DM Make up Water Reduction in Power Plants Using DMAIC Methodology a Six Sigma approach

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Abstract- DM water is life line of a power plant. Presently DM make up for all NTPC running plants is around 0.84% of BMCR, however percentage figure seems misnomer if we observe the absolute values. Overall in NTPC for the year 2010-11,11-12 & 12-13 DM make up has been 55 Lacs MT, 57 Lacs MT & 63 Lacs MT respectively and this DM Make up has financial implication on cost in terms of crores of Rupees. However significance of every additional DM Make up in present cost competitive scenario is such that it needs special focus. Stringent norms of CERC recently has given a red wake up call to run our plants at maximum efficiency level and keep our performance at better heat rate possible . On this motivation we have made our research that will focus on how efficiently we are using this scarce and precious commodity and how we can further improve and increase overall profitability of our stations . Main aim of this paper was to find statistical as well as subjective solutions for minimizing DM water wastages or leakages. To initiate our research , we firstly found loss potential of DM water statistically. How much loss we find due to increased consumption and how much it affects our performance level. DMAIC approach is used to find out at what sigma level our plants are performing. We have taken data of Dadri (Thermal) stage- 1 unit -3 three months data from feb 2013 to Aug 2013. The process capability analysis of these data says that DM consumption rate was less than 95 % conformal and the consumption rate is **+0.16σ**. (To be very much particular regarding this sigma value two things are most important. Sigma value is a variable term . In a layman's language it can be said as if any company is running under six sigma levels, it doesn't mean It will always remain at that value. It may increase or decrease any time depending upon its performance at any point of time.) For finding monetary loss analysis we have used heat transfer method to find out the percentage loss in heat rate by additional DM make up . If we include cost of heat loss due to loss of enthalpy net additional make up of DM costs us Rs 1225 per metric ton. This figure itself shows that if we reduce DM leakages even by 0.1 % we can save so much of money. For coming to solution we have drafted a thirty question audit based online survey and on the base of that analysis a bar chart and a paretochart has also prepared. This water audit helped us to develop a framework not only for finding the root cause for poor sigma level of DM make up pattern but also gives some suggestive solutions that will help plants in finding solutions and comprehensive plans to plug them. Lastly we have formulated a *0.1% reduction strategy on* the basis of various inputs collected through our research.

Index Terms- DM make up, DMAIC, Minitab 16.0 , process capability , six sigma , 0.1% reduction strategy

I. Introduction

DM water is life line of a power plant. Presently DM make up for all NTPC running plants is around 0.84% of BMCR; however percentage figure seems misnomer if we observe the absolute values. Overall in NTPC for the year 2010-11,11-12 & 12-13 DM make up has been 55 Lacs MT, 57 Lacs MT & 63 Lacs MT respectively and this DM Make up has financial implication on cost in terms of crores of Rupees. However significance of every additional DM Make up in present cost competitive scenario is such that it needs special focus. Stringent norms of CERC recently has given a red wake up call to run our plants at maximum efficiency level and keep our performance at better heat rate possible . On this motivation we have made our research that will focus on how efficiently we are using this scarce and precious commodity and how we can further improve and increase overall profitability of our stations. Main aim of this paper was to find statistical as well as subjective solutions for minimizing DM water wastages or leakages. To initiate our research, we firstly found loss potential of DM water statistically. How much loss we find due to increased consumption and how much it affects our performance level. DMAIC approach is used to find out at what sigma level our plants are performing. We have taken data of Dadri (Thermal) stage- 1 unit -3 six months data from Feb 2013 to Aug 2013. The process capability analysis of these data says that DM consumption rate was less than 95 % conformal and the consumption rate is +0.16σ. (To be very much particular regarding this sigma value two things are most important. Sigma value is a variable term. In a layman's language it can be said as if any company is running under six sigma levels, it doesn't mean it will always remain at that value. It may increase or decrease any time depending upon its performance at any point of time.) In dadri presently DM make up in our plant is around 0.55-0.56%. DM leakages can occur from 'n' number of points. To initiate our work a DM water audit sheet (online survey) has been designed to find out various aspects of DM consumption in NTPC Dadri plant. We all know there are two mode of research – one is application research and second is developmental research. This audit cum survey*acts as a tool for both type of research. This audit sheet (**which** can be viewed online at http://www.surveymonkey.com/s/ZVDCHDS, http://www.surveymonkey.com/s/JLSKPR8,http://www.surveymonkey.com/s/JX5CW2D) can be applied to any plant to find out the DM make

up trend in any utility or industrial boiler. Before starting DMAIC firstly we see what the financial implications of this mych hyped thing are.

1.a. financial implications

Our current process in DM cycle make up and its analysis suggest that there is a considerable scope of improvement in plugging leakages and reducing variability. Cost of every additional DM makeup at any given plant depends on cost of raw water, chemical consumption and heat energy loss (of course additional makeup is required due to some sorts of steam leakage). Considering case study of NTPC Dadri where cost calculation for steam leakage works out to be in the range of Rs. 790 to Rs. 1225/MT depending upon where the leakage is occurring in the cycle. Our calculations suggest that every 0.1% reduction in DM Makeup at Dadri alone will result in saving of Appx. 2 Cr every year. However at NTPC level these figures become further staggering at any thing between 60Cr. to 90Cr. depending on primarily heat rate calculations of other plants .To reiterate once again, as on today our plants do not have system to carryout regular flow audits to identify sources & quantify leakages and objective of our paper is to sensitize people with regards to DM makeup and its actual considerable financial impact.

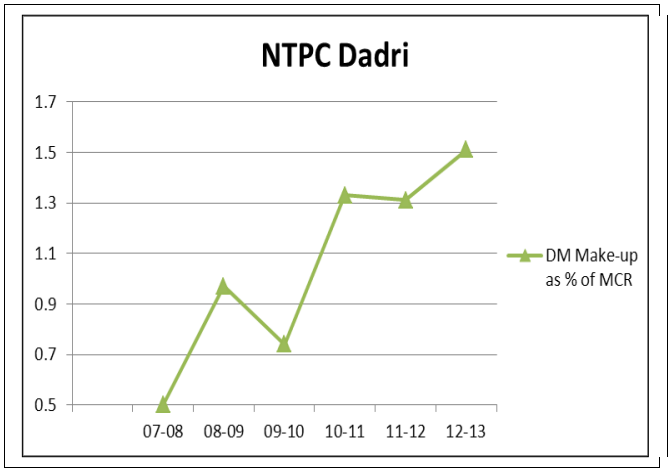

Fig.1 DM make up pattern in Dadri

II. DMAIC APPROACH IN NTPC DADRI -A CASE STUDY

To start the main content firstly it is necessary to know about DMAIC process. The DMAIC (Define-Measure-Analyze-Improve-Control) method is a formalized problem-solving process of Six Sigma. It's made-up of five steps to apply to any procedure of a business to improve effectiveness. These five phases are design, measure, analyze, improve and control. In power plants we all know DM water is main working fluid in generation cycle and its process parameters are flow, pH, conductivity, silica, COC, total hardness , TDS, langelier index etc. The core philosophy of this paper is how to increase our performance level in DM consumption and how can we attain close to six sigma .If we increase sigma value by this approach we will certainly improve our efficiency and will make our process more sustainable.

Flow diagram of DMAIC :

Supplier	Input	Process	Output	Customer
DM plant	Make -up	Opn practices	Reduction in m/u	**NTPC Management**

Steam is produced by DM water . So , It is main motive element in generation cycle. DM water is of two kinds – cyclic and non-cyclic DM. Cyclic dm water is that which is a part of steam cycle and non cyclic dm water is used in various applications like Stator water, SG ECW/ TG ECW etc. Here our focus is on cyclic DM water consumption only. Calculations are based on six months dm water trend of unit - 3 of stage- 1 dadri plant. DM make up water enters in a condenser at atmospheric temperature that is heated around 537°C for raising steam. DM integrator is used to measure daily cycle make up water as percentage of feed water flow. Presently, makeup water consumption of Dadri is around 0.55-0.56% of MCR (Maximum Continuous Rating) {while the best figure till date is 0.45%). **One of the best figures of DM make up is of Dhanu Plant where make up was 0.37% (and this figure is of 2005, so indeed we have much to do!)**

III. METHODOLOGY ADOPTED

To apply DMAIC approach in minitab 16.0 software six month data from 1st Feb'13 to 31st July data of unit 3 has been taken. (Just as random sample). Cycle make up water consumption has to be converted in terms of percentage of MCR of feed water flow so that this methodology can be applied to other power plants. As it is not possible to reduce cycle make up water consumption to zero and minimum is the best, LSL (lower specification limit) cannot be fixed for water consumption. Hence, only USL (around 100 tons = 0.65%) and target value of 50 tons has been taken.

Define

The first phase defines the problem statement and goal statement necessitating the team to identify the need of implementation of six sigma and major challenges faced. Goal statement – To minimise variability in DM consumption and keeping consumption in a fixed band of percentage BMCR flow. In define phase we define Critical success factors (CSF), which are those factors which need to be worked upon for achieving goal statement. Following are the critical success factors: Reduction in DM make up and its inventories, Improvement in heat rate due to reduction in APC and Secondary benefits and periodically water audit for continuous improvement.

Measure

There is a very basic fact that we cannot control what we don't measure. In cycle make up water consumption at TPP, make up water flow is measured by an integrator. Although we can use ultrasonic flow meter for finding velocity and flow from any pipe easily. Every plant must have this apparatus as it is very easy to handle and find out flow from any pipe easily. This phase involves analyzing CSFs determined in measure phase. It also identifies the Before Improvement Values (BIV) for each CSF which will help in evaluation of monetary savings. Just before going to six sigma tools a graphical summary is plotted for six month data. It is a graphical summary of DM makeup.

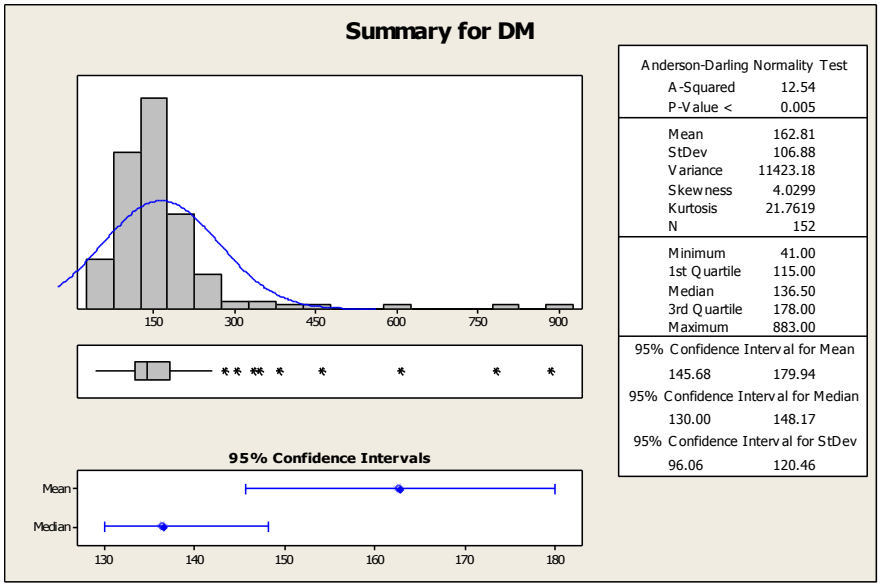

Fig.2 DM consumption stats in unit 3 (Data : Feb-Aug 2013)

ANALYSE

Firstly when we take data of six months, minitab16.0 firstly trims value of top 5 % and bottom 5% data. As these data are like outliers. (What is outlier – It is just like a boy coming school daily on time but gets delayed on some day it doesn't mean that he is a late comer. In a same way some max or min DM data may be due to unit light up / shutdown or whatever). .We see A squared value is 12.54 .Graph is skewed to higher side positively skewed..

Runchart

Runchart was drawn for unit 3 from 1st Feb to 1st August (six month timeframe). This is a DM water integrator reading. P-values for clustering = (0.014), trend = 0.241, oscillation = (0.798) and mixtures = (0.986). As the p-value for the cluster test is less than the alpha value of 0.05, we can conclude that special causes are affecting the process, and we should investigate possible sources. Clusters can be even evidence of sampling or measurement problems, but more to more data collection removes this probability. p value for clustering is less than 0.05 it means that with 95 % confidence we can say that pattern is not normal. We have to look for the reasons for non normality. If p value is more than 0.05 it means that distribution is normal.

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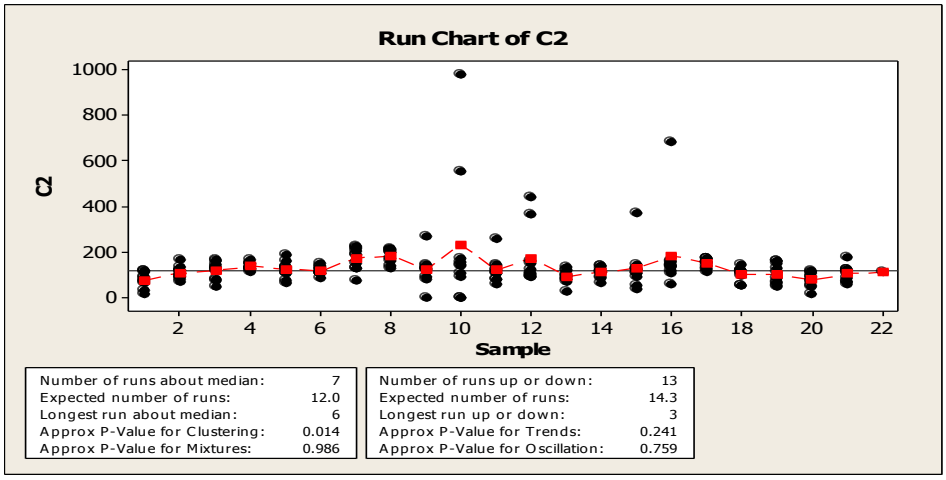

Fig 3. Run chart

Process Capability Analysis

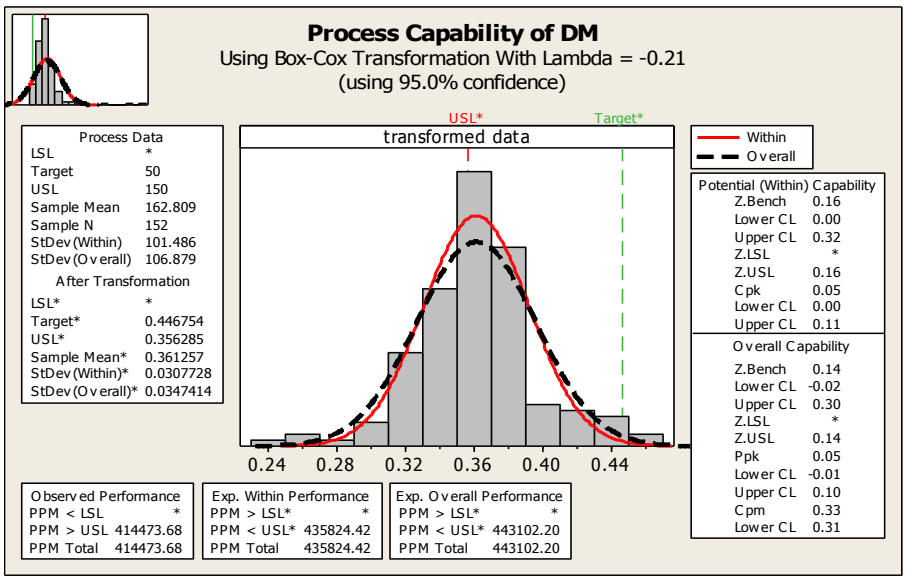

Fig. 4. Process capability

Process capability analysis was performed using minitab to draw curve for cycle make up water from TPP measured through flow meter. In our case Z bench value comes 0.16σ presently dm make up is +0.16 sigma level. If we limit upper specification level around 150 ton (1% BMCR flow) and target value around 50 Ton

Fish Bone diagram

Using survey results and brainstorming fish bone diagram is plotted to find different causes related to man,machine,method and material .

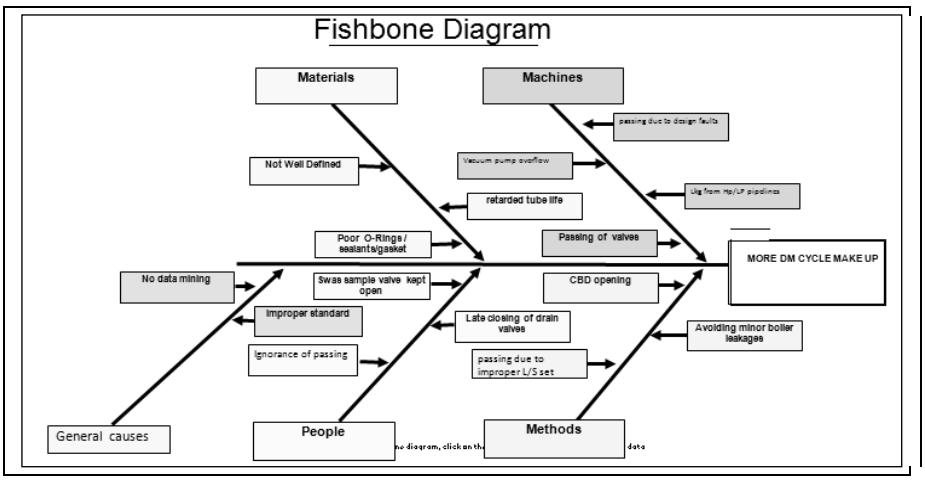

Fig. 5. Fish bone diagram

Bar Chart

Actual DM water wastage from different points was possible. On the basis of audit sheet, bar chart was drawn.

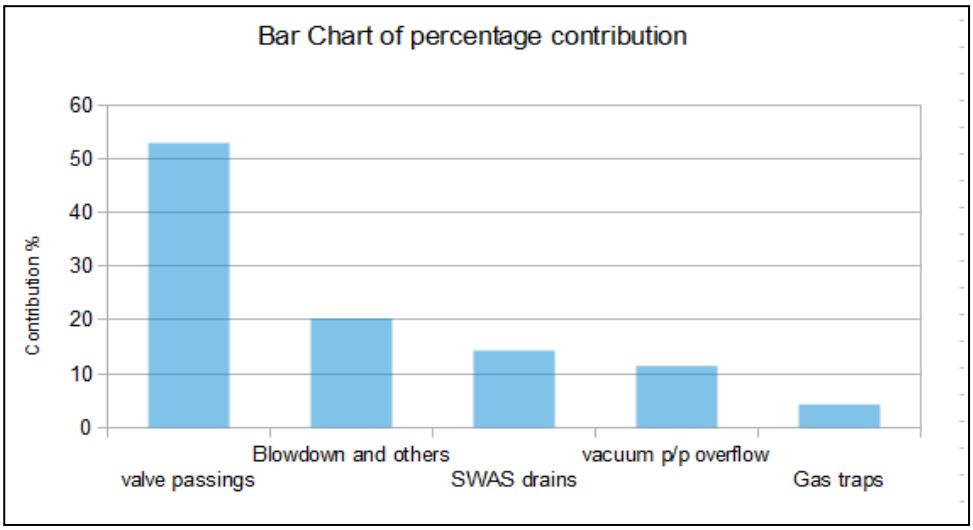

Fig. 6. Barchart

Pareto Chart

Pareto chart is prepared by getting responses from dm water audit survey. The above barchart is replicated into paretochart

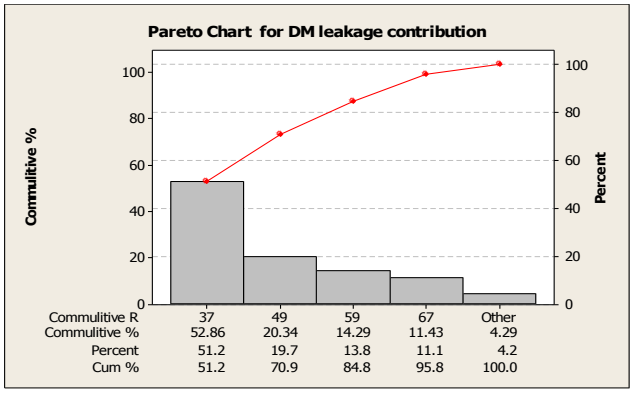

Fig. 7. Pareto Chart

Improve

From the above analysis we find that valve passings like safety valve passing, drain valves passing are the biggest cause of problem. High energy drains are also major culprit. SWAS drains are very much neglected we can reduce DM leakages from swas sample drains by periodic awareness and training of lab analysts, communicationgap between operation and chemistry staff and casual approaches can be removed to find out solutoions. For NTPC this analysis has two -three things which are very important: Firstly Lower limit definition – As we know for any SQC we require UCL /USL (upper critical limit or upper specification limit) and LCL/LSL... OEM gives us relaxation of DM up to 2% of BMCR.. We know our LCL/LSL can't be zero as power generation does not work on isolated system concept. The processes are practically open system (although it should be closed one).So, our goal statement converges to a band of DM (%BMCR) .Say like 0.3 to 0.5%. So for calculation of LCL, we have used statistics.Firstly we see that our DM consumption is following which type of distribution. To get more specific results we find DM distribution pattern individually by minitab16.0.

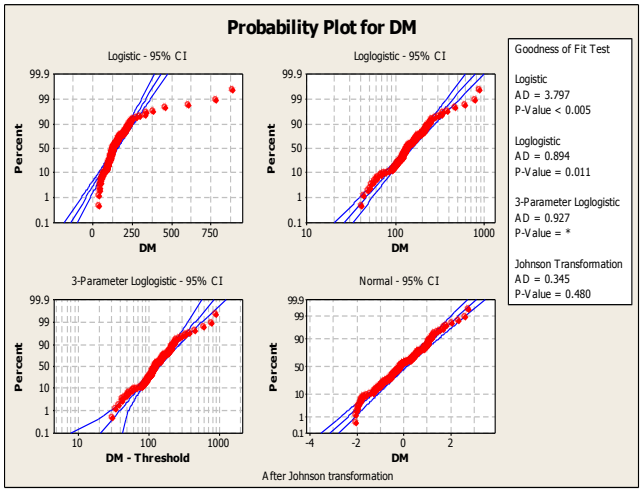

Fig. 8 Probabilistic distribution

We find lologistic normal distribution in dm pattern and p value is more than 0.05 (with 95% conformality). The greater the CpK value, the better. A CpK greater than 1.0 means that the 6σ (±3σ) spread of the data falls completely within the specification limits. A CpK of 1.0 means that one end of the 6μ spread falls on a specification limit. A CpK between 0 and 1 means that part of the 6σ spread falls outside the specification limits. A negative CpK indicates that the mean of the data is not between the specification limits. In layman's language roughly sigma level is 3 x cpk values...

Control

In this stage, new process considerations are documented and frozen into systems so that the gains are permanent. All possible related causes of specific measured or approximated where no measurement was identified problem from analysis phase were tackled and shut out in control phase. With mere 1ton addition of DM makeup in system doesn't only add monetary burden of Rs.1225/-(Ref. Appendix 2). Regular checking of all sources to be done on fixed time basis. We can also go for some retrofitments in flanges as we always see in DM line there is very much flange leakage. Victaulic coupling can be used in place of flanges which have best reliability. Ultrasonic flow meter should be used frequently to find actual amount of DM leakages. Deareator vent valve orifice to be checked during overhauling for its erosion. Presently there is no forum like bureau of water efficiency. On a pilot basis we can pitch this idea .In our audit report we can give some rating analogous to star rating given by BEE for every equipments. We can improve some better operation practices likewise if there is unit light up just after condenser flood test and if we get no abnormality we can send that water to drum directly. (Generally after flood test hotwell is drained). We can use AHU drains in chilling of swas compressors. If ambient temperature is very less during winter season we can even isolate one PHE also. (Turbine ECW has 3 PHE and boiler side have 2 PHE). Passing of some less using valves like pegging steam valve or CRH extraction valves in deaerator or CRH supply to seal steam should be done regularly. Steam traps are very much neglected. Steam trap drains to be collected at one vessel. CBD flow measurement and LPD valves passing to be checked properly. One can say that by regulating so much we can't suffocate our plant operation system. It is a wise idea but we should keep one thing always in mind. And this thing is a Taguchi loss function. This function says even we are under specification limit but we are not at our specified target value we are making our losses in square term. If we are "x" away from target it means our loss into the system is order of "x^2" and this loss is transmitted to society itself. It can be easily depicted by following curve.

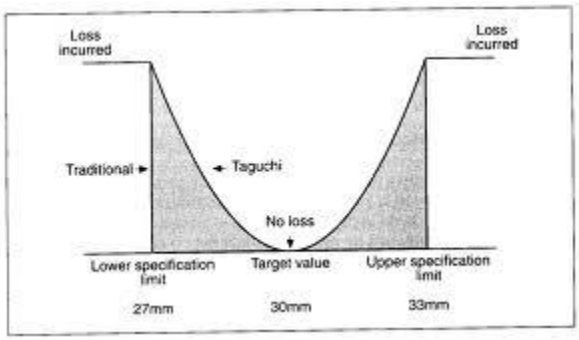

Fig. 9. Taguchi loss function / Learning curve

IV. ANALYSIS AND CONCLUSIONS

The preferred Study proves that we can implement Six Sigma methodology in even power plant to perform better. Higher consumption of DM water is found to be a big problem in a thermal power plant. The causes for more DM water consumption are safety valve passing, swas drain leakage, various pumps seal problems, vacuum pump overflow and of course blow down and drain or vents. This paper is open ended paper as actual quantification of different leakage points to be noted down in plant by using ultrasonic flow meter. Our R&D team can do a cost benefit analysis on use of Victaulic coupling. After doing and implementing DMAIC study a post work financial audit is to be done. We all know in order to minimise our DM consumption we can't suffocate our plant on the basis of equipment healthiness. So after analysing our study O&M management team can see this scenario under acceptable risk, tolerable risk or unacceptable risk. For this purpose a sensitivity analysis is required to be carrying out.

ANNEXURE

[1] Online survey webpage: (In PDF format attached with sheet) http://www.surveymonkey.com/s/ZVDCHDS, http://www.surveymonkey.com/s/JLSKPR8,http://www.surveymonkey.com/s/JX5CW2D

[2] DM heat loss calculation excel sheet (In word format attached with sheet)

REFERENCES

[1] www. minitab.com

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