-

(a) The methodology
An exact definition of how Stadium should work; for example how can we ensure that staff are fully utilised and not standing waiting for work at customer sites or expected to be at two customers simultaneously?

(b) Equipment and tools
Offering a Condition Monitoring service requires access to high technology tools such as Spectrum Analysers, high power PCs and Windows based software. In this area Stadium operates a diverse mix of old and new equipment and this must mean that the standards of reports issued to customers are of an unequal standard.
Any equipment purchased must of course be reliable and have its own Quality assurance program for calibration and repair.

(c) Running material
In the industry that Stadium operates in the material requirement is very low. If the company does plan to move into system sales as previously recommended then this aspect will become more critical.

(d) Personnel
Obtaining staff with the right background and qualifications in this field is very difficult. Training of both experienced and non skilled staff should be a high priority item and retaining those staff is even more important. A quality organisation has a low staff turnover.

(e) Operational Quality control
The service must perform as intended otherwise Stadium will lose customers. Checks must be put in place to ensure that a consistently high level of quality is maintained. With the remote multiple offices and different equipment policies of Stadium this aspect is vitally important.

3. Operating in accordance with the plan

We must by now assume that Stadium has devised just such a plan and that it has successfully planned the service it offers as discussed above. The next step is to ensure that it sticks to this plan accepting that it is harder with staff working remotely from the central office. The better the plan, the easier this phase will be.

There are three steps to ensuring quality of service:- we must start off correctly, we must carry on successfully and most importantly we must finish each job correctly.

(a) Starting correctly
In the Condition Monitoring marketplace starting off correctly means that staff arrive at a customer site on time, well dressed and with a full understanding of what they are supposed to be doing and how they are going to achieve it. It is the responsibility of senior management to ensure that the quality system is clear enough for staff to be aware of this.

(b) Carrying on successfully
Stadium must ensure that it always works to the company quality plan. This can be done in a number of ways:- reports can be checked for accuracy by senior engineering staff, technical exams may be set from time to time or visits to customer's sites can be made to check on the feedback of how well the job is being carried out.

So much of a customer's perception of what a small service company such as Stadium does is based on his relationship with the staff that go to his site. It is therefore vital that these staff are always good ambassadors. Senior management at Stadium must build in a customer feedback system such that any problems can be ironed out before they become damaging.

(c) Finishing correctly

This is a way of helping to close the loop between customer and service provider. For instance reports can be checked and amended before they arrive with the customer.

4. Correcting problems

If a machine has been incorrectly diagnosed and a costly plant failure has occurred then again it is the responsibility of senior management to contact the customer to explain to him where thing have gone wrong and to assure him that it cannot happen again.

Learning from such mistakes is critical since there is an element of art in Condition Monitoring and not just science.

5.5 Preparing for a Quality System

Before AA Stadium can be considered to have a satisfactory Quality System it will be useful for senior management to begin to assess the company against known quantitative categories. These are summarised below:-

1.0 Leadership

Leadership of Stadium's senior management
Quality management
Public awareness

2.0 Analysis and information

How does Stadium manage quality and performance information
Benchmarking against competition in Hungary and overseas
How does Stadium use this data?

3.0 Strategic Quality

What is Stadium's strategic planning process?
What are Stadium's long and short term Quality plans?

4.0 Personnel development

Personnel management
Staff involvement
Staff training provision
Staff recognition
Staff morale

5.0 Managing Stadium's services from a Quality viewpoint

Introducing new services
Maintaining quality of existing services
Maintaining quality backup and support
Subcontractor quality control
Overall quality assessments

6.0 Operational improvements in Quality

Trend the quality of Stadium' services
Trend Stadium's operational results
Trend quality of backup and support
Trend subcontractor quality levels

7.0 Customer satisfaction

How does Stadium manage its customer relations?
What commitments does Stadium make to its customers?
Improving customer relations
Trend customer satisfaction levels and compare these levels with competitors.

6.0 Project Achievements

During the short time span allocated to this project and the tight economic constraints, it is pleasing to report the following achievements:-

- **Purchase of up to date Condition Monitoring system for participants**
- **Purchase of audio visual training aids for participants**
- **Market survey of Hungarian industry**
- **Completed Study tour of UK**
- **Drafting of new Hungarian University courses**
- **Completion of 3 day Vibration seminar**
- **Assessment of Hungarian Condition Monitoring market.**

There are many UK based service companies that provide a high level of service and support independent of equipment manufacturers. Many of these operate in specific industry or geographical areas.

As a result there is much healthy competition and standards are therefore maintained high.

In Hungary Stadium dominates with over 50% of the market. Although their work appears to be carried out to a high diagnostic standard, it is always dangerous for one company to have such a strong influence. This is particularly true of the service versus equipment argument-At present Stadium will only offer prospective customers a service contract and not a professionally installed system of their own. This ultimately leads to a lack of understanding and expertise within a customer site and this does have a long term negative effect on market education and hence growth.

There is an interesting corollary with the UK here of 5 years ago. A similarly sized company to Stadium became the largest service provider and squeezed out some competition. As a result standards fell and a number of customers were let down. Soon staff began to leave this company and set up in competition. Soon afterwards it was noticed that the market began to grow as more and more customers brought in their own systems, having realised that they had been over reliant on the service provider.

It is the experience of the UK that those systems which are run and maintained internally are the most highly regarded.

They are not always, however the most cost effective in the long term.

The author believes that the best and in the long term most cost effective strategy for adopting Condition Monitoring is as follows:-

Service provider conduct trial application 6-12 months at consultancy rates

Customer procure own system via service provider who also gives training, set-up assistance and support.

After two years the system will be fully understood by the customer and accepted as yielding a positive payback.

Service provider contracted back to take over routine monitoring at normal labour rates. Specialist assistance as required.

7.0 Summary

Application experts have a far bigger influence in the UK than the equipment suppliers. This leads to quality installations where the onus is on economic success and not engineering ability.

Wage costs are higher in UK than the cost of the equipment. In Hungary the reverse is true.

Most good Condition Monitoring schemes in the UK realise that continual investment in technology and training is required in order to generate continual plant improvements. In Hungary it is hard enough to purchase the systems in the first instance, let alone reinvest for the future.

In the UK Condition Monitoring implies a variety of different techniques, in Hungary the main technique offered is vibration analysis.

Hungarian Condition Monitoring experts have a focus on high level diagnostics rather than routine trend techniques as generally seen in the UK. This might be because the biggest savings to be had from Condition Monitoring are in the reduction in planned maintenance levels which are primarily governed by labour costs.

Greater emphasis on balancing is seen in Hungary, whereas in the UK it is alignment. This might be because of the higher relative energy losses through misalignment and higher energy (privatised electricity industry) costs in the UK.

UK Universities have a greater involvement in the development of Condition Monitoring than in Hungary. Products such as Motormonitor have been primarily developed through academic links.

Condition Monitoring teaching in the UK is based on practical demonstrations and industrial links. In Hungary the approach is still theoretical in uses a lot of old techniques and textbooks.

In the UK a number of excellent Government initiatives have helped industry to benefit from this technology. In Hungary no Government Money (except the UK Government money funding this project) is forthcoming.

Training courses in the subject are widely available in the UK. Some are available in purpose built laboratories with machinery designed to mimic typical plant problems.