ULOGA ULTRAZVUČNE TEHNOLOGIJE U POUZDANOSTI

ULTRASOUND IN RELIABILITY

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REZIME

Realnost u industriji, govoreći o pristupu održavanju u velikom broju slučajeva, u velikom je nesrazmjeru s raspoloživim znanjima i dostupnim tehnologijama. Ovakva situacija mnoge tvrtke čini nekonkurentnima ili bitno smanjuje projicirani profit. Na suvremenom globalnom tržištu, kada su resursi stabilnih ili rastućih cijena, a finalni proizvodi sve nižih cijena, budućnost se mora tražiti unutar kompanije, a održavanje u tom slučaju može i mora biti generator profita. Rast pouzdanosti se može očekivati tek kada postane nešto što se tiče svih, a ne samo tima kojem je zadatak dodijeljen. Širi pogled na dostupne tehnologije dovodi do uključivanja većeg broja zaposlenih u proces podizanja Pouzdanosti, najčešće kroz uključivanje u Nadzor stanja. Ultrazvuk u održavanju nudi širok raspon aplikacija, ali i širok raspon onih koji tehnologiju koriste, zavisno od sposobnosti i obuke.

Conference paper*

SUMMARY

Reality in industry, thinking of maintenence approach in many cases, is disproportional with available technologies and knowledge. This situation is decreasing company´s competitiveness or decreasing the possible or projected profit. In the global market, when resources show stable or increasing prices, and final product price drop, future is to be found within the system, and maintenance must be a profit generator. Reliability increase can only happen once it becomes everyone's concern, not only the concern of the team in charge. Wider acceptance of available technologies inevitably leads to inclusion of larger number of employees in Reliability improvement process, most often through their participation in Condition Monitoring. Ultrasound in maintenance covers wide area of applications and wide range of employees that can use it, depending on their skills and training applied.

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1. POUZDANOST I NADZOR STANJA; RASPOLOŽIVA ZNANJA I TEHNOLOGIJE NASUPROT REALNOSTI U INDUSTRIJI

Koje metode/tehnologije/alate koristite u procesu nadzoru stanja ili dijagnostici?

- *Ništa !*
- *Vrlo jednostavne alate u vrijednosti nižoj od 500 €*
- *Vib, Ut (ae), Ir, Oa … sve ili nešto od toga*

Da li taj dio posla za vas obavljaju vanjske tvrtke ?

- *Ne !*
- *Ir, Vib, Oa .. u prosjeku jednom godišnje*

Ova su pitanja dio svakog razgovora na temu uvođenja novih ili dodatnih tehnologija u smjeru unaprijeđenja.

1. RELIABILITY AND CONDITION MONITORING; AVAILABLE KNOWLEDGE AND TECHNOLOGIES vs REALITY IN INDUSTRY

What methods/technologies/tools you use in process of CM and diagnostics ?

- *None !*
- *Very simple tools in value less than 500 €*
- *Vib, Ut, Ir, Oa … all or some of it*

Is that part of the job done by outsourced companies for you?

- *No !*
- *Ir, Vib, Oa .. once a year*

These questions are part of every meeting and discussion on introduction of new or additional technologies in order to achieve improvements. Answers are listed by percentage (high to low) and „None“ and „No“ keep their leading position Poredana su prema odgovorima, i prva mjesta

zauzimaju tu poziciju vrlo čvrsto. Zasigurno se ne mogu smatrati anketom ili podacima koji predstavljaju presjek ove teme, ali u svakom slučaju mogu i trebaju izazvati zabrinutost i pogled na realnost iz jedne sasvim druge perspektive. Velika većina opreme i procesa je tretirana u „run to failure“ ((Rad do Ispada) modelu, ali ne kao dio strateške odluke zasnovane na cost/benefit analizi Prediktivnog ili Preventivnog pristupa, već kao odraz, nažalost, nemoći i degradacije u kojoj se održavanje tretira kao prvi „trošak“ koji treba „rezati“.

Degradiranje struke možemo i ne moramo gledati kao na nešto tragično, ipak je kvalitetno održavanje stvar izbora, no takav stav degradira ljude, održavaoce čiji posao gubi dignitet u mnogim sredinama. Nemoguće je ne primjetiti status podmazivača, npr., čiji je posao jedno od ključnih područja u kvalitetnom održavanju.

Važno je naglasiti da je ukupno raspoloživo znanje u akademskoj zajednici na vrlo visokom nivou, da je nivo kvalitete obrazovanja obzirom na prilike vrlo zadovoljavajuć, no most koji je oduvijek povezivao razvoj i primjenu je urušen ili u potpunosti nestao. Dok je važnost tog mosta u visokorazvijenim industrijama odavno prepoznata na području održavanja, u našoj se regiji desilo urušavanje ili rušenje mosta, zavisi kako na to gledamo, u posljednjih 25 godina. Shvaćanje održavanja kao neizbježnog ili nepotrebnog troška umjesto generatora profita dovodi do onoga što se ne može nazvati nikako drugačije nego anomalija s vrlo skupim i dugoročnim posljedicama.

Jaz između raspoloživih znanja i realnosti primjene dovodi i do gubitka generacija koje uz formalnu edukaciju stiču iskustvo radom sa starijim kolegama, do gubitka kontinuiteta sustava u kojemu se nove tehnologije i znanja relativno lako implementiraju u manjim koracima stalne nadogradnje, te neminovno i do gubitka profita vodeći u nezaustavljivu spiralu *nedostatak profita-urušavanje sustava-dodatni gubitak profita*. Pod sustav moramo razumijevati ciljeve, strategije, opremu, kulturu rada i ljude. Dok su prve tri stavke skupe ali mogu biti brzo „nabavljene“, posljednje dvije su također skupe ali njihova „nabavka“ podrazumijeva mnogo vremena. Nerijetko je odgovor na ovakav slijed događaja dodatno „rezanje“ upravo tamo gdje nikako ne bi trebalo, bez dubljeg prepoznavanja gubitka koji nosi degradacija održavanja ili prepoznavanja dodatnog profita koji unaprijeđenje održavanja donosi.

very strongly. And that happens in the region that exports knowledge! This can not be considered as a scientific research or survey, but in any case can (and should) cause deep concern and change the perspective of reality. Most of the equipment and process is treated in „run to failure“ mode, but not as a part of strategic decision based on cost/benefit analysis whit in PdM or PM, but as a reflection of infirmity and degradation of maintenance where it is treated as a first „cost“ that needs to be „cut off“.

We may look at degradation of profession as something tragic or not, as good maintenance practice is a matter of choice after all, but such an attitude is degrading people, maintenance people who´s work has lost dignity everywhere around us. It is impossible not to notice the status of lubrication people, „grease guy“, who´s job plays one of the most important role in modern, quality maintenance.

I will strongly emphasize that available knowledge in academic society is at the very high level, that level of education quality is satisfactory (considering all), but the bridge that that was connecting technological evolution and reality in the field has collapsed or has been completely destroyed. While importance of that bridge in area of maintenance, in highly developed industries around the world, was recognized long time ago, in our region that bridge has collapsed, or has been destroyed deliberately in the past 25 years. Considering maintenance as unnecessary or inevitable cost instead of positioning it as a profit generator leads to something that can not be called by any other name but anomaly, with costly and long-term consequences.

Gap between available knowledge and reality also leads to loss of generations of maintainers that, besides formal education, need to gaing experience working with more experienced colleagues, leads to loss of continuity of new technologies and approaches introduction in small, constant and easy steps, and eventually leads to unstoppable spiral of *lack of profit-system collapse-additional loss of profit*. By system, we need to understand all of it´s elements; goals, strategies, equipment, culture and people. While first three elements are expensive but can be „delivered“ quite fast, last two elements are not only expensive but come with enormously long delivery time. Answer to this chain of events is often making additional „cuts“ exactly where they shouldn´t be done, with no deeper understanding of the loss that maintenance degradation brings, or understanding the benefits and additional profit that it should be able to bring.

Iz do sada navedenoga moram izuzeti određeni broj kompanija koje smatramo liderima u regiji, u kojima je situacija potpuno drugačija.
Upravljanje imovinom, pouzdanost, održavanje, nadzor stanja , kultura rada i ljudi su prepoznati kao budućnost i rezultati su vrlo jasni. Te kompanije mogu služiti kao primjer, sjajan primjer, ali od samog gledanja u njih kao izvrsne primjere ne možemo očekivati rezultate. Loš pristup i neulaganje u primjenu tehnologija i potrebnih znanja donio je u velikom broju slučajeva vrlo jasne i poznate katastrofalne posljedice. Nepovratan ulazak u područje reaktivnog održavanja, visoki troškovi održavanja, propadanje opreme, neplanirani zastoj, veliki gubici energije, povećanje troškova proizvodnje i pad konkurentnosti, gubitak poslova, gubitak kvalitetnih ljudi i konačno, minorizacija uloge na trzištu koja vodi u neminovno gašenje. Znanja i tehnologije su dostupne i svakim danom sve naprednije.

No, pojmovi znanje i tehnologija su neodvojivi i moraju biti dio „paketa“. U protivnom , postavlja se pitanje da li se nešto *kupuje* ili *implementira*. Uz veliki broj slučajeva kada se ne poduzima gotovo ništa, i onaj manji dio primjera kada i dođe do odluke o investiciji, ostane na kupovini i vrlo malom ili nikakvom obimu obuke. To su situacije kada tehnologija „podbaci“ i ne ispuni očekivanja. U praksi kompanija na našem području gotovo je redovna pojava da se posjeduje oprema čijih se svega 10% mogućnosti koristi.

Vibrodijagnostički uređaji naprednih mogućnosti koje se koriste u rangu „vibro olovka“, Ultrazvučni uređaji koji se koriste isključivo da se locira „šištanje“, IC kamere (Infracrvene kamere) isključivo u arsenalu elektro održavanja, itd. Vjerujem da smo svi imali prilike vidjeti nevjerovatne primjere koji su samo poslužili kao razlog za eliminaciju bilo kakvih budućih investicija. Odluke o primjeni tehnologija i raspoloživih znanja leže na upravi kompanije, ali u procesu koji vodi do kvalitetne odluke je mnogo sudionika i svi moraju snositi odgovornost. Godinama potiskivani održavaoci u uvođenju novih tehnologija u svoj brojčano osakaćeni tim često vide samo novo dodatno opterećenje i stres, i time se gubi strast i želja, uz izostanak dodatne pomoći u prevladavanju implementacijskog perioda.

I need to exempt certain numbers of companies in our region from all mentioned before, companies that we consider regional leaders with completely opposite approach from what I described.
Asset management, Reliability, Maintenance, Condition Monitoring, working culture and people are recognized as a future, and results are very clear. Those companies need to be an example, a great one, but nothing can be achieved just by looking at the great example. Wrong approach and poor investments in technologies and needed skills in many cases created known and very clear catastrophic consequences. Irreversible drowning in area of reactive maintenance, high maintenance costs, deterioration of equipment, high downtime, huge energy loss, increased production costs and decrease of competitiveness, loss of orders, loss of quality people and finaly, minorization of the market role that leads to inevitable eternal shut down. Knowledge and technologies are more advanced every day.
But, technology and knowledge/skills are inseparable and need to be a „package“. Having technology without skills and knowledge arises a question about *purchasing* or *implementing*. With so many cases when nothing is done, even that small number of attempts of purchasing instruments stays exactly there, on purchase with none or very basic trainings and concept. Those are the situations when „technology fails“ and does not meet the expectations. Common case with companies in our region is to own instruments whose 10% of abilities is practicaly used.
Advance Vibration Analysis devices used at a level of vibro pencil, Ultrasound devices used exclusively to hear air leaks „whistling“, IR Cameras exclusively in electricians toolbox, and so on. I believe that we´ve all seen incredible examples that were good for one thing only; to eliminate any future investment in maintenance. Decision about aplying technologies and available knowledge are in the domain of management, but there are many levels involved to lead to that decision, and they should all be held responsible. Mainteners, suppressed for years, can see only additional stress and workload for their maimed team, while no help and support is given during implementation period, and passion and vision soon fade away.

U uspinjanu uz „*initial hump*“ (inicijalno dodatno opterećenje) većina pravih promjena i prestane postojati. U velikom broju slučajeva su očekivanja uprave potpuno nerealna i bez pravog uvida u sve potrebno za uspjeh, tražeći cjelovito rješenje u svega jednom segmentu. Iako mnoge studije napominju da udio odgovornosti odjela održavanja u unaprijeđenju pouzdanosti rijetko prelazi 20%, dramatične promjene se očekuju upravo tamo, često vjerovanjem u „čarobni štapić“ u obliku nabavljenog instrumenta.

Uz neadekvatno reportiranje, projekti se ukidaju kao besmisleni i neprofitabilni. Sindrom „*Ministarstva za prevenciju Zemljotresa“*. Veliki broj onih koji nude tehnologije su, nažalost, „isporučioci kutija“ i isključivo trgovci opremom. To podrazumijeva trzišno ponašanje, uz dužno poštovanje naravno, i utrka za profitom nužno vodi ka prevelikim obećanjima koja su obrnuto proporcionalna pravoj podršci korisniku. Time su na gubitku svi. Luksuz takvog plasiranja tehnologije je prošlost, potrebna su cjelovita rješenja. Ponuda tehnologije mora sadržavati cijeli paket sa „zašto“, „što“ i „kako“ i korisnici se moraju naviknuti da na tome inzistiraju.

Unaprijeđenje Pouzdanosti je sustav, promjena pristupa i involviranost apsolutno svih. Svojedobno je JFK rekao „Poslat ćemo čovjeka na Mjesec“ i kreirao ideju, cilj. Tijekom posjeta Nassa-inim prostorima upitao je čistača s četkom u ruci što radi.: „Šaljem čovjeka na Mjesec“. Koliko god to zvučalo senzacionalistički i kao odjavna scena filma osrednje kvalitete, zanimljivo je upitati se s koliko žara, osjećaja pripadnosti i truda je taj čovjek radio svoj posao. Pratio je cilj, bio je dio strategije, i osjećao je svoj posao kao važan. Nažalost, ponovno buđenje u realnosti. Najčešći odgovor kada se postavi pitanje o nekom problemu je bio : „To nije moj posao“. Vjerujem da to nije krivnja onoga koji je dao odgovor, već onih koji trebaju biti lideri i kreirati strategiju. Da li moraju stvoriti nešto što podsjeća na „part-time“ religiju od 07-15? Uvjeren sam da da, to rade oni koji uspješno implementiraju uspješne promjene s minimalnim sredstvima, jer u centar strategije stavljaju ljude, sve ljude od portira do generalnog managera.

Most of the real changes ceases to exist in first few steps up the „*initial hump*“. In most of the cases, management expectations are not realistic, without real understanding of all needed for success, while trying to have a complete solution with involvement of one single department. Although many studies show that can be held responsible for 20% of the Reliability problems, all the dramatic changes and improvements are expected to come from that department only, often through deep believe in „magical stick“ in shape of some of the CM instruments.

Followed with inadequate reporting or no reporting at all, projects are canceled as meaningless or unprofitable. „Earthquake Prevention Department“ sindrom. Most of those who offer CM technologies are, unfortunately, nothing more than „box shifters“, just merchants. That is how sometimes business is percieved, with all due respect, but leads to magical promises inversely proportional to real support given to user. At the end, that makes everybody a loser. Luxury of placing technology on the market that way is a history, solutions are needed. Supply of technology, instrumments or tools means whole „package“including *why, what and how* and users need to become aware of the fact that they *must insist on that*.

Reliability improvement is a system, change of approach and attitude and requires absolutely everyone to be involved. When JFK said „We choose to go to the Moon“, he created an idea, a goal that everyone felt a part of. During his visit to NASA, he approached a janitor; "Hi, I'm Jack Kennedy. What are you doing? - "Well, Mr. President," the janitor responded, "I'm helping sending a man to the Moon." However it may sound sensationalistic or like a final scene of some movie, or even being a real event or just a good marketing, it would be interesting to understand that passion, effort and sense of belonging shown by this man. He was following an idea, he was part of the strategy and he felt his job as an important part of it. Back to reality now. Most common answer when question is asked regarding some problem was; „That´s not my job“. I believe that the person who gave the answer is not to blame, but blame should be addressed to those who were supposed to be leaders and create a strategy. Do they need to create a something that has elements of „part –time“ religion? I believe yes, as that is what is done by those who successfully implement long lasting changes with minimum financial resources, by putting people in the center of their strategy, all people from doorman to general manager.

Prije 20-tak godina smo kao imperativ vidjeli najnovije tehnologije, što je apsolutno ispravno, no zaboravljano je da je u našem poslu tehnologija samo kutija s alatom, namijenjena ljudima.
Citirat ću jednog kolegu koji je nekada davno bio entuzijast, danas razočaran : „Ma kakav trening. Računovodstvo i tajnice idu na simpozije i usavršavanje svake godine, u Dubrovnik. Održavanje ne ide nigdje.“

2. ROTIRAJU LI SVI PROBLEMI? JESU LI TRENDIBILNI? ŠTO JE POD NADZOROM I JE LI TO DOVOLJNO?

Primarni fokus Condition Monitoringa (Nadzor Stanja) je često stavljen isključivo na rotacionu opremu, ne s punim pravom. Hidraulični i pneumatski sistemi, ventili, kavitacija u pumpama, klipna oprema, itd. Iznimno velik uticaj na pouzdanost, no nažalost često izostavljeno iz redovitog nadzora stanja. Razloga je mnogo, od tradicionalnog pogleda na kritičnost opreme, manjka ljudi ili prikladne tehnologije, do nedostatka kvalitetne analize i pripreme. Idealan omjer bi bio da je pod nadzorom sve što je financijski opravdano ili prema RPN (Risk Priority Number -Koeficijent rizika) ulazi u kritičnu ili srednje kritičnu opremu.

No, opreme koja zadovoljava jedan od ova dva uvjeta je u prosjeku 80%, dok je u programu nadzora daleko manje. Naravno, govorimo o idealnim situacijama, o nečemu prema čemu treba težiti. Realnost, i sjajan korak prema povećanju pouzdanosti kroz CM (Condition Monitoring - Nadzor Stanja) je prihvaćanje različitosti tehnologija koje omogućavaju brzu „trijazu“ i uključenost većeg broja ljudi, primarno kroz Operator Driven Reliability (Uključenost Operatera u unaprijeđenje Pouzdanosti). Takva tehnologija mora omogućiti efikasnu upotrebu kroz veliki raspon raspoloživih ljudi i njihovih kompetencija i znanja. Jednostavna kada to želite, kompleksna kada je to potrebno. Upravo takvu raznolikost primjene pruža Ultrazvuk.

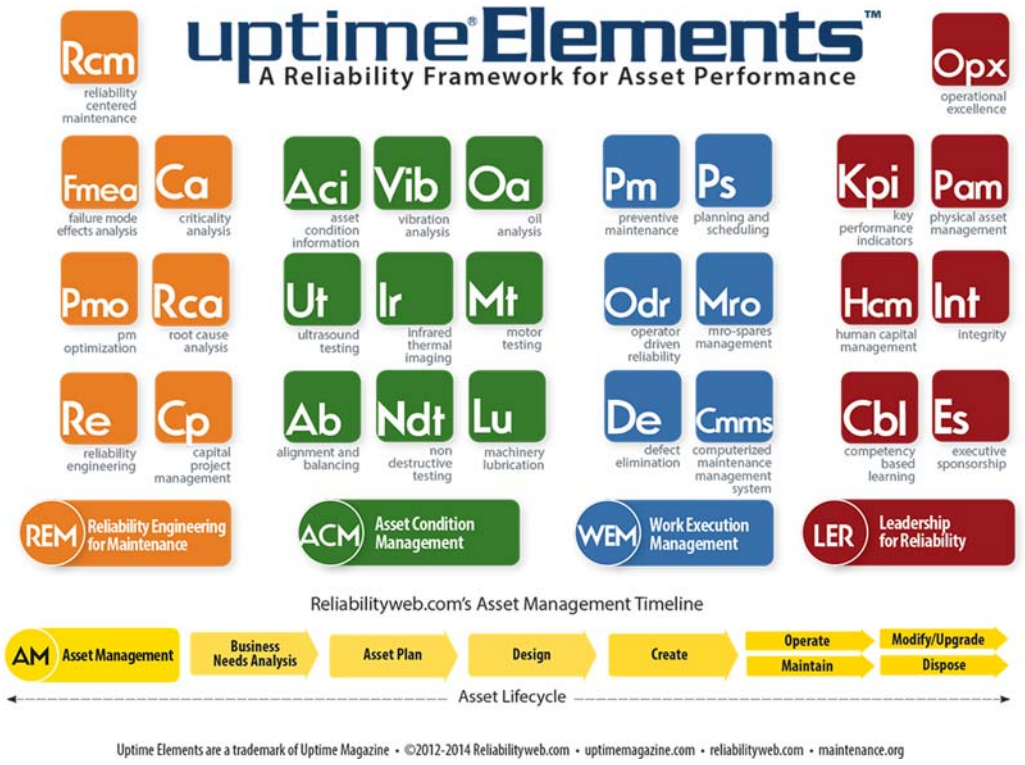
20 years ago we set up priority in having new technologies, wich is absolutely correct, but we forgot that in our work technology is just a toolbox, ment to be used by people.
I will quote one of our colleagues who once was enthusiast, now disappointed: „What training?. Accounting and secretaries have a seminar and conference in Dubrovnik, once a year. Maintenance goes nowhere“.

2. DO ALL PROBLEMS ROTATE? ARE THEY ALL TRENDIBLE? WHAT IS MONITORED AND IS THAT ENOUGH?

I will quote one of our colleagues who once was enthusiast, now disappointed: „What training?. Accounting and secretaries have a seminar and conference in Dubrovnik, once a year. Maintenance goes nowhere“.
Primary focus of Condition Monitoring is usually and exclusively rotating equipment, not entirely justifiably. Hydraulics, pneumatic systems, valves, pump cavitation, reciprocating machinenry .. have the same, huge impact to Reliability, but often left out from Condition Monitoring. There are many reasons for that, from quite traditional view on equipment criticality, shortage of man power or appropriate technology, up to lack of proper analysis and work organisation. Ideal situation would be to include in Condition Monitoring everything that is financial justifiable or is highly or moderately critical regarding its RPN. But, sometimes 80% of the equipment meets criteria, and Condition Monitoring cover much less. Of course, we are talking about ideal situations, about something that we should seek for. Reality, and a great, big step towards Reliability improvement through Condition Monitoring is accepting different technologies that allow fast triage and involvement of larger number of people through Operator Driven Reliability. That technology must perform efficiently tgrough wide range of available operators and their knowledge and competences. Simple when you want it, complex when you need it. That is exactly the versatility we can find in Ultrasound.

3. "RELIABILITY FRAMEWORK" KAO PLATFORMA PROJEKTIMA PODIZANJA POUZDANOSTI.

3. "RELIABILITY FRAMEWORK" – PLATFORM FOR RELIABILITY IMPROVEMENT PROJECTS



***Slika 1**. Uptime elements*
***Figure 1.** Uptime elements*

Uptime Elements Reliability Framework Trade mark, (Specificirana okosnica strukovnih elemenata u unaprijeđenju Pouzdanosti organizacije ReliabilityWeb) već duže vrijeme predstavlja sjajan pregled elemenata potrebnih za uspješno unaprijeđenje pouzdanosti. 29 područja koja imaju apsolutno jednaku važnost i zaokružuju 4 temeljne grupe.

Bitno je i iz ovog pregleda zaključiti već navedeno – u unaprijeđenju pouzdanosti moraju sudjelovati SVI, i to je jedini način koji garantira uspjeh. Pristup je holistički i u svojoj osnovi vrlo jednostavan. 29 „struka" s pripadajućim pravilima i znanjima koja više ili manje nije pretjerano teško steći. No, ono što razlikuje uspješne projekte od neuspješnih je interakcija između sudionika i involviranost. Uspješan Reliability Department (Odjel za unaprijeđenje Pouzdanosti) se sastoji od SVIH zaposlenih, umreženih u strategiju, sa zajedničkim ciljem, sa zadacima koji su prilagođeni kompetencijama. Strategija koja je kreirana u izolaciji od ljudi i kulture rada koji ju trebaju izvršiti je osuđena na propast od samog početka.

„Uptime Elements Reliability Framework" represents great overview and system of elements needed for success Reliability improvement. 29 areas that have equal importance, placed in four fundamental groups.

What is important to understand, and it is visible at first glance is what was mentioned already befor – Reliability improvement involves EVERYONE, and that is the only way to have longlasting success. It is holistic approach and in its basics it shows 29 disciplines with all accompanied knowledge and rules that need to be integrated in one system. What often differentiates successful projects from less successful is interaction between stakeholders and level of involvement. Successful Reliability Department consists of all employees, networked in precise strategy, with mutual goal and tasks distributed according to competences. Strategy created in isolation from the people and work culture that is supposed to execute it is doomed from the very beginning.

Potrebni alati i znanja su s nama odavno; Analiza vibracija od 1950-tih, Termografija od 1920-tih, FMEA (Failure Mode & Effect Analysis – Analiza oblika defekta, njihovih simptoma i efekata na proces) i RCA (Root Cause Analysis – Analiza uzroka) od 1950-tih, Ultrazvuk od 1960-tih, RCM (Reliability Centered Maintenance – Održavanje fokusirano na Pouzdanost) od 1970-tih, CMMS (Computerized Maintenance Management System) od 1960-tih …itd.

Ukratko i realno, ništa novo i nepoznato i već nekoliko generacija ima pristup tim alatima. No, da li je to unaprijedilo Pouzdanost onoliko koliko je moglo i trebalo ? U pravilu ne. Primarni razlog je upravo činjenica da uspješan projekt u fokus stavlja ljude, njihovo vjerovanje u cilj, motiviranost, osjećaj pripadnosti … ali i osjećaj osobnog unaprijeđenja kroz opće unaprijeđenje. Odlučnost i vjerovanje u projekt mora biti preneseno na sve i, koliko god ta usporedba zvučala preslobodno, takav projekt svojim oblikom ima elemente religije. Kao što mnogi fitness, vegetarijanstvo, yogu ili meksičke sapunice shvaćaju gotovo kao oblik religioznog putovanja prema cilju, neshvatljivo je da se takav stav u Pouzdanosti nije stvorio u onome što je kritično za pojedinca, kompaniju i društvo u cjelini; osobni napredak pojedinca, profitabilna kompanija za stabilno društvo, održivi razvoj za čist okoliš. Ideja o projektu mora evoluirati u ideju o načinu i kulturi rada koja traje i razvija se, a kritičan element je inspirirati ljude i dati im adekvatna znanja za sudjelovanje u promjenama.

Ono što osobno vidim kao primarnu prepreku da se to i ostvari je „leadership“ koji često nastupa kao Edward I iza svojih trupa, a premalo kao Leonidas. Predstavljanje 29 elemenata kao specijalističke alate (što realno i jesu) ali ne omogućiti svima da ih prihvate barem u određenoj mjeri je pogrešno, jer se time jasno odvajaju alati od onih kojima bi oni trebali služiti. Apstrahiranje vodi u nezainteresiranost i nesudjelovanje i ima dalekosežne posljedice. Pogledajmo malo manje znanstveno a malo više ljudski i osobno Uptime Elements i pouzdanost uopće. Nije li cijela ta disciplina nastala kao sistematiziran pristup onome što gotovo svi primjenjujemo u svojim domovima i svakodnevnom životu? FMEA i RCA su usađeni u naše svakodnevno ponašanje, Condition Monitoring također, KPI (Key Performance Indicators – Indikatori uspješnosti provodjenja aktivnosti) koristimo apsolutno svakodnevno iako ih tako ne nazivamo … itd.

Most of the tools have been with us for quite some time; Vibration Analysis since 50´s, Infrared Thermography since 20´s, FMEA and RCA since 50´s, Ultrasound since 60´s, RCM since 70´s, CMMS since 60´s .. and so on.

In short words and realistic, nothing so new and unknown, and many generations had access to this tools. Did it really improve Reliability as much as it could have or should have ? Basicaly not. Primary reason might be the fact that successful improvement focuses on people, their belief in mutual goal, motivation, sense of belonging .. but also a perception of personal progress through success of the project. Determination and belief in the project needs to be transferred to all included and, however this might sound strange, project needs to have some elements of religion. Considering that many people take workout, fitness, vegetarianism, yoga or mexican soap operas as a kind of religious journey towards the goal, it is hard to understand that this kind of attitude was not generated in Reliability, in something so critical for each individual, for company and for sociaty in general; personal progress, profitable company for stable society, sustainable progress for clean enviroment. Idea about the project must evolve to idea about way and culture of work that lasts and develops, and critical element is to inspire people and giving them knowledge and tools necessary to be involved in changes.

What I personally see as a first obstacle to make it happen is leadership that often marches behind the troops as Edward I, while it should be marching in front of them, more like Leonidas. Presenting all 29 elements as only specialistic tools (what they really are), but not bringing them closer to everyone to use them at certain level is wrong, because it strictly divides tool from those who should use them or those who have a chance to bring benefit by using them to at least certain extent. Dividing leads to disinterest and non-involvement and it has long lasting consequences. Let us look at all Reliability issue a little bit less professional, and a bit more himan end personal. Doesn´t this discipline look like a sustemized approach to what we all do in our personal life, in our family, our homes? FMEA and RCA are deeply implanted in our behaviour and life, Asset Condition Monitoring even more, KPI-s are use daily even we do not call them that way…

Shvatimo li ih tako, i budu li tako prezentirani svima, postiže se uključenost svih, na određenom nivou. Apstrahiranje izaziva strah od nepoznatog i nerazumljivog i čini neophodne alate rezerviranima za „elitu“. Raditi više ima svoje limite, no raditi pametnije nema. Smatrao bih uspjehom kada bi se svaki lider upitao o psihološkom stanju svojih uposlenih, njihovom obiteljskom životu, entuzijazmu i u srednjoj životnoj dobi.

Nekoliko globalnih kompanija je radilo istraživanje o stopi razvoda njihovih zaposlenika i usporedili su to s njihovom efikasnošću, istraživanje je obuhvatilo sve, od podmazivača do generalnog managera. Rezultat je zanimljiv, no prije svega je zanimljivo što se to netko uopće upitao. Nameće se zaključak da ključ uspjeha leži u „leadership-u“. *„Leadership je umjetnost služenja drugima, pružajući im znanje, alate i ljude kao i svoje vlastito vrijeme, energiju i emocionalnu inteligenciju kako bi oni ispunili svoj puni potencijal, kako osobni, tako i profesionalni“- Daphne Mallory, , kolumnistica* ***Entrepreneur Magazine časopisa***
Mislim da bi ovu definiciju trebalo kao mantru povezati s unaprijeđenjem Pouzdanosti.

Presenting Reliability tools to literally everyone in a way they can recognize the beauty, and actually recognize themselves in it will bring us absolute involment, transforming brakes to motors. Isolating generates fear of unknown and complex making necessary tools reserved exclusively for the „elite“. Working more has its limits, but working smart doesn´t. I would consider a great success if every leader would ask himself about psychological state of his employees, their personal life, family, their enthusiasm even in the autumn of their working life.
Several companies did a research on divorce rate of their employees and compared it to their efficiency and progress, covering all from grease guy to CEO. Results are more than interesting, but the most important thing is that someone actually wanted to know that in a first place. So, however we look at it, the keys of success are in leader´s pocket, and leader is as good as leaders he created. *“Leadership is the art of serving others by equipping them with training, tools and people as well as your time, energy and emotional intelligence so that they can realize their full potential, both personally and professionally.” according to Daphne Mallory.*
Make 100 people be 1% better, and it will make you be 100% better.. according to my humble self. Attitudes like „that´s not my job“ need to be part of the history.

4. ULTRAZVUK (ULTRAZVUČNA EMISIJA); PREGLED APLIKACIJA KROZ “RELIABILITY FRAMEWORK”

Ultrazvuk, po samoj prirodi tehnologije, nalazi svoje mjesto u velikom broju Uptime Elemenata. Od jasno utemeljene uloge u nadzoru stanja, preko ODR do ljudskih potencijala i ostalih elemenata. Pojednostavljeno, razlozi su vrlo jasni; pokrivanje velikog broja aplikacija, rano otkrivanje anomalija, mogućnost upotrebe od vozača kamiona do dijagnostičara, mogućnost vrlo brze obuke za vrlo vrijedne zadatke te odličan uticaj na promjenu kulture rada. Popis aplikacija je vrlo dugačak, te ću nabrojati samo neke od njih; rotaciona oprema, podmazivanje prema realnom stanju, kavitacija u pumpama, izmjenjivači topline, hidraulični sistemi, pneumatski sistemi, električne instalacije, propuštanje instalacija pod pritiskom, parni sistemi … Lista je impresivna i omogućava iznimno veliku primjenu u svim industrijama.

4. ULTRASOUND (ULTRASONIC EMISSION); OVERVIEW OF THE APPLICATIONS ACROSS THE “RELIABILITY FRAMEWORK”

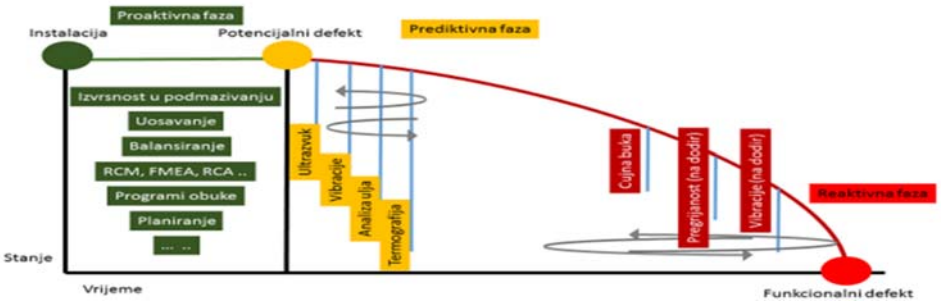
Ultrasound, by very nature of technology is involved all across the Uptime Elemenats. From clear and highly important role in Asset Condition Monitoring, through ODR, to Human Capital Management … and many others. To make it simple, reasons are very clear; Ultrasound covers waste number of applications, brings early detection of anomalies, involves everyone from specialistic diagnostic team to truck drivers, can be used for some simple but very valuable tasks even with very brief training, and it has tremendous impact to change of culture by involving many. List of applications is very long, but some of the most known are found in rotational machinery, on-condition lubrication, cavitation in pumps and valves, heat exchangers, hydraulic, pneumatics, electrical, leaks, steam systems … List is impressive and brings Ultrasound to every corner of the process in every industry.

5. ULTRAZVUK U NADZORU; RANO OTKRIVANJE ANOMALIJA, ODR, POVEĆANJE POKRIVENOSTI NADZOROM.

Ultrazvuk nudi izuzetno vrijedan kvalitativni pomak u nadzoru stanja kroz rano otkrivanje anomalija. Ovakav pristup otvara daleko veci P-F interval (krivulja razvoja od Potencijalnog do Funkcionalnog defekta), što je ključno u kvalitetnom pristupu održavanju, ali i u povećanju pouzdanosti. Ipak, važno je naglasiti da se oprema ne ponaša uvijek onako kako teoretske analize o učestalosti i progresiji defekta govore.

5. ULTRASOUND IN ACM; EARLY DEFECT DETECTION, ODR, INCREASE IN COVERAGE

Ultrasound offers a huge qualitative improvement in ACM through early detection of anomalies. This approach opens up a wider P-F interval, giving more time to maintainers and improving Reliability. Still, it is important to understand that machinery does not always behave the way different curves ssuggest. Having usefull information just in time is a must.



Slika 2. *Primjer jedne od P-F krivulja, vjerojatnost razvoja/detektibilnost*

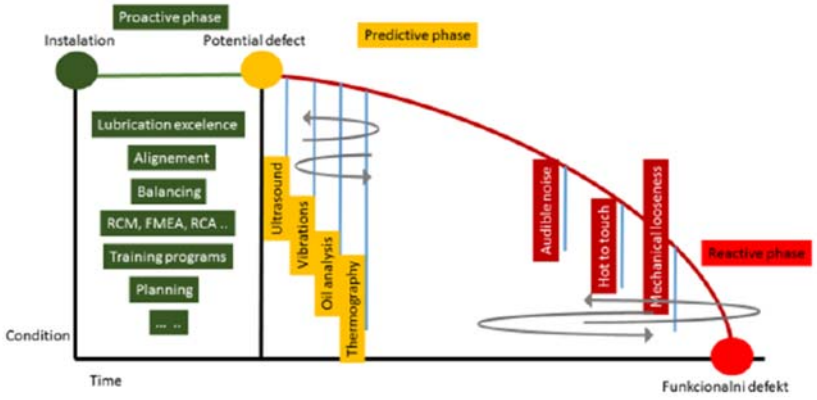


Figure 2. *An example of one of the P-F curve, the likelihood of developing / detectability*

U slučaju kotrljajućih ležajeva, visokofrekventni, random impakti koji karakteriziraju ranu fazu defekta se najranije i najpouzdanije otkrivaju upravo Ultrazvukom. U slučaju prenosa, situacija je gotovo ista. Kavitacija u pumpama, propuštanje ventila, stanje podmazanosti, električne instalacije.. Ultrazvuk je generiran *trenjem, impactom, turbulencijom i ionizacijom*, što otvara iznimne mogućnosti nadzora kroz praćenje promjena u Ultrazvučnoj emisiji.

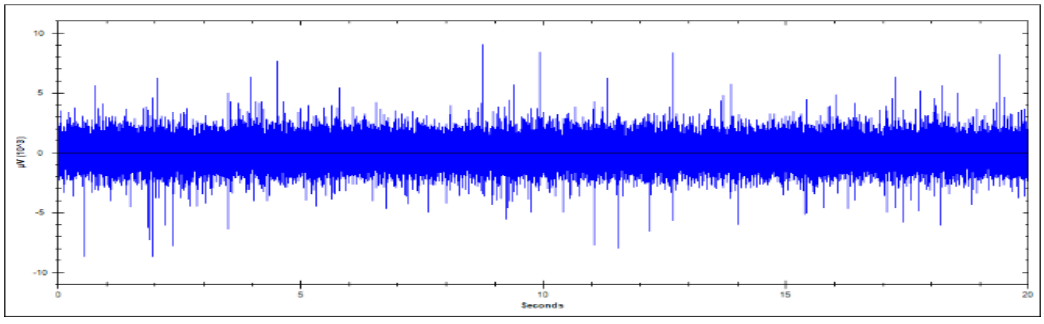
In case or rolling elements bearings, high frequency, random impacts are characteristic of early stage of defect, and can be easily detected by Ultrasound. In case of gearboxes as well. Pump and valves cavitation, passing or blocked valves, lubrication, electrical equipment .. both improvement of detectability and improvement of inspector´s safety. Ultrasound is generated by Friction, Impacts and Turbulence and we always need to come back to that fact, not leaving it behind as something trivial.

Gledajući pomno FMEA, upravo promjene vezane uz ova četiri fenomena nam u većini slučajeva govore iznimno mnogo. Današnji sofisticirani Ultrazvučni uređaji nude velike mogućnosti; kroz osnovne indikatore idealne za trendiranje i alarmiranje, te kroz mogućnost dublje analize dinamičkog signala, ali i kroz mogućnost „live“ donošenja zaključaka u određenim aplikacijama.

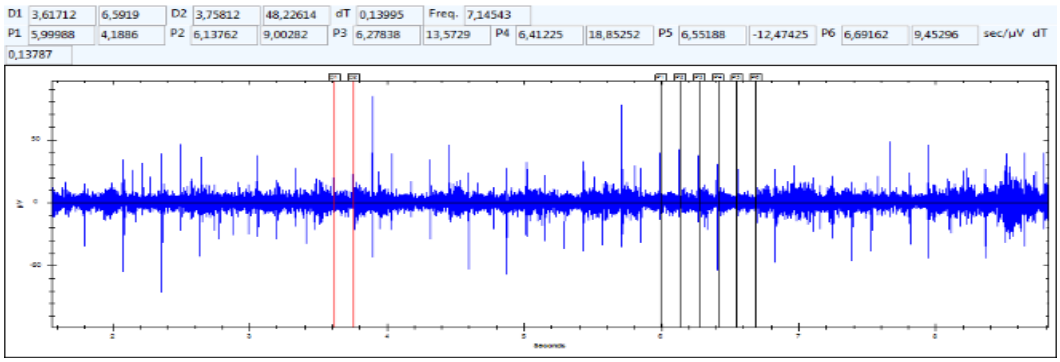
Uz „prvu liniju obrane“ u procesu Condition Monitoringa, Ultrazvuk otvara iznimno velike mogućnosti u području ODR-a (Operator Driven Reliability) koji je u pravilu lakmus papir za kvalitetnu implementaciju unaprijeđenja Pouzdanosti. Kroz ODR se vrlo brzo može vidjeti koliko je uspješno kreirana atmosfera sudjelovanja svih, ka zajedničkom cilju. Takodjer, ODR, primijenjen na pravi način, efikasno i brzo mijenja navike i kulturu rada nabolje. Uzevši u obzir široko područje primjene Ultrazvuka, vrlo kratka i pouzdana mjerenja i mogućnost da neka od njih vrše i manje specijalizirano osoblje, bitno se podiže pokrivenost opreme nadzorom. Pod pojmom „prva linija obrane“, korisnici Ultrazvuka često podrazumijevaju „trijazu“; preglede opreme u potrazi za indikacijom na koju će se fokusirati specijalisti koristeći sve raspolozive metode. Ovdje je takodjer važno naglasiti da je nadzor stanja multidisciplinarni proces u kojemu ne postoji bolja ili lošija metoda, već samo oni koji su bolje ili lošije shvatili imperativ da sve raspoložive metode rade nadopunjujući jedna drugu. Kao potvrdu komplementarnosti metoda možemo posebice navesti opremu niskih okretnih brzina, gdje je Ultrazvuk nezamijenjiv kao alat.

Forgeting simple, basic things makes complex one a mistery. Looking carefully at you FMEA, changes connected to those three phenomenas are giving us priceless information. Modern, sophisticated Ultrasound devices are offering great possibilities; condition indicators ideal for trending, comparing and setting alarms, deep analysis of dynamic signal, but also ability to make „live“ decisions on spot, in certain applications, keeping it simple when it needs to be simple and fast.

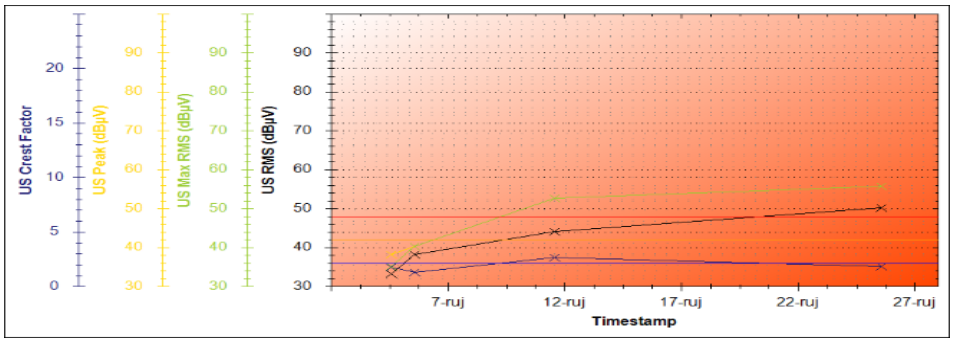
Besides having a role of „first line of defense“, Ultrasound opens a large opportunities in Operator Driven Reliability area that actually represents a litmus paper of implementation quality of many programs. ODR, in a matter of weeks, shows how successfully is the atmosphere of changes and involvement created. ODR, if implemented properly, changes bad habits and work culture rapidly, for better. Considering wide area of applications, short duration and reliable measurement process, as well as a possibility that they can be done by personal with some basic training, coverage increases considerably. By „first line of defense“ Ultrasound users often consider triage; inspections in search of indications that will focus specialists exactly where their valuable time needs to be spent, using Ultrasound deeply, but all other available methods as well. It cannot be emphasized enough that Asset Condition Monitoring is a multidisciplinary activity where there is no better or worse method, only people who understand their proper use or not. Different methods are not competing each other, but improving each other.



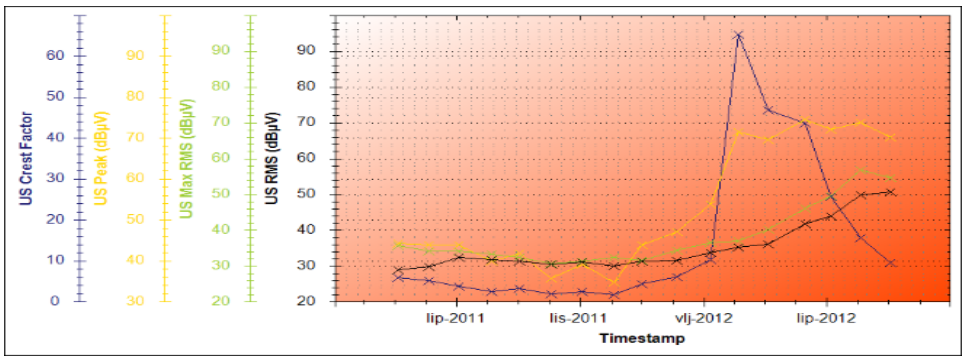
Slika 3. *Rana faza promjena u ležaju*
Figure 3. *Early phase changes in the bearing*



Slika 4. *Definiran defekt, kroz repetitivne impakte*
Figure 4. *Defined defect, through repetitive impactor*



Slika 5. *Aktiviran alarm, promjena vezana uz povećano trenje*
Figure 5. *Activated alarm, changes related to increased friction*



Slika 6. *Praćenje sva 4 indikatora do ispada*
Figure 6. *Monitoring all 4 indicators to failure*

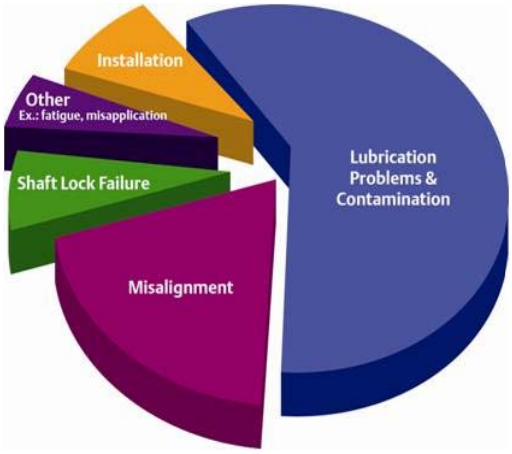
6. PODMAZIVANJE PREMA REALNOM STANJU; POTREBA, PRIMJENA I REZULTATI

Podmazivanje predstavlja ključni element koji osigurava adekvatan rad opreme. Iako je ova činjenica neupitna i deklarativno je podmazivanje istaknuto kao ključno, u praksi je to potpuno obrnuto. Podmazivanje je posao koji se često radi daleko ispod nivoa koji je potreban. Rezultati su, nažalost, vrlo porazni, ali i zanemareni jer su postali uobičajeni.

6. ON-CONDITION LUBRICATION; WHY AND HOW

Importance of lubrication does not need to be mentioned. It is known well, and declaratively mentioned as a top priority many times. On the other side, practice, it looks completely different. Declaratively most important job is actualy being done „by the way“. Results are devastating both for company and people, but not considered alarming because they became „normal“ over the years.

Gotovo 60% ispada je uzrokovano problemima s podmazivanjem i kontaminacijom, što nije podatak koji je nov ili nepoznat. No, taj postotak je već dugo s nama i ne pokazuje tendenciju pada, jer nije došlo do promjene prakse koja takve rezultate uzrokuje. Ipak, ovakva distribucija uzročnika ispada će se shvatiti i kao dobra vijest, uzevši u obzir da se promjenom prakse u samo jednom segmentu može postići izniman napredak u Pouzdanosti.



Nerijetko je podmazivanje organizirano koristeći moto: „tako smo to radili oduvijek“, te su tako pristupi podmazivanju prema *„osjećaju“*, *„dok mast ne izađe na drugu stranu“* ili tablice definiranog intervala podmazivanja kao jedini kriterij. Alternativa ovom pristupu je podmazivanje prema realnom stanju, „On Condition Lubrication“. Ovakav je pristup utemeljen na osnovama ovisnosti stanja podmazanosti o viskozitetu, opterećenju i brzini, ali i mnogim drugim faktorima koje je često nemoguće pretpostaviti.

Uzevši u obzir Stribeck-ovu krivulju, jasno je da je područje stanja optimalne podmazanosti iznimno usko, te da sve promjene uvijek i jedino povećavaju trenje. Dok prva dva pristupa zaista ne pripadaju sadašnjosti, postavlja se pitanje i da li su vremenske tablice dovoljne, ukoliko uzmemo u obzir da su rezultat izračuna na osnovu pretpostavljenih zadanih parametara, koji se u praksi gotovo redovito mijenjaju. Uloga Ultrazvuka u ovoj aplikaciji je bazirana na činjenici da Ultrazvuk detektira i evaluira trenje i impact, što ovu tehnologiju stavlja u ključnu poziciju primarnog alata u podmazivanju. Upotrebom Ultrazvuka, primarni zadatak tima podmazivača je mjerenje, definiranje potrebe za podmazivanjem te podmazivanje uz „live“ mjerenje kako bi se odredila idealna količina.

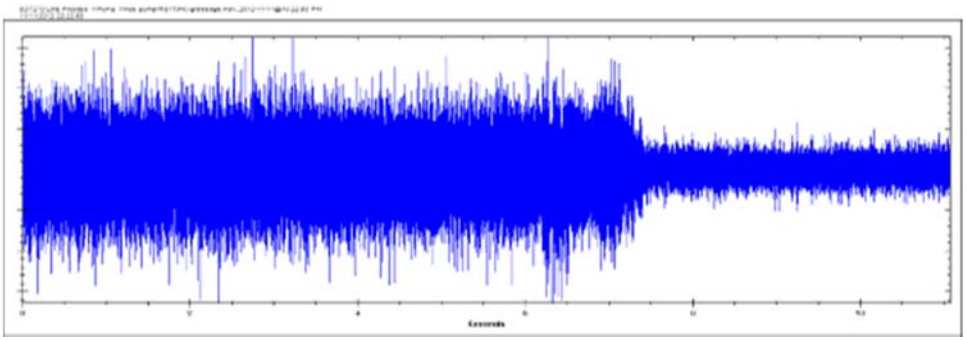
Almost 60% of the failures are caused by lubrication and contamination of lubricant, data that is not new nor unknown. But, that percentage has been with us for quite some time and is not showing any tendency to decrease, as no practice that caused has been changed. Still, there is a very optimistic side of this distribution of causes; radical change in on, just one area of our activities can actualy bring tremendous improvement in Reliability.

Lubrication is often organized according to someone´s „feeling“, „until the grease goes out on the other side“ or using time tables as one exclusive criteria. There is a different way, proven to be better. On Condition Lubrication. This approach is considering fundamentals of level of friction and factors that influnce it; speed, load, viscosity but also factors that we can not include in theoretical calculations to determine a time interval and quantity.

Considering Stribeck curve, it is clear that there is a small window, area of friction level were we would like our machinery to be, and all changes of other parameters always and only increase friction. While first two mentioned „strategies“ simply belong to history, we need to ask ourselves if time tables are enough to be trusted without any audit or adjustment, considering that parameters used to create them often and constantly change, even if the time calculation was done properly. Role of Ultrasound in this application is based on a fact that Ultrasound devices detect and evaluate friction and impact, and it is positioned in a center of lubrication strategy and used as a perfect tool to perform Acoustic Lubrication. Using Ultrasound, primary task is to measure and evaluate in order to determine weather lubrication is needed or not, and if it is .. how much, using Ultrasound „live“.

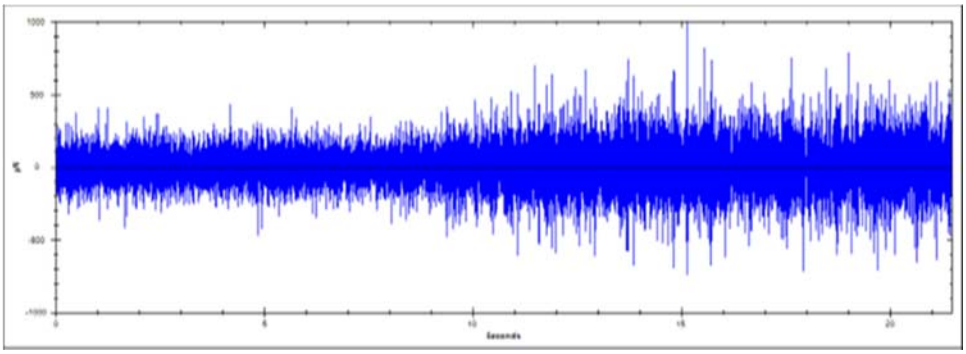
Primjer mjerenja tokom podmazivanja na dva ležaja na istom motoru. Predefinirani režim podmazivanja je sugerirao jednaku količinu maziva u oba ležaja, u istom vremenskom intervalu.
DE ležaj je trebao podmazivanje, no svega trećinu od sugerirane količine. Trenje je smanjeno na minimum.

Example of recording during the lubrication procedure on two bearings on a same shaft. Predefined lubrication regime suggested the same quantity of lubricant, same periodicly.
DE bearing needed grease, but only third of suggested quantity. Friction at the minimum level.



NDE ležaj je već bio prepodmazan. Dodatno apliciranje maziva je povećalo trenje. Aplicirana je svega trećina sugerirane količine, trenje je bitno povećano.

NDE bearing was already overlubricated. Additional grease increased friction. Only one third of suggested quantity was applied.



„On condition lubrication“ uz Ultrazvuk je već etabliran pristup koji donosi izuzetno vrijedne rezultate. Prije svega kroz povećanje Pouzdanosti, eliminirajući one defekte koji svoj korijen imaju u neadekvatnom podmazivanju, ali i produzujući eksploatacijski vijek opreme. Uz to, utrošak maziva u pravilu bitno opada, što donosi dodatni financijski učinak. Tim podmazivača uz vrlo kratak trening prolazi kroz velike promjene i postaje izuzetno bitan faktor, temeljen na znanju i tehnologiji. Uz to, obavljajući svoj posao, tim podmazivača osigurava veliki broj redovnih mjerenja potrebnih za Condition Monitoring.

On-condition lubrication using Ultrasound is well established approach that brings valuable results. Primarily, through increased Reliability, by eliminating those defects caused by improper lubrication, decreasing downtime and increasing operating lifetime of assets. Besides that, most often there is a significant decrease of lubricant consumption, bringing additional financial benefit. Lubrication team, after a training and havin a proper technology, becomes a key factor, performing a job based on data and qualified decisions. Besides that, through their daily practice they provide significant quantity of measurements needed for Condition Monitoring. From doing this highly important job „by the way“, to top performance lube team is not a long journey

7. ENERGETSKI ASPEKT, POVEĆANJE POUZDANOSTI TE SIGURNOSNI ASPEKT PRIMJENE ULTRAZVUKA

Kroz tri svakodnevne i sveprisutne aplikacije, prikazat ćemo unaprijeđenja koja upotreba Ultrazvuka donosi.

7.1. Komprimirani zrak (gubici kroz propuštanja) i parni sustav (propuštanja i „ kondenz lonci" – korišteni vlastiti podaci) su gotovo temeljne i najjednostavnije aplikacije Ultrazvuka. Dok je obuka operatera i kvalitetna implementacija programa rada brza i jednostavna, financijski učinci su iznimno veliki. Iako svijest o magnitudi gubitaka ne postoji u onoj mjeri u kojoj je potrebno, sve je više kvalitetnih primjera onih koji su ovakvim pristupom ostvarili izuzetno velike uštede. Prema prosjecima, neinspektirani sistemi komprimiranog zraka gube i do 35%. Na primjeru dva korisnika iz naše regije, gubici od 30% su svedeni na operativne gubitke ne veće od 3%, investicija je isplaćena u 2-4 mjeseca, te su uštede dosegle iznose u jednom slučaju prezentirane na vrlo zanimljiv način; „ *Ukupne mjesečne uštede su dosegle iznos dovoljan za zapošljavanje dva inženjera u odjelu održavanja, sa svim uključenim troškovima*" . Ova rečenica odražava mnogo toga što je u samim temeljima Pouzdanosti. Financijska odgovornost za uštede, socijalna odgovornost za društvo u cjelini, te briga za okoliš.

7.2. Redovit nadzor ležajeva niskih okretnih brzina te implementacija podmazivanja prema realnom stanju (korišteni vlastiti podaci) u prvoj fazi, te uključivanje i ostale opreme u proces nadzora u drugoj fazi, doveli su do smanjenja direktno vezanih troškova za 30%. Povećanje eksploatacijskog perioda i Uptime (vrijeme raspoloživosti opreme i kapaciteta) su donijeli iznimno veliku korist. Uz to, postignuta je evidentirana ušteda od prosječnih 1,5% u potrošnji električne energije nakon uvođenja podmazivanja prema stanju na elektromotorima. Projekt nije zahtijevao novo zapošljavanje, niti je rezultirao povećanim brojem radnih sati.

7.3. Uvođenje Ultrazvučnih ispitivanja u inspekcije električnih instalacija donosi unaprijeđenje u dva kritična aspekta; sigurnost inspektora i povećanje detektibilnosti. Ultrazvuk omogućava ispitivanje s većih udaljenosti i primarno ispitivanje bez otvaranja panela, što uvelike povećava sigurnost i velikim dijelom eliminira opasnost od stradanja zbog Arc Flash i Arc Blast (explozivne visokorizične pojave uzrokovane električnim lukom).

7. ENERGY SAVING, RELIABILITY INCREASE AND INCREASED SAFETY THROUGH ULTRASOUND IMPLEMENTATION

Through three usual applications of Ultrasound, we can show the benefits it brings.

7.1.Compressed air (leaks) and steam system (steam traps and steam leaks) are most common and widely present applications of Ultrasound. Operator´s training and program implementation are very fast and financial results are rapid and huge. Even though the understanding of magnitude of loses is not at the level it should be, we have more and and more examples of success in our region, and results and savings they achieved. According to international averages. Uninspected systems leak up to 35%. Two examples of users in our region are showing that loses were cut downt to 3-5% and investment returned in 2-4 months including both conpressed air and steam systems. In one of the cases, savings were presented in a very interesting way; „ Total savings reach the amount sufficient to employ two engineers in maintenance department, all expenses included". This sentence really describes another aspect of Reliability – social responsibility and impact of each company to society in general.

7.2. Regular monitoring of low speed bearings and On-Condition lubrication implementation as a first stage and including other equipment in ACM in later stages, decreased costs by 30%. Increase of equipment lifecycle and Uptime were significant. Also, 1.5% savings in energy were achieved after introducing on-condition lubrication on electric motors. Project didn´t require new employees, or additional working hours.

7.3. Implementation of Ultrasound inspection in electrical equipment brings improvement in two critical areas; inspector safety and increased detectability. Modern Ultrasound devices allow inspector to perform inspections from the safe distance or behind closed door. Dramatically increasing safety and reducing a risk from Arc Flash and Arc Blast injury or fatality.

5. ZAKLJUČAK

Nedovoljno omasovljena primjena raspoloživih znanja i tehnologija u održavanju neminovno uzrokuje gubitke i pad konkurentnosti kompanija. Čvrsta implementacija programa podizanja Pouzdanosti je nužnost, kroz sve elemente i uz uključenost svih. Nadzor stanja, kao bitan segment Pouzdanosti može igrati ključnu ulogu ukoliko se poveča uključenost zaposlenih i pokrivenost opreme i imovine nadzorom. Ultrazvuk nudi jedno od rješenja kroz angažman u vrlo velikom broju aplikacija te mogućnost uključivanja zaposlenih na svim razinama edukacije.

6. CONCLUSION

Insufficient involvement and use of technology and knowledge on all levels causes huge damage, loses and lack of competitiveness. Reliability improvement is a must, through all elements and with everyone involved. Asset Condition Monitoring, as a critically important element, plays huge role. Ultrasound is important part of solution, through waste number of applications and involvement of all levels of employees, at different levels of skills and education.

7. REFERENCES

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