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Continuous Improvement Process Fundamental Quality Tools

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Abstract

If organizations wish to achieve continuous quality improvement they need to use appropriateselection of quality tools and techniques. In this paper a review of possibilities of the systematic use ofseven basic quality tools (7QC tools) is presented. It is shown that 7QC tools can be used in all processphases, from the beginning of a product development up to management of a production process anddelivery. It is further shown how to involve 7QC tools in some phases of continuous improvement process(PDCA-cycle), Six Sigma (DMAIC) and Design for Six Sigma (DMADV) methodologies, and Lean SixSigma.

Keywords:DMAIC,improvementprocesses,qualitytools,SixSigma,PDCA,7QCtools,DMADV

INTRODUCTION

Continuous quality improvement process assumes and requires that a team of experts together with the company leadership actively use quality tools in their improvement activities and decision making process.
Currently there is a significant number of quality assurance and quality management tools available, so the selection of the most appropriate is not always an easy task. Tools are essential ingredients of a process and basic instruments for the success of a quality program. Many companies have used tools without giving sufficient thought to their selection and have then experienced barriers to progress. Quality Tools cannot remedy every quality problem but they certainly are a means for solving problems. Consequently, it needs to be emphasized that while tools can be very effective in the right hands, they can be very dangerous in the wrong hands. It is, therefore,

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important to know how, when and which tools should be used in problem solving or improvement processes.

Today there are more than a hundred different tools available. Many scientists have tried to define them and differentiate among them on various bases [1]. Tools are generally a means of accomplishing change and in this paper we will focus on the most fundamental quality tools called the seven basic quality tools - 7QC tools. They are easy to learn and handle and are used to analyze solutions to existing problems.

Thesesevenqualitytoolswhicharebasicforallothertools are:

- Flowchart
- Paretodiagram
- Checksheet
- Controlchart
- Histogram
- Scatterplot
- Cause-and-effectdiagram.

Thesevenqualitytoolswerefirstemphasized by Ishikawa (in the 1960s), who isone of the quality management gurus. His originalseventoolsincludestratification,whichsomeauthors later called a flow chart or a run chart.They are also called the seven "basic" or "old"tools.Afterthatothernewtoolshavebeendeveloped for various purposes but the basis forevery work is related to the 7QC tools [3].Thesetools are also fundamental to Kaizen and Juan'sapproachtoquality improvement[2].

1APPLICATIONOF7QCTOOLS

Thesesimplebuteffective"toolsofimprovement"arewidelyusedas"graphicalproblem-solvingmethods"andasgeneralmanagementtoolsineveryprocessbetweendesignanddelivery.Thechallengeforthemanufacturingandproductionindustryisfor:"Everyonetounderstandanduseheimprovementstools intheir work".

Some of the the seven tools can be used inprocessidentificationand/orprocessanalysis.

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Onepossibleapproach,proposedbyJ.G.Pimblott [4] is presented in Fig. 1 where Paretoand Cause and effect diagrams are common andessentialinbothprocesses(identificationandanalysis).

The current approach for using 7QC tools,accordingtoEOQ(EuropeanOrganisationforQuality) [5], is shown in Fig. 2. The process ofdataacquisitionsincludesthreetools(Checksheet,HistogramandControlchart),andtheprocessofanalysis anotherfourtools(Paretodiagram, Cause and effect diagram, Scatter plot,andFlow chart).

Thereisadistinctionbetweenthetwoapproachesrepresentedin Figs.1and2.Theapproachin Fig.1ismucholder(1990)andtherefore, there are some key distinctions. Sometoolswhicharenowusedonlyforanalysis wereat that time considered as tools for identificationor for both processes (identification and analysis).But even then scientists were attempting to findappropriate utilizations of each tool in differentprocessesandmethodologiesofimprovement.

The tools mustmeet themain purpose orreasonfortheirapplication.Nosingletoolis more important in isolation, but could be mostsignificantforaspecificapplication[1

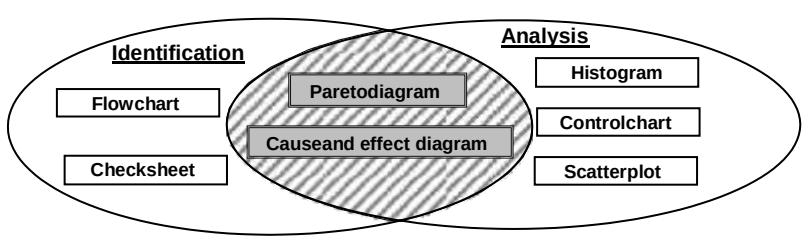
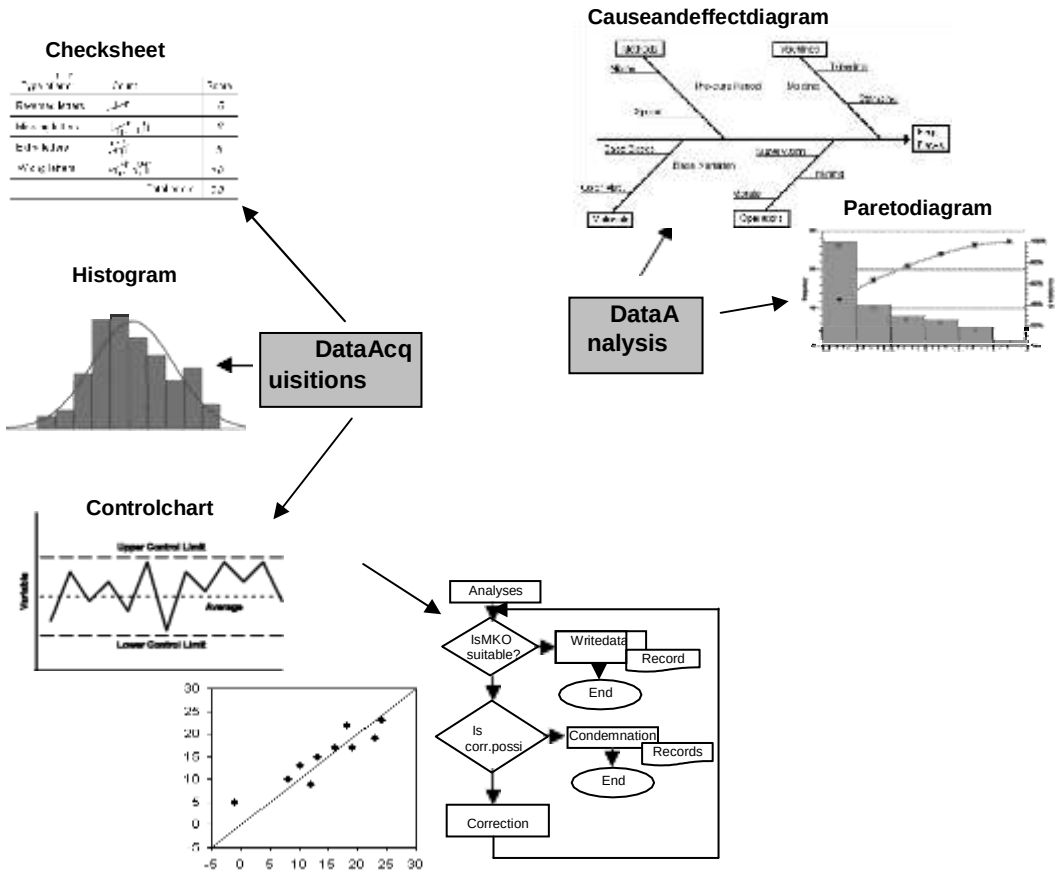


Fig.1.*Useof7QCtoolsinprocessidentificationandanalysis*



Scatterplot

Fig.2.*Currentapproach forusing7QCtools(accordingtoEOQ*

Fig.3.*Developmentofqualitymanagementconcept*

2 7QCTOOLSTHROUGHPDCA-CYCLE

Insuccessfulapplicationofqualitytoolsa n implemented quality management system is anadvantage.Thequalitymanagementprinciple sareastartingpointforthecompany'smanageme ntstrivingforcontinuousefficiencyimprovemen toveralongperiodoftimeandcustomersatisfacti on.Aqualitymanagementsystem is based on the integrity of all productionand support resources of a certain company. Itenables a faultless process flow in meeting relatedcontracts,standardsandmarketqualityre quirements.Implementationofaqualitymanage mentsystemisalwaysapartofacompany'sdevel opmentprocess,Fig.3[6]**.**

Having a quality management system inplaceisaprerequisiteforitssuccessfulapplicati ononaday-to-daybasis.Themanagementhastoshowcommitm enttodevelopmentandimprovementofaquality managementsystem.Throughaqualitymanage mentsystemthecompany'sleadershipimpleme nts their quality policy. Furthermore, aqualitymanagementsystemhastobewelldocu mented.Wheninfunction,thequalitymanageme nt system provides useful informationobtained by different process analyses and audits.Ifacompany'sfocusisonthecustomer,the company has to select the most efficient ways ofdataacquisitionandmarketsurveytoconfirmt hatthecompany'sproductsorservicesmeetcusto merdemandsandexpectations.Thegathered information is invaluable in the decisionmaking process based on fact. Data collection andanalysisisalsosignificantindefiningopportu nitiesforfurtherprocessesandproductqualityim provement.

Continuousimprovementasafifthprinci ple of QMS (ISO 9001:2000) could not berealized without quality tools which are presentedthroughfourgroupsofactivitiesofDe ming'squality cycle or PDCA-cycle, shown in Fig. 4 [6]**.**The PDCA-cycle is an integral part of processmanagementandisdesignedtobeusedas a dynamic model because one cycle represents onecompletestep ofimprovement.

ThePDCA-cycleisusedtocoordinatecontinuousimprovem enteffort**s.**Itemphasizesanddemonstratesthati mprovementprogramsmust start with careful planning, must result ineffectiveaction,andmustmoveonagaintocare fulplanninginacontinuouscycle–theDeming's quality cycle is never-ending. It is astrategyusedtoachievebreakthroughimprove ments in safety, quality, morale, deliverycost,andothercritical business objectives.

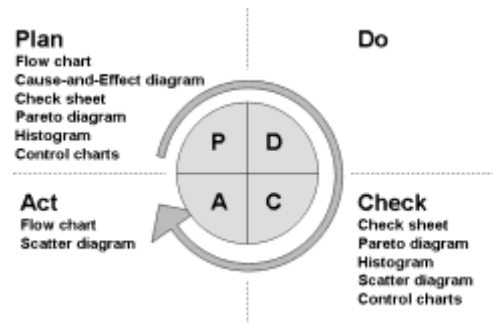


Fig.4.*PDCA-cycle*

Thecompletionofonecyclecontinueswit h the beginning of the next. A PDCA-cycleconsists of four consecutive steps or phases, asfollows:

- Plan-analysisofwhatneedstobeimprovedbyta kingintoconsiderationareas that hold opportunities for change.Decisiononwhatshouldbechang ed.
- Do - implementation of the changes thataredecidedonin thePlanstep.
- Check-Controlandmeasurementofprocesses andproducts in accordance tochangesmadeinpreviousstepsandinac

cordancewithpolicy,goalsandrequirements onproducts.Reportonresults.

- Act - Adoption or reaction to the changesor running the PDCA-cycle through again.Keepingimprovementon-going.

Table1.*SevenbasicqualitytoolsincorrelationwithPDCA-cyclesteps*

Seven basicquality tools(7QC tools)	StepsofPDCA-cycle				
	Plan	Do	Plan,Check	Plan,Act	Check
	Problem identification	Implement solutions	Processanalysis	Solutions development	Result evaluation
Flowchart	✓			✓	
Cause-and-effectdiagram	✓		✓		
Checksheet	✓		✓		✓
Paretodiagram	✓		✓		✓
Histogram	✓				✓
Scatterplot			✓	✓	✓
Controlcharts	✓		✓		✓

ThemainpurposeofPDCA-cycleapplicationliesinprocessimprovement[7].Whenprocessimprovementstartswithcarefulplanning, it results in corrective and preventiveactionssupportedbyappropriatequalityassurancetoolswhichleadtotrueprocessimprovement. The application of the seven basicqualitytoolsincorrelationwithfourstepsofPDCA-cycleisshowninTable 1[8].

AsshowninTable1,mostofthe7QCtoolscanbeusedforproblemidentification:Flowchart,Cause-and-Effectdiagram,Checksheet,Paretodiagram,HistogramandControlcharts.Forproblem analysis the following tools can be used:Cause-and-Effectdiagram,Checksheet,Paretodiagram, Scatterplot and Control charts. When ateamisdevelopingasolutionfortheanalyzedproblem,FlowchartandScatterplotcanbeusefulaswell.Inthephaseofachievedresultsevaluation,mostof7QCtoolscanalsobesuccessfullyimplemented:Checksheet,Paretodiagram,Histogram,ScatterplotandControlcharts.

For effective and successful team work insolvingdailyqualityproblems,weproposeasimplemodelforsystematicusageof"basicqualitytools"forprocessmonitoring,dataacquisitionandqualityimprovement,Fig.5[6]and[9].

Loop1focusesontheanalysisofthebiggestcausesfordefectswhicharefoundbyParetodiagram,andLoop2focusesoncontinuousprocessimprovement,whichisoneoftheeightQMSprinciples.Theimplementationofthisprincipleisabig stride forward which a company can take inorder to change their static quality management to adynamicone.

3 7QCTOOLSINSIXSIGMA

Six Sigma is an organization-wide approachused to specify exactly how organization managerssetupandachieveobjectives.Itdemonstrateshowbreakthroughimprovementstiedtosignificantbottom-lineresultscanbeachieved[10].

The Six Sigma methodology goes beyond theimprovement process and tools because it requiresan intelligent use of data, emphasis of statisticalanalysisanddesignedexperiments. SixSigmaprescribesanimprovementprocess knownasDMAICmethodology[3]**:**

- Define-improvementofprojectgoals,goalsbasedoncustomerneedsandwants
- Measure-currentprocessandestablishmetrics to monitor the path to achievementofgoals
- Analyze-currentprocesstounderstandproblemsandtheircauses
- Improve - process by identifying and pilotingsolutionstoproblems
- Control-improvedprocesswithstandardizationandongoingmonitoring.

Eachoftheseprocesses(phases)canberealizedwithdifferentqualitytoolsandtechniques (also 7QC) while some tools can beused in more than one processes (phases). Onepossible classification (use) of different qualitytoolsandtechniquesintheSixSigmamethodology,proposedbytheauthorsispresentedinFig.6[9].

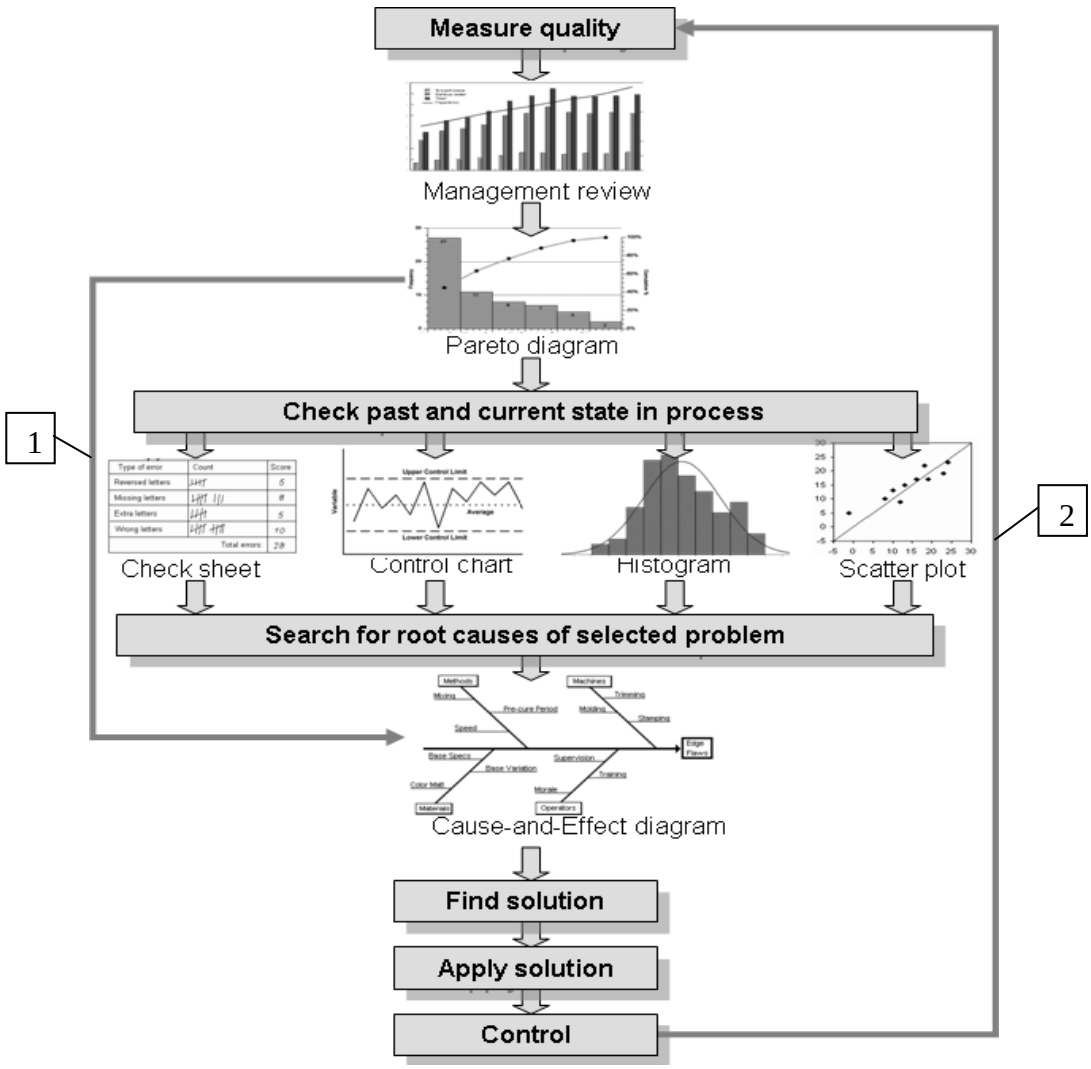


Fig.5.*Sevenbasicqualitytools(7QCtools)forqualityimprovement*

In Fig. 6 the tools which are used in allphasesofDMAICmethodologyarepresented. Below each phase of DMAIC the main tools foreach process are presented. Lower still the toolswhich are not essential for that process but canalso be used (Additional tools) are shown. It canbeseenthat,exceptIheImprovephase,theAnalysisandControlphaseshaveoneormoreQCtools.

For the development of a new product or aprocess which focuses on "problem prevention"there is a modified version of Six Sigma calledDesign for Six Sigma (DFSS). The fundamentalcharacteristic of DFSS is the verification whichmakesitdifferentfromSixSigmabutthe proponents of DFSS are promoting it as a holisticapproachofRe-engineering.ItisalsoknownastheapplicationofSixSigmatechniquestothedevelopmentprocess. DFSSiscentredondesigninga new product and services while Six Sigma isprimary a process improvement methodology. TheprocessesoftenusedinpracticeinDFSSarecalledDMADV(define,measure,analyze,design, verify)or IDOV (identify, design, optimise and validate).ThefirstphaseinDMAICandDMADV (orIDOV)is the same (define the goals of the activities) butafterthatprocessesgoindifferentways.Ifaproc

essexists then you go by the DMAIC way and if not,youfollowtheDMADV[11].

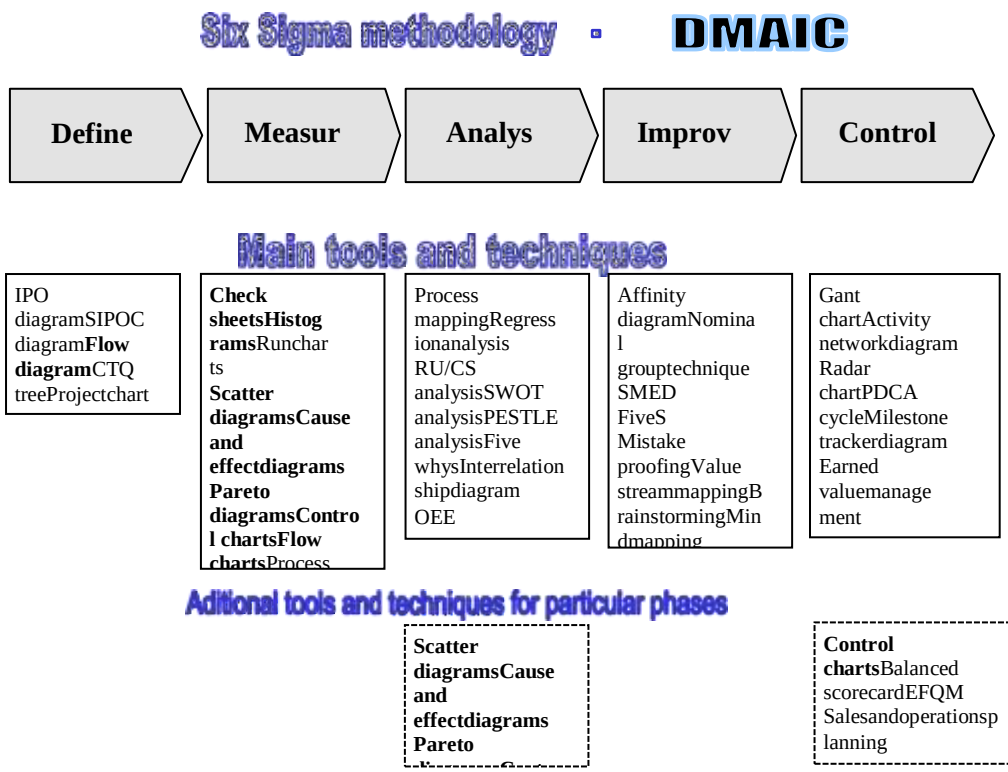


Fig.6.*QualitytoolsandtechniquesinDMAICmethodology*

InTable2apossibleinclusionof7QCtoolsin three methodologies is presented: continuousimprovement PDCA-cycle, Six Sigma and DesignforSixSigma[12].Indifferentphasesofthepro cesses various tools can be taken while somephases like (Plan for the future in PDCA-cycle) needsome other management, planning or other tools andtechniques.

In this approach (Table 2) it is also shownthat in the Improve phase of DMAIC two basicquality tools (Control chart and Pareto diagram)could be used while in Fig. 6 this phase does notcontain any basic tools. On the other hand, in theDefinephaseofDMAICmethodology,Fig6,therei sonebasicqualitytool(Flowdiagram)whereasinTable 2theDefinecolumnisempty.

When comparing the inclusion of 7QC toolsin PDCA methodology in Tables 1 and 2 it can beseenthattheauthorsinbothreferences[8,12]conside rthatnotasinglebasicqualitytoolcouldbeinvolvedinth eprocesswhichmeansrealization(DoorImplementSol utions).

Theseapproachesaredifferentanddefini telyneed a deeper analysis but it is evident that 7QCtools have a big role in all the key phases of thesemethodologies.

4 7QCTOOLSINLEANSIXSIGMA

Lean Six Sigma are a set of methods thatcompaniescanapplytoanymanufacturing, transactional or service process to reduce waste,eliminate non-value-added actions and cut time.Combining "Lean" with "Six Sigma" can produceaprogramthatbringsbothshort-termresultsthrough the power of Lean, and long-term changethroughthe power of SixSigma. It is for thisreasonthatmanycompaniesareturningtoa combinedLeanandSix Sigma effort.

- Leanmeansspeedandquickaction(reducingunneededwaitingtime).
- Six Sigma means identifying defects andeliminating them.
- Lean Six Sigma Engineering means best-in-class [13] and [14]. It creates value intheorganizationtobenefititscustomers

andsavesmoneywithoutcapitalinvestment.

Both,theLeanandtheSixSigmamethodologies have proven over the last twentyyears that dramatic improvements in cost, quality,and time can be achieved by focusing on processperformance.Mostpractitionersconsiderthesetwomethodsascomplementingeachother toachieveworldclass performance(WCP).

Bringingthetwoconceptstogetherdeliversfasterresultsbyestablishingbaselineperformancelevelsandfocusingontheuseofstatisticaltoolswheretheywillhavethemostimpact.Mostcompaniesusingbothmethodologies began by applying basic Lean - manufacturingtechniques-the5Ss,standardized work and the elimination of waste. Once Leantechniques eliminatemuch of the noise from aprocess, Six Sigma offers a sequential problem-solvingprocedure,theDMAICcycle,andstatistical tools so that potential causes are notoverlookedandviablesolutionstochronicproblemscan bediscovered[14].

One may obtain Lean Six Sigma trainingcertificationbycompletingtheimprovementmodelforLeanSixSigmaBlackBelt.Thistraining is available at academic institutions, aswellasqualitysocietiesorothercertifiedorganizations. The preceding steps with qualitytools (also 7QC tools) andtechniquesfor LeanSix Sigma Black Belt are shown in Fig. 7 below[13].

Table2.*QualityToolsandTechniquesSelectorChart*

Methodology / Tools andtechniques	Continuous improvement(PDCA-cycle)							SixSigma(DMAIC)					Designfor Six Sigma(DMADV)				
	Identify opportunity	**Analyzetheprocess**	**Developsolutions**	**Implementsolutions**	**Evaluateresults**	**Standardizesolutions**	**Planforthefuture**	**Define**	**Measure**	**Analyze**	**Improve**	**Control**	**Define**	**Measure**	**Analyze**	**Design**	**Verify**
7QCtools																	
Cause-and-Effect diagram		**x**								**x**				**X**			
Controlchart			**x**		**X**				**x**		**x**	**x**				**x**	**x**
Checksheet	**x**												**x**				
Histogram	**x**								**x**				**x**				
Paretodiagram					**X**				**x**		**x**		**x**	**X**			**x**
Scatterdiagram		**x**			**X**					**x**		**x**		**X**			
Flowchart																	
• Deployment flowchart	**x**	**x**	**x**			**x**							**x**				
• Linear or activityflowchart	**x**	**x**	**x**			**x**							**x**				
• Opportunity flowchart		**x**	**x**			**x**							**x**				

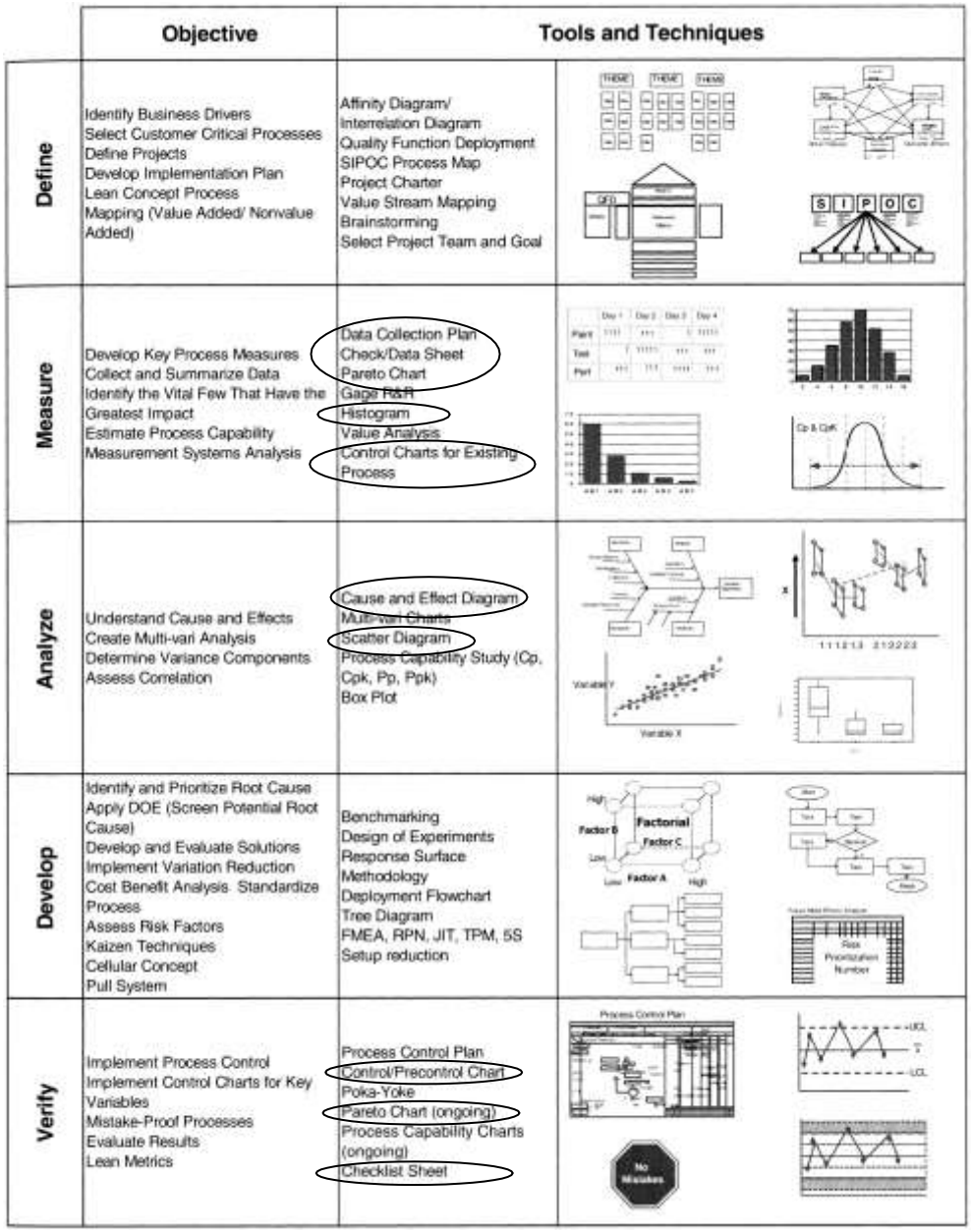


Fig.7.*LeanSixSigmaBlackBeltimprovementmodel (useof7QCtoolsisemphasized)*

5 CONCLUSIONS

This paper aimed at defining the role andsignificanceofsevenbasicqualitytools(7QCtools) within a quality management system. Theprincipleofcontinuousimprovementusingtheseve nbasicqualitytoolswhichguaranteeorganizationstomo vefromstatictodynamicimprovementstatuswaspresen ted.Asshown,the 7QCtoolshaveanimportantplaceindatacollecting,anal yzing,visualizingandallotherphasesinPDCA-cycle,DMAICandDMADVphases, and also in *Lean Six Sigma*. Furthermore,systematic application of 7QC tools will enable asuccessfulqualityimprovementprocess. Itisevidentthatacontinuousimprovement process cannot be realized withoutqualitytools,techniquesandmethods.These

toolsalsohelpthequalityengineertouseaccessible datain decision processes.
Therefore,itisveryimportantthatthepassivestatus(identificationneededfortools,techniquesandmethods)ofusingthesetools,techniquesandmethodsistransformedintoproactivestatus,which is the only way towards further affirmationofacontinuous improvementprocess.
In view of this,it is evident that an evenmuch more synthesized process could be realizedand improved using different tools and techniqueswhichhave*7QCtools* astheir basis.

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