Predictive Maintenance and Use of Internet of Things

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ABSTRACT

Maintenance of equipment's and assets is an important part of any manufacturing plant or industry. A well maintained plant not only reduces the cost of production and increases safety but also improves the quality of the product. Keeping this in mind, this paper intends to Study Predictive maintenance and compares it with the traditional approaches such as reactive and calendar based maintenance. The paper discusses how the predictive approach overcomes disadvantages such as replacement costs and unplanned downtime and thus has potential to cause a disruption in the maintenance sector.

Moving forward the paper discusses the use of Internet of Things (IoT) in predictive maintenance. The paper shows how this method is made better than the traditional and manual approach by this technical revolution. Aspects such as skillfulness of labor are taken into consideration while comparing. The use of IoT helps in presenting augmented solutions and also in better plant and system management.

Conclusion - That predictive maintenance helps one improve quality of product at lower costs of production and should be embraced by industry. It also says that the use of IoT helps in effective predictive maintenance and improves the ease of production. The society in general is benefited by implementing these technologies as we get better products at lower costs. While this is true, risks of IoT such as cyber security and privacy must be considered and taken care of.

Key Words*: predictive maintenance, manufacturing plant or industry, IoT, technical disruption*

I. INTRODUCTION

In today's world of competitive industries and marginal profits to manufacturers, getting the optimum usage out of one's resources has gained the utmost importance. For the machines and equipment's to work efficiently, their regular and proper maintenance is essential. Lack of proper maintenance leads to machine failure or downtime. Unplanned downtime costs industrial manufacturers an estimated $50 billion annually. Equipment failure is the cause of 42 percent of this unplanned downtime[1]. While deciding on the maintenance strategy, the manufacturer faces a trade-off. If the interval between maintenance is too short, we cannot get the most use out of the equipment leading to additional costs. But if we wait till the equipment fails, it will lead to downtime and will again be a cost to the manufacturer. Thus, the question of when maintenance should be done is critical. Predictive maintenance helps us address exactly this problem. By 'predicting' when equipment is going to fail, predictive maintenance helps us use the equipment for the maximum amount of time but prevents downtime.

In general, there are four types of maintenance strategies:

1.Reactive
2. Proactive
3. Planned and
4. Predictive.

As we will discuss, even though in some rare case other strategies may work better, predictive maintenance overcomes most of the disadvantages of other strategies.

Another part of the paper is looking how IoT is naturally integrated with predictive maintenance and makes it more effective. Internet of Things, popularly known as IoT, is capable bringing about a change in many sectors including predictive maintenance. Centralized data collection, quick and actionable results are some of the many advantages of IoT and predictive maintenance makes full use of these.

1.1 Aims and objectives

1. To understand existing and traditional maintenance strategies and compare their advantages and dis-advantages with predictive maintenance.

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2. To see how Internet of Things helps in betterment of predictive maintenance and see some of the advantages of using IoT.

II. RESEARCH METHOD

Desk and descriptive research.

III. IMPORTANT TERMINOLOGIES AND WHAT THEY MEAN

3.1. Predictive Maintenance

Definition: The aim of predictive maintenance (PdM) is first, to predict when equipment failure might occur, and secondly, to prevent occurrence of the failure by performing maintenance[2]. The beauty of this strategy is that we need to repair or replace a part only and exactly when required. Parameters based on which failure is determined are very important for predictive maintenance. Some of them are [3]

- Vibration: Monitoring the vibration of equipment, usually bearing vibration
- Temperature: Monitoring the temperature variation.
- Oil Levels: Measuring the variation in oil levels of equipment.
- Acoustics: Using ultrasound to detect changes in sound made by the equipment.
- Motor voltage and current: Monitoring for nuisance corona, destructive corona, arcing and tracking.

What failure model is used depends on whether the manufacturers know what the correct combination of the parameters is. If they do not know, complex machine learning algorithms are used which develop these specification based on previous data.

3.2 Condition based monitoring

Condition Based Monitoring is a process by which the condition of a machine is continuously
monitored by looking at pre-defined parameters of the equipment. Doing so enables the
tracking of patterns that might indicate equipment failure [3].

3.3 Internet of Things (IoT)

Definition: A network of internet-connected objects able to collect and exchange data using embedded sensors [4]. What exactly IoT does, is very beautifully explained in fig 1 [13]:

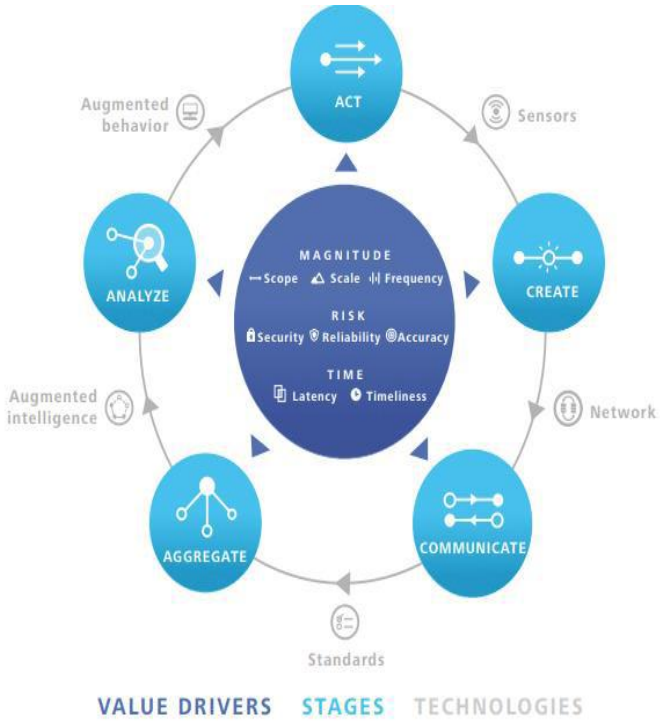

Fig 1: Iot activity

IV. TRADITIONAL MAINTENANCE STRATEGIES

4.1 Reactive maintenance

It involves restoring the equipment or part when it fails or breaksdown. Hence it is also known asemergency or breakdown maintenance. Although it may seem cost effective in the beginning, improperly maintained machinery only add up to the costs.

Advantages / uses:

1. It is used for maintenance of parts that are cheap and easily replaceable.
2. It has low labour and planning requirements
3. It may be used for maintenance of equipment that is very remote and very costly to access for regular maintenance.

Shortcomings:

1. Higher overall cost: Organisations pay a lot for emergency shipping of spare parts and repairs
2. Inefficient use: This method does not let the equipment to be used to its maximum capacity because it is not maintained properly.
3. Safety issues: While repairing in an emergency safety protocols might not be followed or implemented, making the equipment a safety risk in case of repeat failure.
4. Energy management: When equipment is not properly maintained, it uses more energy.

Doing simple things like greasing moving parts or changing filters can reduce energy consumption by 15% [5].
There are many other issues such as collateral damage, not keeping up with assigned tasks, time factor, etc. to name a few.

4.2 Proactive maintenance
This method is based on the ideology of treating the disease rather than the symptoms. This strategy locates the problems that can cause failure and fixes them.
Advantages:
1. The lifespan of the equipment increases.
2. Lesser number of failures leads to lesser downtime of equipment.
Shortcomings:
1. Cannot be implemented for each and every small source of error or failure.
2. More skilled labour is required to identify the problem and find a solution to it.
3. By itself it does not include regular and time to time monitoring of equipment and assessment of its status.

4.3 Planned / Calendar Maintenance
As the name suggests, this approach has maintenance done after specified time interval. It involves maintaining the equipment before it breaks down.
Advantages:
1. There is a lot of reduction in unplanned downtime.
2. Reducing failures makes it more cost efficient than reactive approach.
3. Planning in advance helps us allocate resources well in advance.
Shortcomings:
1. It increases planned downtime.
2. Spare parts need to be kept in the inventory for the regular maintenance.
3. Replacement and repair costs.
Maintenance strategies can be summed up in the following figure:

Fig 2

Figure 2 shows the regions in which different maintenance strategies operate as the asset quality decreases.

V. ADVANTAGES OF USING PREDICTIVE MAINTENANCE

1. Product Quality:
In a paper [6], the authors have conclusively found that regular maintenance improves the product quality and increases profitability for the company. Higher quality also indirectly helps the company by increasing its respect and brand among the consumers.
2. Cost Effectiveness:
As discussed in the introduction predictive maintenance gives the answer to the trade-off of when to do maintenance. Thus giving the optimum and cost effective solution to us.
3. Lesser inventory stocking:
By giving prior idea of when maintenance needs to be done, spare parts are brought only when needed
4. Less time is spent planning for maintenance
5. Lesser downtime: By doing maintenance only when necessary, the downtime is kept to its minimum with the help of predictive maintenance.
6. Safer:
Predictive maintenance actually prevents failure from happening, thus making it a lot more safer. Thus, we can say that predictive maintenance is giving the manufacturers a competitive edge [7]

VI. SOME EXAMPLES

1. Studies by some of the largest and most technologically advanced companies such as General Motors and 3M have shown that average rate of return ranges from 7 to 1 to as high as 35 to 1, depending on the industry. In other words, for every dollar spent on a predictive maintenance program, a company will save anywhere from 7 to 35 dollars. This is real money that would have been spent on lost production, added inventory, labor, parts duplication and equipment redundancy, etc. [8]
2. A particular oil and gas company implemented predictive maintenance on their plant. The cost of Non-Productive Time per asset during drill to completion is $500K - $1M per day, and post completion is $40K-$300K per day on average [9].
3. A large iron ore mining company in Australia partnered with Advisian, a company within Worley Parsons Group, for a predictive maintenance project. The evident outcomes resulted in a cost efficient predictive maintenance approach on the basis of analysis of field data and equipment data. It also helped in significant reduction of equipment downtime, due to

continuous monitoring technique [10].
4. The findings of a recent chemical industry survey by Emerson point to a substantial benefit from a PdM program — the plants responding averaged a 625% return on investment (based on an average benefit of $2 million with an average cost of $320,000). Major savings came in production (42%), parts (21%), labor (15%) and quality/scrap (10%) [11].

VII. WHY IT IS NOT VERY WIDELY IMPLEMENTED YET?

Even if Predictive maintenance has so many benefits as shown above, reactive maintenance remains the most commonly used strategy [12]. Even in North America more than 55% factories use reactive maintenance [5]. The answer to the question why is interesting. Predictive maintenance requires collection of large amounts of data and then figuring what that data means. Manually collecting data and then crunching the algorithms is too time-consuming and we may miss on some valuable insights if we are not presented with the data in a proper format. Thus implementing predictive maintenance without the use of computers and big data computing algorithms is not so useful.

IX. IOT MADE EASY BY TECHNOLOGICAL ADVANCEMENT

IoT is the mesh of objects that transmit data to each other through sensors embedded in them. This makes data collection very easy and user-friendly. Now-a-days a host of connected technologies is advancing rapidly, including high-quality sensors, more reliable and powerful networks, high-performance computing (HPC), robotics, artificial intelligence and cognitive technologies, and augmented reality [13]. Four major areas in technological advancements that have given a boost to the use of IoT are [3]:

- Connected devices and sensors. Manufacturers are building sophisticated, connected

gateway products. These products provide standardized ways to talk to the world of sensors.

- Data networks. Telecom companies are building better and cheaper data networks with widespread coverage.
- The rise of the cloud and the big shift from enterprise to Software as a Service (SaaS) platforms.
- Big-Data Technology: The ability to process large amounts of data in a standardized way.

These advancements in technology have made IoT easier and cheaper to implement for any application including predictive maintenance.

X. HOW IOT HELPS MAINTENANCE

1. Easier Data Collection:
With all the equipments connected to a common network via sensors, all the required information can be attained by looking at a single computer connected to the network.
2. Real time data analysis is possible:
By analysing the current situation of all the components of the system better decisions can be made by manufacturers as well as predictive algorithms analysing the data.
3. Some important statistics such as average time between failures of an equipment can be quickly and accurately calculated which can help identify some technical issues with the machines.
4. When you have such statistics of several different components of your manufacturing plant,you can gain insight into whether action on one component is causing failure in other components.
5. Automatic software updates:
When the manufacturers want to update the software or make some software changes in the sensors or equipments, they can do it at one go because all of them are connected to Integrated platforms with the application of IoT to inventory, supply chain, maintenance contractors and equipments, etc. can help us reap additional benefits of using IoT:
6. Repair actions can be recommended:
Based on previous data, the system can tell you what needs to be done. It can also isolate the data needed to be given to the maintenance technician so that maintenance can be rapidly done.
7. Better inventory management:
By intimating the parts that will be needed for maintenance in the near future and checking with inventory availability, only the required parts can be bought freeing up a lot of space and capital.

XI.PITFALLS OF IOT

From the previous discussion it may seem that IoT is a magic wand. But if proper care is not taken it poses some risks too.
1. Security and privacy: Access to critical equipments and software must be properly protected against. If not

taken care of, it leaves important business data open to cyber hackers.
2. The labour force needs to learn new skills to operate the updated machinery and equipments.
3. Although the returns of implementing are huge, initial investment can form a barrier to entry.

XII. PROJECTED DISRUPTIONS BY PREDICTIVE MAINTENANCE AND IOT

Looking at the advantages of both predictive maintenance and IoT discussed in this paper, it is only natural that more and more manufacturers will adopt this strategy in the coming years. Some projected statistics are:
1. The Industry 4.0 market which has IoT and its application as a major part is supposed to increase from $66.67 billion in 2016 to $152.31 billion in 2022 [14].
2. The overall predictive maintenance market is poised to grow at a CAGR of 28.4% until 2021 [15].
3. April 2017 research from Frost & Sullivan states that Industry 4.0 is opening growth opportunities for advanced asset tracking and production technologies [15].
4. In the announcement, the research firm states that it expects that by 2021 various industries will have adopted asset tracking technologies in order to achieve their Industry 4.0 goals, enhanced workflow and smart manufacturing ambitions [15].

XIII.CONCLUSION

1. Predictive maintenance has a lot of advantages compared to other maintenance strategies in terms of product quality, cost effectiveness, safety, etc.
2. IoT helps in better implementation of predictive maintenance and has given it the potential to disrupt the market as shown by projected reports.
3. Low cost and better quality products are made available to the consumers, which is definitely profiting to the society.

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