# Improving Performance Reliability of a Mechanical System for a Water Treatment Unit in a Thermal Power Plant by Pro-Active Maintenance Approach Adoption

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**Abstract**

The research attempts to an active pursuing of ( pro – active maintenance approach ) as a recent and advanced maintenance methodology , entering in matching between concept practical and design considerations of that approach. The paper encompasses particular emphasis on some dynamic mechanical non- metallic elements in the chain subsystem of traveling band screen in suspended solids removal unit of raw water treatment system in a thermal power plant as an applied case in practice. Improved new designs of those elements had been accomplished. Also, the present work includes an analysis and assessment of those elements performance according to what had been selected as a manufacturing engineered material due to design point of view. Design updating and improvements conducted on the existing parts which were driven by pro–active maintenance approach fulfill the requirements for the application under study, significantly result in enhancing quality of those elements and components involved and upgrading performance reliability of the system dealt with by an added ratio of about 45%. Pursuing of such an approach adopted herein proves that it can be a more effective tool contributes to enrich working life of the system implemented for.

**Keywords:** Pro-active Maintenance , Mechanical System ,Quality , Performance and Water Treatment Unit.

# تحسين معوّلية أداء منظومة ميكانيكية لوحدة معالجة مياه في محطة توليد قدرة حرارية باعتماد أسلوب الصيانة الإستباقية

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**الخلاصة**

يسعى البحث نحو انتهاج فاعل لأسلوب من أساليب الصيانة الحديثة والمتقدمة وهو (الصيانة الإستباقية) ، والولوج في المواءمة بين اعتباراته التطبيقية والتصميمية واستيحاء ما ينطوي عليه مفهومه. يتناول البحث منظومة ميكانيكية فرعية لنقل الحركة بالسلسلة تنتظم فيها مشبكات حُزمية متحركة لوحدة إزالة العوالق في منظومة معالجة الماء الخام لمحطة توليد قدرة حرارية من خلال تركيزٍ على بعض العناصر الميكانيكية الحركية غير المعدنية فيها عبر دراسة حالة تطبيقية. تم انجاز تصاميم محسّنة جديدة لتلك العناصر والأجزاء الميكانيكية. كما انطوى البحث على تحليل وتقييم أداء تلك العناصر في ضوء ما تم اختياره تصميمياً من مادة هندسية لتصنيعها. ولقد حقق تحديث التصميم والتحسينات المجراة على الأجزاء الموجودة والتي ساقها أسلوب الصيانة الإستباقية متطلبات التطبيق قيد البحث ، كما أثمر عن ترصين نوعية تلك العناصر والمكوّنات التي تضمنها البحث والارتقاء بمعوّلية أداء المنظومة التي تم التعاطي معها بنسبة مضافة تقرب من 45% . برهن اعتماد مثل ذلك الأسلوب التي تبنّاه البحث على أنه يمكن أن يكون وسيلة أكبر تأثيراً ترفد في إثراء العمر التشغيلي للمنظومة التي يتم تطبيقه لها.

**الكلمات المفتاحية** : الصيانة الإستباقية ، منظومة ميكانيكية ، الجودة و الأداء و وحدة معالجة مياه.

## Introduction

Maintenance Engineering of plants, systems and infrastructures is multidisciplinary in nature , cutting across many disciplines of science and arts. The field of maintenance engineering is changing as rapidly as any other field . One of the main areas of those changes is the growing expectations of maintenance function . The maintenance profession , in general, underwent a transformation from almost dependence on time – directed tasking ( preventive or planned maintenance ) to much more condition – directed tasking . At the present time many sectors are still performing maintenance on machines and equipments in a reactive manner , and that assures the necessity for a better understanding about machinery and equipments performance behaviour .

It is significant to develop the professionalism and practice for maintenance , replacement and design changes related to those elements ( parts ) , components and subsystems in the plants ( units or systems ) of several applications and sectors . In a world of competitive climate , the desire and need to reduce operating costs and improve quality have brought with them a need to focus on developing more efficient and effective maintenance techniques . It is of a great importance to pursue a maintenance approach that has been proven to work in one of the most demanding environments of the world today .

Maintenance as a reliability function has a significant impact on system ( or plant ) availability and reliability .

Reliability identifies propensity for failure of a component ( part ) . It is an important need to deepen the understanding of pro-active maintenance (PAM) approach as a recent and advanced maintenance method , and to empower the maintenance and reliability community to perform PAM practices . Those practices and implementations allow prospering in today world of increasing performance with less recourses and different technical and management challenges within the economic implications involved .

In the maintenance and reliability filed , professionals are constantly challenged to implement the best way to ensure equipment or machine is available as and when it is needed at a reasonable cost (Gulati and Smith, 2009) . Several plants had implemented wide life style change to push the limits of maintenance into a new realm of reliability. The following strategic considerations play the most important and vital role for a reliable plant that a reliable future might start with . They strategically provide the tools and solutions for building a rock-solid and ironclad foundation for the future of the plant .Those considerations are: synopsizing, reliability, lubrication, safety , energy and sustainability (Noria Corp., 2010).

The present work attempts to center its attention to the necessity for adopting and an active pursuing of PAM approach by the maintenance departments in the services, utility, infrastructure and industrial sectors .

## Some Considerations for Pro-Active Maintenance Approach

The cost – saving trend throughout the world is towards a maintenance program that targets the root causes of machine wear and failure , and also by establishing a pro-active line of defense against machines and equipments damage. Advanced and recent maintenance approaches target the warning signs of impending failure and the recognition of small failures that begin the chain reaction that leads to big failure (i.e. , damage control ) .

Condition –based monitoring of the machines and equipment has created the birth of the invisible wrench (Trodd and Western, 2005).

It is preferable for maintenance to refocus its efforts on condition monitoring activities during normal operation to uncover those defects or

deficiencies requiring action . While production wants to reduce downtime and increase production , maintenance wants to take that one step further . Its advanced maintenance technique encompasses re-functioning pro-actively. By routinely monitoring the machines and equipments of the system dealt with so when testing shows something awry , downtime can be scheduled and supplies ordered in-time , before failure occurs .

Pro-active maintenance (PAM) is the maintenance performed to head off failure and breakdown . While correcting machines and equipments failures efficiently and effectively is important , anticipating and heading off failures is also a major part of the maintenance management tool box ( Plamer , 2006 ) .

PAM approach supplants the maintenance philosophy of " failure reactive" with " failure pro-active " by avoiding the underlying conditions that lead to machine faults and degradation . PAM is the discipline that takes a micro view on machine or equipment damage – concentrating on the causes instead of symptoms of wear . It is quickly being recognized worldwide as a more important method of achieving savings unsurpassed by conventional maintenance techniques (The Plant Maintenance Resource Center, 2005) .

While the root causes of failure are many , or at least presumed to be , it is generally accepted that 10% of the causes of failure are responsible for 90% of the occurrences . Most often , the symptoms of failure mask the root causes or they are presumed themselves to be the cause ( Fitch , 2005 ) . PAM is an important means to cure failure root causes and extend machine life .

PAM (or prevention based maintenance) programs utilize predictive , preventive maintenance techniques with root cause failure analysis to detect and pinpoint the precise problems combined with advanced installation and repair techniques including potential equipment redesign or modification to avoid or eliminate problem from occurring (TWI Press , 2000) .

The advantage of PAM over other maintenance approaches is ability to pinpoint and eliminate a problem before any symptoms occur in the machine and that would save money and keep the machine out of the overhaul in the long run . PAM commissions corrective actions aimed at the sources of failure (failure root causes , not just symptoms). It is designed (and that is its central theme) to extend the life of machinery as opposed to : (1) making repairs when often nothing is broken (2) accommodating failure as routine and normal , and / or (3) preempting crises failure maintenance in favor of scheduled failure maintenance (The Plant Maintenance Resource Center, 2005) , ( Fitch , 2005 ) .

**Implementing Pro-Active Maintenance Approach**

The approach of the evolving concept of PAM could have particular relevance to systems and utilities in power plants. The present work attains an attempt to implement PAM approach through particular emphasis on some dynamic mechanical non – metallic elements in the chain subsystem of traveling band screen (TBS) (see Fig.(1)) in suspended solids removal unit (SSRU) of raw water treatment system (RWTS) in a thermal power plant of an available capacity within about 600MW as an applied case in practice.

The traveling (moving) water band screen (TBS) at the surface water intake has fine screens so that suspended solid particles, foreign bodies, and accumulated debris in the water are removed by filtering through screens and carried away from the flow. The SSRU is one of the parts of the treatment system of raw water for make up and boiler feed water in the thermal power plant.

The PAM approach applied in this paper is characterized by comprehending the contents of the mechanical design regards associated with the

maintenance function aspects , and by pursuing a process for continual improvement (ISO 9004 , 2000) as shown in Fig.(2).

Some adjusting procedures, primary routine maintenance, and sometimes replacements of those elements by other manufactured elements had been conducted previously and before proceeding the present work, but those actions don't prove reliability in the performance of those elements. This can be deduced from several faults, troubles, shutdowns and replacements that had been happened in the system causing major problems that could not be corrected with regular in–service actions. Performance is a dimension of quality that refers to the efficiency in which a part or an element performs its intended purpose (Foster , 2001) . Unsatisfactory functional performance represents a sign of asset failure ( Ben-Daya and Duffuaa , 1995). A lack of accurate and dependable historical data about those events had been pointed out and that represents one of the main limiting factors in applying PAM approach. Downtime prompts upgrading of those elements for enhancing performance.

The non-metallic mechanical elements in the chain subsystem dealt with in the present work are:

1. Guide piece (for centering and fixing TBS), Fig.(3) .
2. Main chain roller, Fig.(4) .
3. Intermediate piece (for fixing), Fig.(5).

The mechanical elements that can be monitored firstly by external inspection are limited only by access; any problems need to be deduced from the observations made.

An active pursuing of (SAQCEADS) (Site Applications of Quality Characteristics Evaluation And Design Standardization) approach (Mustafa , 2009) had been performed in the implementing of PAM approach adopted in the present work .

The work depends upon visual inspection of the above mentioned mechanical elements, in addition to what had been facilitated to carry out some tests for the sake of assessment of the worn parts of those elements. That might be considered an entry as a primary approach to wear debris analysis.

**Results and Discussion**

An analysis which is one of the maintenance performance measures (metrics) had been made by analyzing number of failures per period per category of the system under study in the present work. Those failures are due to: defects of the above mentioned elements, mechanical design deficiencies and process upsets. The analysis of failed components can indicate the need for PAM.

The previous manufacturing material of the above mentioned existing elements showed some type of (decay: due to perishing) (wear particles of it had been noticed due to wear action on those non - metallic elements) because it is not compatible with the reliable standard specifications.

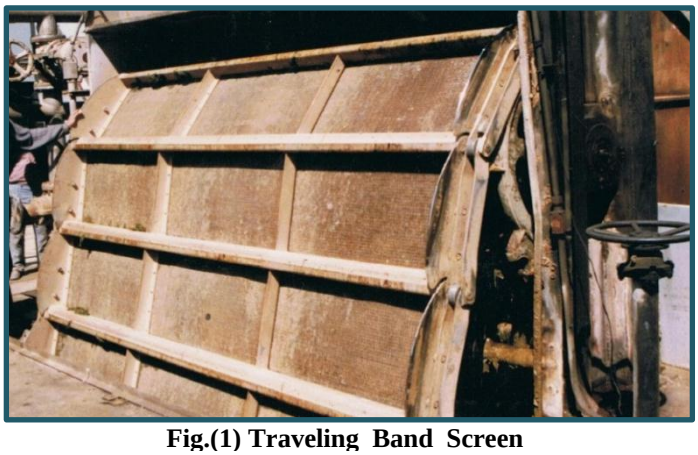
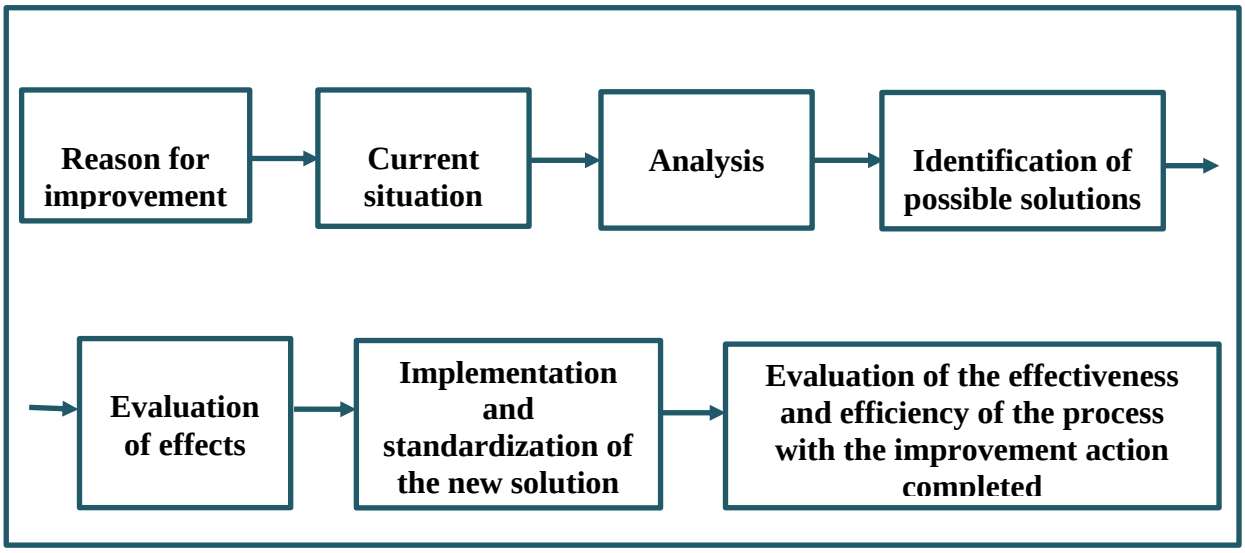


**Fig.(1) Traveling Band Screen**




After Studying, analyzing, and evaluating the factual findings of those elements in the system under study in the present work, it is a must to replace the manufacturing material of those elements so as to comply with the requirements of the accomplished improved new designs and the required performance of them in the system. And that can be considered as an engineering judgment based upon what have been previously mentioned above. Also adherence to reliable standard specifications in the manufacturing material selection of those mechanical parts (elements) after careful consideration of the mechanical design and the performance required of them in the unit under study is an effective tool for quality upgrading and enhancing.

The manufacturing material of the above mentioned redesigned elements had been selected as:

MOLDED POLYAMIDE PA0123 according to the references (ASTM D 6779, 2006) and (ASTM D 789 , 2005); unreinforced polyamide 66, heat stabilized, with a minimum viscosity number of 210mL/g.

A design process for equipment upgrading and reliability improvement had been conducted, and improved new designs for those elements of the equipment dealt with in the present work had been accomplished as shown in Fig. (3) , (4) , and (5) as a more constructive solution and a more proactive approach. In those designs some important considerations of the PAM approach had been carefully taken into account after manifesting what it comprises of conceptual regards. An analysis and assessment of those elements performance according to what had been selected as a manufacturing engineered material for them due to mechanical design point of view had been made .

Design updating and improvements conducted on the existing parts which were driven by PAM approach fulfill the requirements for the application under study, significantly result in maintenance effectiveness promotion, increasing its efficiency, enhancing quality of those elements and components involved , and upgrading performance reliability of the system concerned with by an added ratio of about 45%.

Mechanical design point of view should be given proper considerations for manufacturing above mentioned parts and elements .Greater challenges arise when the design must meet two or more conflicting objectives (such as minimizing mass , volume , cost , and environmental impact ( Ashby , 2007).

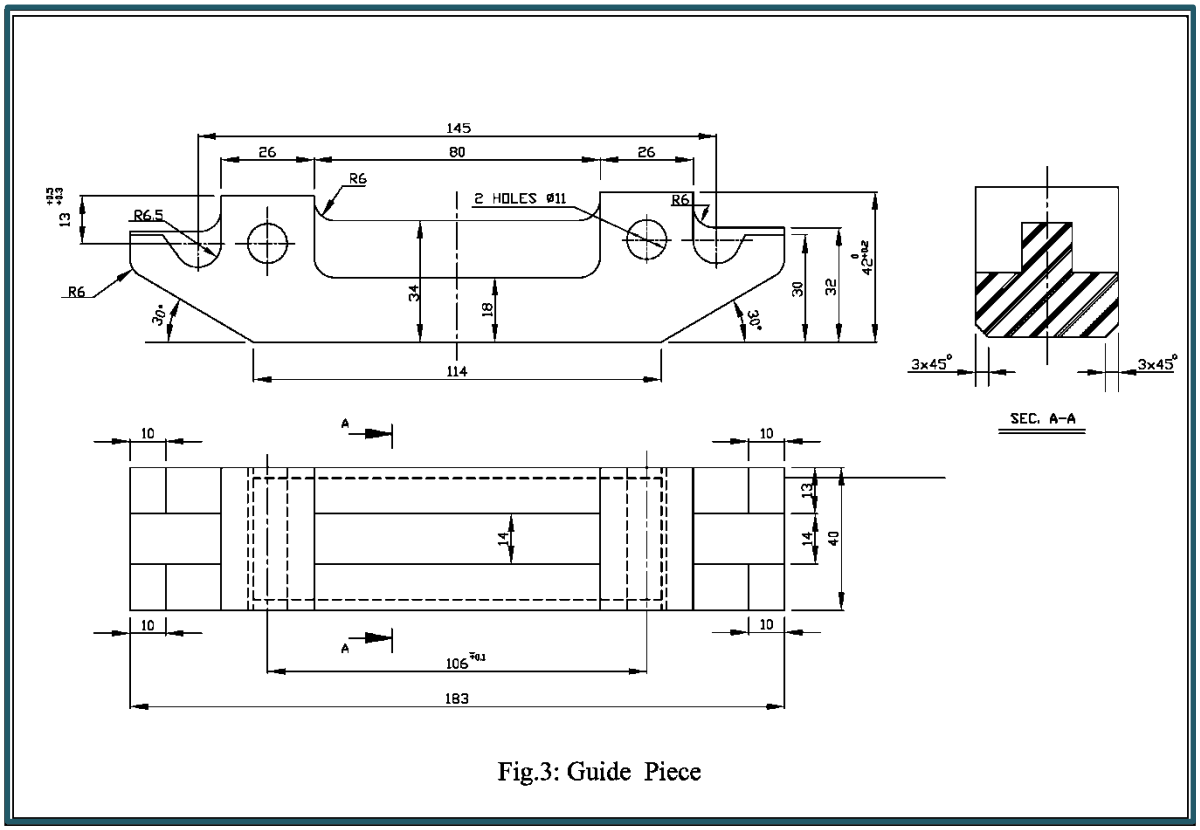



Fig.3: Guide Piece

**Fig.(3) Guide Piece**

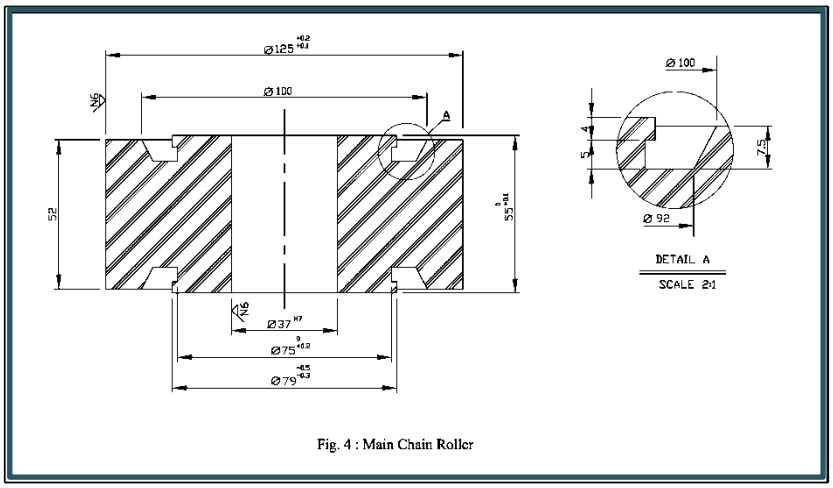



Fig. 4 : Main Chain Roller

**Fig.(4) Main Chain Roller**

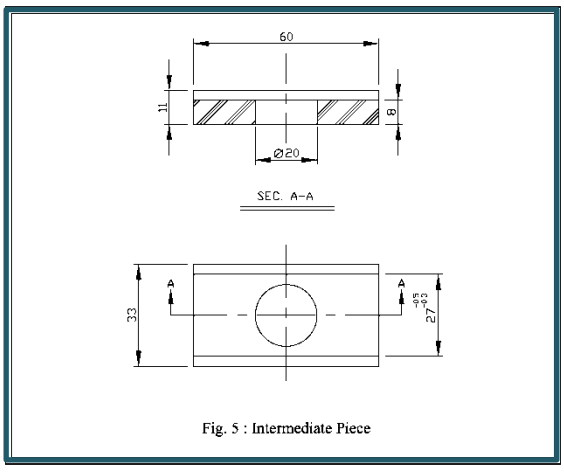



Fig. 5 : Intermediate Piece

**Fig.(5) Intermediate Piece**

Other specialized maintenance engineering efforts through some adjusting and improving procedures had been carried out to the chain subsystem in order to boost its performance and improve system reliability by improving the control function of chain slack indicator and the inductive proximity sensor that had been added to the system dealt with in the present work.

Condition – based monitoring of the subsystem dealt with in the present work and the analysis that had been undertaken rather than turning wrenches as in conventional maintenance practices had well impacted the system of the plant . The implemented PAM approach in the present work to improve performance reliability of the mechanical system concerned with revolves around three principal maintenance techniques or activities: predictive , condition – based and reliability – centered .

Pursuing PAM approach adopted and conducted herein returns several outputs for the system dealt with such as:-

1. Minimizing unplanned downtime while maximizing safety and operational availability by a ratio of about 55%.
2. Minimizing inspection overhauls by a ratio of about 45%.
3. Reduced maintenance costs through minimizing requirements for time directed maintenance by a ratio of about 40%.
4. Improving system operational flexibility and being able to tune the maintenance with other process factors.

Additional savings over conventional maintenance programs could be yielded by implementing such an approach. The present work is highlighting the necessity for focusing suitable attention to adopt and take up the approach conducted in it for several targeted advantages that might be gained through its implementation and as an endeavor to approach horizons of future development in that field .

**Conclusions**

1. Pursuing of such an approach adopted in the present work proves that it can be a more constructive solution and a more pro-active approach to avoid performance weakness and major problems that might occur in the system. It is vital and worthy that some important considerations of PAM approach had been carefully taken into account after manifesting what it comprises of conceptual regards.
2. Understanding and implementing PAM approach and reliability related practices in a cost – effective way is essential . It is of great importance to pursue PAM approach that could promise to advance maintenance and reliability programs to higher levels of achievement. That prompts the mechanical group in the concerned maintenance department and management to re-evaluate their current maintenance practices .
3. Applying PAM approach in the present work has led to an improved process for facilitating maintenance function by avoiding unnecessary preventive maintenance through condition knowledge; and by constantly being pro-active in seeking to improve reliability and uptime.
4. Improving performance reliability and system availability through anticipating to eliminating the failures due to gradual deterioration of mechanical parts by adopting and implementing PAM approach in the present work as one of its targets had been satisfied .
5. PAM approach is a valuable tool which can yield substantial improvements in equipment performance. It summed up the case for quality, sound engineering and good design.
6. The present work hopes to make a valuable contribution to better dissemination of existing knowledge

in the important field dealt with . Updating the maintenance and reliability engineering programs represents an important responsibility for the sake of attempt to build maintenance management systems on PAM as a radically innovative approach and a breakthrough strategy in maintenance improvement to meet utilities and infrastructure sector needs.

7. It is an important need to transfer knowledge and technologies for machinery diagnosis and prognosis in terms of failure prevention strategies and condition monitoring approaches, to provide an advanced methodology through technology
8. convergence in specialized maintenance engineering applications for achieving optimum designed- in reliability of components. Current practices and future developments in the area of failure prediction and integration with maintenance planning systems could be involved in many aspects of PAM , prompting technical excellence in maintenance, moving from a reactive to a pro-active culture.

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