IMPROVE SIX-SIGMA MANAGEMENT BY FORECASTING PRODUCTION QUANTITY USING IMAGE VERIFICATION QUALITY TOOL

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ABSTRACT

With the emergence of a business era that embraces changes as one of its major characteristics, manufacturing success and survival are becoming more and more difficult to ensure. The emphasis is on adaptability to changes in the business environment and on addressing market and customer needs proactively. Changes in the business environment due to varying needs of the customers lead to uncertainty in the decision for requirements from supplier. Flexibility is needed in the value stream map (VSM) to counter the uncertainty in the decision for requirements from supplier. VSM adapts the changes if it is flexible and agile in nature. In this paper a model is presented, which encapsulates the market sensitiveness, process integration, information driver and flexibility measures of VSM demands from supplier and grantee customer requirements. The model was addressed validation to preventive and verification to corrective (VPVC) that is a concept within six-sigma definition. (VPVC) depends on the systematic investigation of discrepancies (failures / deviations) which must be applied in lean six-sigma environment that adopt one piece flow layout. The model is consists of two phases, the first phase is a mathematical model explores the relationship among customer demand, quality, and service level and the leanness and agility of VSM in fast moving consumer goods. The second phase is a quality assurance process of establishing evidence that provides a high degree of preventive that a product involves acceptance of fitness for purpose with customers'. The paper concludes with the justifications of the system input, which depends on the effect of the jerky demand of the market with high quality specification.

KEYWORDS: *Six-Sigma, VSM management, Simulation Steps.*

I. INTRODUCTION

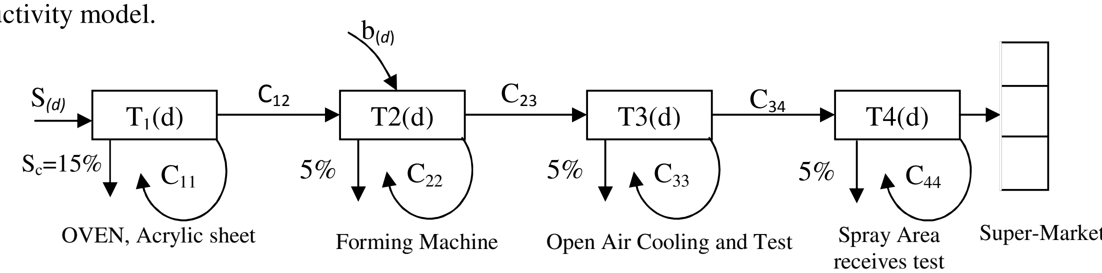
The concept of quality is first emerged out of the industrial revolution. Previously products had been made from start to finish by the same team, with handcrafting and tweaking the product to meet 'quality criteria'. In the late 1800s pioneers such as Frederick Winslow Taylor and Henry Ford recognized the limitations of the methods being used in mass production at the time and the subsequent varying quality of output. Taylor established Quality Departments to oversee the quality of production and rectifying of errors, and Ford emphasized standardization of design and component standards to ensure a standard product was produced. Quality was the responsibility of the Quality department and was implemented by Inspection of product output to 'catch' defects.

The Lean Six-Sigma aims to establish a continuous improvement system using a value stream thinking that can be one of the key sources of competitive advantages [1], [2], This work is based on determine economic quantity that was conducted at the company and customer needs. The work examines the operations of the specific company and analyzes the opportunities for the application of Value Stream principles [4]. This work will also audit current material flows and scheduling practices using Value Stream Mapping and Profitability Mapping to identify potential improvements. Based on this information, and the supplemental research, a future state of operations will be recommended as a mathematical model. These objectives postulates in [1], [3],[5]. Total Quality Management is a guide to implement logistics management to control task direction [7]. The Human Equation-Building Profits by Putting People First [8] indicate the simple think about profits but without simulation model

predict future state situation quantity and price. The main objectives are set the economic quantity after known duration to determine VSM orders [10, 12].
Verification of machinery and equipment usually consists of Design Qualification - DQ [13], Installation Qualification - IQ [14], Operational Qualification - OQ [15] and Performance Qualification - PQ [16]. DQ is usually a customer's job by confirming through review and testing that the equipment meets the written acquisition specification. Otherwise, the process of IQ, OQ and PQ is the task of validation.
In such a situation, the specifications of the parts and restructuring proposals should be appended to the qualification document whether the parts are genuine or not. Torres and Hyman have discussed the suitability of non genuine parts use and provided guidelines for equipment users to select appropriate substitutes which are capable to avoid adverse effects [17]. When machinery/equipment qualification is conducted by a standard endorsed third party such as by an ISO standard accredited company for a particular division, the process is called certification [18], [19]. Prospective validation - the missions conducted before new items are released to make sure the characteristics of the interests which are functional properly and which meet the safety standards [20], [21]. Some examples could be legislative rules, guidelines or proposals [22], [23], [24], methods [25], theories/hypothesis/models [26[, [27].
The other function is retrospective validation - a process for items that are already in use and distribution or production. The validation is performed against the written specifications or predetermined expectations, based upon their historical data/evidences that are recorded. If any critical data is missing, then the work can’t be processed or can only be completed partially [20], [26].
Verification can be expressed by the query "Are you building the thing right?" and validation by "Are you building the right thing?" "Building the right thing" refers back to the user's needs, while "building it right" checks that the specifications be correctly implemented by the system.

II.PRODUCTION MODEL (PHASE I)

Mat-lab and C# software used to formulate a two phases code that present an economic order quantity after known days (future state), also used to determine best quantity with respect to profits taking into account marketing and inventory costs that appeared if company produce extra product. The unit price is exchange if customer demands difference about company productivity. The ideal situation when customer demand is equal to company productivity with acceptance requirements.
The next sections are divided to two parts, the first section (Company production model) determines the forecasting quantity based on rework and scrap, the second section (Economic Production Quantity) determines the economic quantity based on customer needs and company profits.
Sketch-1 consider the following company’s productivity model is analyze the effect of supplier provide quantity retention rate on the company productivity’s form so that it can predict the future need for number of machines, labors and resources. Assume that the company has estimates of the percentages of parts reworking or scraping before day off, this estimation represent current state of productivity model.



$S_{(d)}$: Quantity provided by Supplier
$b_{(d)}$: beside parts fed Machine T_2 ,
$T_i(d)$: Task series in day (d),
C_{ji} : No. of work piece transferred from j to i.
Sc: Scrap percentage

Sketch-1: Sequencing machine and its

In this work develops a matrix equation helps in this analysis to control quantities and its direction weather feed or feedback. The next values used in model to illustrate the model working, these values may change to match different company model. The first phase illustrates in (Figure 1).

Suppose that the current order is 500 parts, and the company managers decide to increase productivity to 1000 per day from now on. The company estimates that [10%] of the $T_1(d)$ will reworking. The number of $T_1(d+1)$ in the following day will be 0.1(500) +1000=1050, then it will be 0.1(1050)+1000=1105, and so on. Let T_1 (d) be the number of oven acrylic sheet in day d, where d=1, 2, 3, ... then in day d+1, the number of oven acrylic sheet is given by: $T_1(d+1)$=10% of previous oven acrylic sheet repeating in the same day + 1000 new oven acrylic sheet, [0.1 x $T_1(d)$+1000]. The number of $T_1(d)$ is known in the first day of analysis (which is 500); the previous equation will solve step by step to predict the number of $T_1(d+1)$ in the future that shared in feeding super-market in the final station in the production line. If 15% of parts in $T_1(d)$ are scraping, then $T_1(d)$feed $T_2(d)$by C_{12} = [100% of parts] – [10% reworked in previous step + 15% scraped from previous step]= 75% of parts returns as $T_2(d)$, also C_{22} = 5% of $T_2(d)$rework its operation. And 200 extra parts fed from $T_1(d)$ from besides production line. Then in day (d+1) the number of forming acrylic sheets is given by: $T_2(d+1) = 0.75\ T_1(d) + 0.05\ T_2(d) + 200$

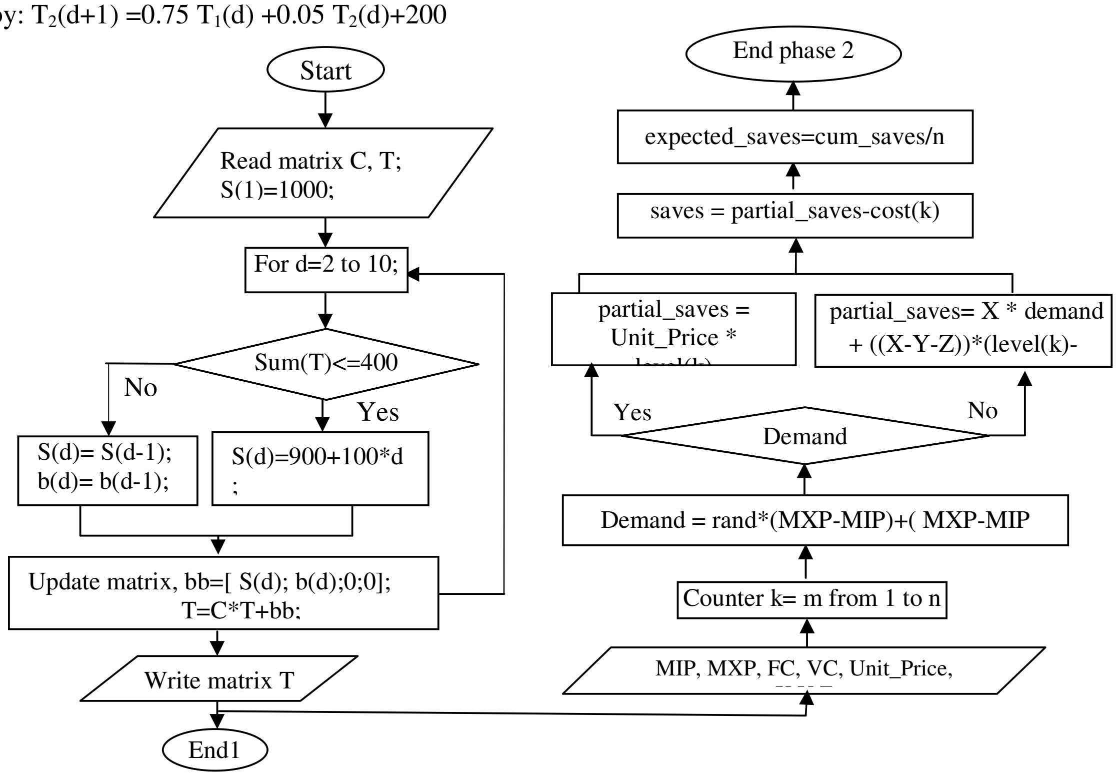


Figure 1. Flow-Chart of phase I of simulation program.

Suppose that [5%] of the $T_2(d)$ and $T_3(d)$ scraped. And C_{22}, C_{33}, C_{44} = 5% of the $T_2(d)$, $T_3(d)$ and $T_4(d)$ reworked. C_{23}, C_{34} = [100% - 5% reworked on previous station – 5% scraped from previous station] =90% of the forming machine operation and open air cooling test return to increase its quality.

$T_3(d+1) = 0.9\ T_2(d) + 0.05\ T_3(d)$

$T_4(d+1) = 0.9\ T_2(d) + 0.05\ T_3(d)$

The next matrix formulate the previous situation, it may take different values with respect to any company situation. The suitable matrix will form as next:

$$\begin{bmatrix} \mathbf{T_1(d+1)} \\ \mathbf{T_2(d+1)} \\ \mathbf{T_3(d+1)} \\ \mathbf{T_4(d+1)} \end{bmatrix} = \begin{bmatrix} 0.1 & 0 & 0 & 0 \\ 0.75 & 0.05 & 0 & 0 \\ 0 & 0.9 & 0.05 & 0 \\ 0 & 0 & 0.9 & 0.05 \end{bmatrix} \begin{bmatrix} \mathbf{T_1(d)} \\ \mathbf{T_2(d)} \\ \mathbf{T_3(d)} \\ \mathbf{T_4(d)} \end{bmatrix} + \begin{bmatrix} \mathbf{1000} \\ \mathbf{200} \\ \mathbf{0} \\ \mathbf{0} \end{bmatrix}$$

To study the effects of supplier provide quantity and thermoforming sheets that fed from other oven, the model must be generalized to be:

$T_1(d+1)=C_{11}\ T_1(d)+ S(d)$
$T_2(d+1)=C_{12}\ T_1(d)+ C_{22}\ T_2(d)+b(d)$
$T_3(d+1)=C_{23}\ T_2(d)+ C_{33}\ T_3(d)$
$T_4(d+1)=C_{34}\ T_3(d)+ C_{44}\ T_4(d)$

$$\begin{bmatrix} T_1(d+1) \\ T_2(d+1) \\ T_3(d+1) \\ T_4(d+1) \end{bmatrix} = \begin{bmatrix} C_{11} & C_{21} & 0 & 0 \\ C_{12} & C_{22} & 0 & 0 \\ 0 & C_{23} & C_{33} & 0 \\ 0 & 0 & C_{34} & C_{44} \end{bmatrix} \begin{bmatrix} T_1(d) \\ T_2(d) \\ T_3(d) \\ T_4(d) \end{bmatrix} + \begin{bmatrix} S(d) \\ b(d) \\ 0 \\ 0 \end{bmatrix}$$

Suppose that the initial total productivity order is 1512 consists of 500 parts at $T_1(d)$ station, 375 parts at $T_2(d)$, 337 parts at $T_3(d)$, 304 parts at $T_4(d)$. The company wants to study the over 10 days the effects of increasing supplier provides 100 each day and fed from other oven by 50 per day until the total productivity orders reaches 2554 product, then the customer orders fluctuation between the productivity after 10 days and 2500 parts.

S(d)=900+100*d
b(d)=150+50*d where d: 1, 2, 3, 4, . . . 10

The model is simulated by MATLAB; a Matlab script file to predict the future state productivity to feed super market for the next 10 days appears in the next table:

```
% model's coefficients
      C =[0.1,0,0,0;0.75,0.05,0,0;0,0.9,0.05,0;0,0,0.9,0.05];
% initial vector of current state values
        T =[500;375;337;304];
% initial supplier provide and fed from beside production line
      S(1)=1000;
      b(1)=200;
% E is 4x10 matrix
      E(:,1)=T;
% Counter over days from 2 to 10
      for d=2:10;
        %maximum WIP
        if sum(T)<=2554;%maximum WIP
        %increase supplier provided and fed from other production line by 100
          S(d)=900+100*d;
        %increase supplier provided and fed from other production line by 50
          b(d)=150+50*d;
        else
        %hold status quo quantity
        S(d)= S(d-1);
        b(d)= b(d-1);
      end
```

```
        %Update matrix
                bb=[ S(d); b(d);0;0];
                T=C*T+bb;
                E(:,d)=T;
        end
%plot the results
plot(E'),hold,plot(E(1,:),'O'), plot(E(2,:),'+'), plot(E(3,:),'*'),...
plot(E(4,:),'x'),xlabel('days'),ylabel('Number of orders'),...
gtext('OVEN'), gtext('Forming Machine'), gtext('Open air test'), gtext('Spray area
received'),title('Economic order quantity')
```

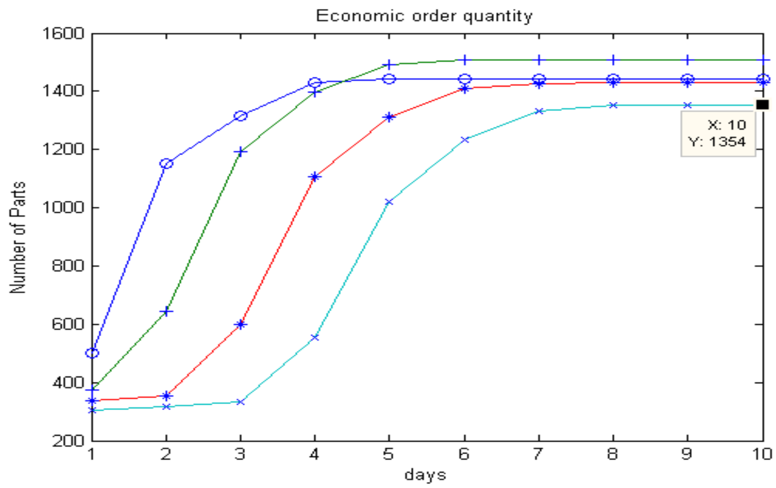


Figure 2. # Of products estimated from a certain production line

(Figure 2) illustrates the predicted quantity that follow the previous speculates about specific company. The quantity is 1345 parts appears after 8 days. The customer requirements are fluctuated between **1000** and **2500** parts in determined days.

III.OPTIMAL ECONOMIC ORDER QUANTITY

The optimum production level handling between different tasks station, the transportation cost will be large if line produce too many units without market form, if there is any units not handled weather transportation system become in position will increase transportation cost and that is a worst case. The fixed cost of the transportation system is $4 part/day; the cost of producing forming bathtubs during these four steps is $35 above the fixed cost. The historical file illustrates that there is a fluctuation between 1000 and 2500 parts are produced, if the parts handled in its time will save $160/day (unit price) but else if not handled in time (over production)will cost company $60 for transportation and $45 for inventory, this mean part will sell by $55.

The simulated model to estimate the optimum quantity to produced and transported to design a suitable super market:

```
        %number of simulation runs
                n=10000;
        % 1354 parts exists + 1000+200 provided from besides =2554
                Min_Productivity = MIP;
                Max_Productivity = MXP;
                Fixed_Cost = FC;
                Variable_Cost = VC;
                level=[ MIP: MXP ]; %(1200)+1
```

```
            cost = FC + VC * level;  %fixed cost + production cost*# of products
                    for k=1:1201 %1201 = (2554 – 1354) +1
                        cum_saves=0;
                        for m=1:n
                            demand = floor(rand*( MXP - MIP)+ (MXP-MIP)+1);
                            if demand >= level(k)
    %unit price - transportation cost = $160 net profit
                                partial_saves = Unit_Price * level(k);
                            else
    %extra product have transportation cost and inventory cost
            bulimic_Unit_Price = X;
            transportation cost= Y;
            Inventory cost= Z;
                        partial_saves= X * demand +((X-Y-Z))*(level(k)-demand);
                 end
                        saves = partial_saves-cost(k);
                        cum_saves = cum_saves+saves;
                 end
                        expected_saves=cum_saves/n;  % y axis
                        p(k,1)=level(k);
                        p(k,2)=expected_saves;
                 end
plot(p(:,1),p(:,2),'+',p(:,1),p(:,2),'-'),xlabel('NO. of bathtubs'),ylabel('Transportation saves $')
```

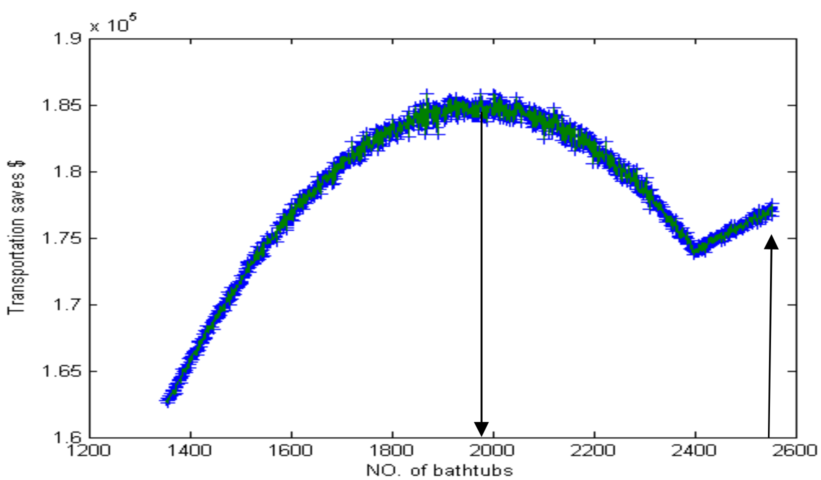


Figure 3. Optimum order quantity

(Figure 3) illustrates the optimum quantity saves the handling cost and increase profit is 1990 parts/day that represents pacemaker quantity. Also (Figure 3) illustrates unobserved behavior after producing 2400 parts, this behavior set domain for productivity as follow:

$$\#\text{of products} \begin{cases} P = 1990 / \text{day} \\ P > 2400 / \text{day} \end{cases}$$

IV. QUALITY MODEL VPVC (PHASE II)

Lean Six-sigma tools must be integrated by the factory to reduce defects and achieves customer requirements. (Figure 4) illustrates the VPVC flowchart, VPVC is a program need a digital cam which fixed to prevent scrap via pick sequence of pictures related with time to stop machine when process cycle time completed. The program applies the same code among processes to reduce inspection time (NNVA) from 1.25 *min* to 0.28 *sec.*

(Figure 4) consists of two steps, the first step is the validation code and the second step is the verification code. The main objective is produce customer demand meet with his specification.

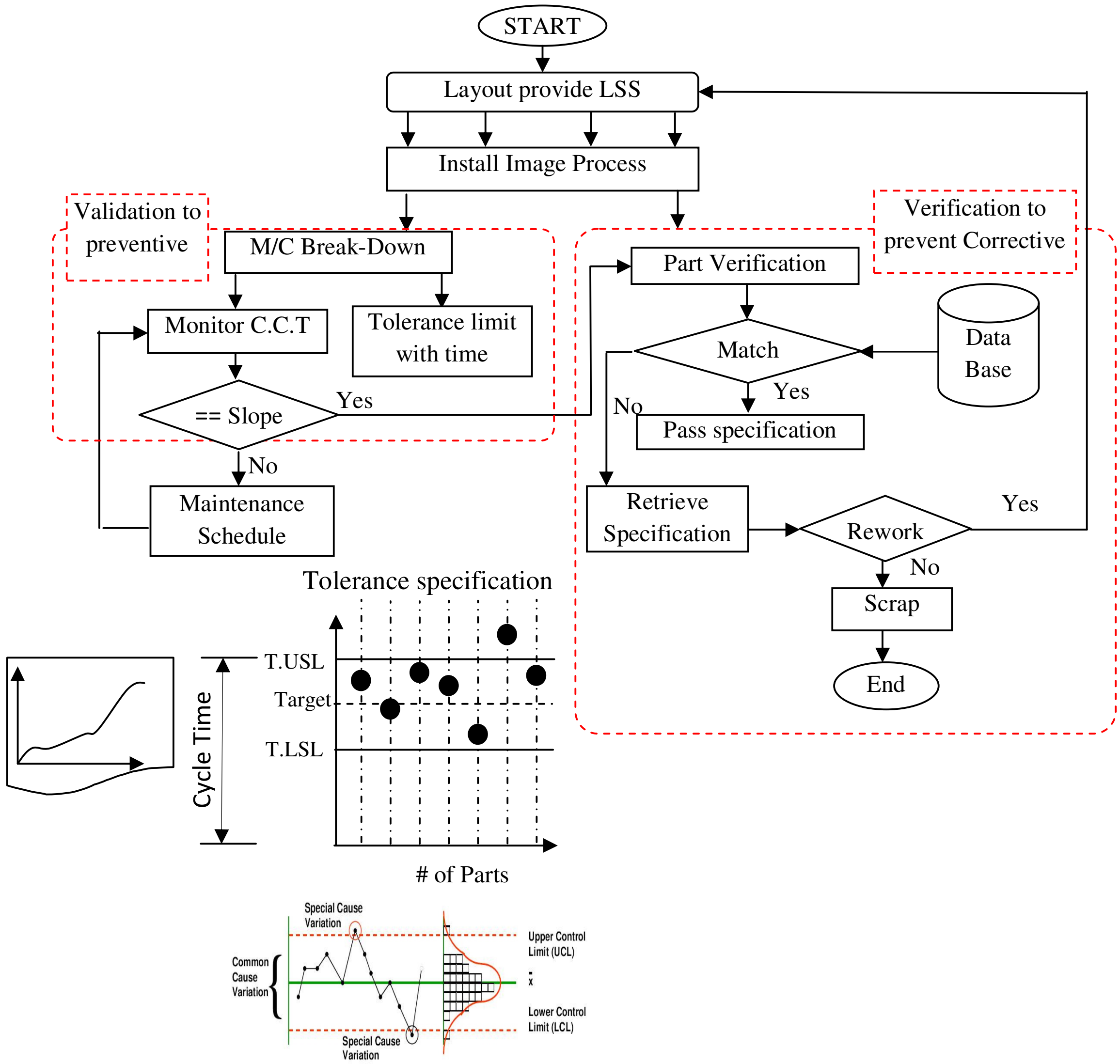


Figure 4. The VPVC flowchart.

4.1. Validation Code (Step I):

Validation to preventive is executed on machines by monitor cumulative cycle time of the sequence activities in VSM to build a standard reference time line for every part. If there is any deviation far this reference the validation will diagnosis the fault. The reference line will thrown preventive attention.

1. READING Labor _ID.
2. READING Job_ID and stamp the Clock$_{(start)}$
3. Reading VSM data (Supplier serial, R.M serial, loaded M/c, Clock$_{(end)}$)

    t=[0:1:12]';

    y=[Comulative Clock picked up for start and end of every product]';

```
yy=[Clock without any follow up for the labors]';
n=3
P=Polyfit (t, y, n), PP=Polyfit (t, yy, n);
Plot (t, y, 'r.-', t, yy, 'g.-'); hold on; h = plot (t, y, 'r', t, yy, 'r'); hold off; ylim([0 200])
hold, grid on, type fitfun
start = [1;0]; options = optimset('TolX',2);
estimated_lambda = fminsearch (@(x) fitfun(x, t, y, h), start, options)
xlabel ('The Scanning steps for assembly Line'),...
   ylabel ('The Expected time monitoring with Validation System in (Sec)'),...
   gtext ('The Standard Scanning time with I.Verification')
   title ('Using Time Line to control IdealStandard lines')
```

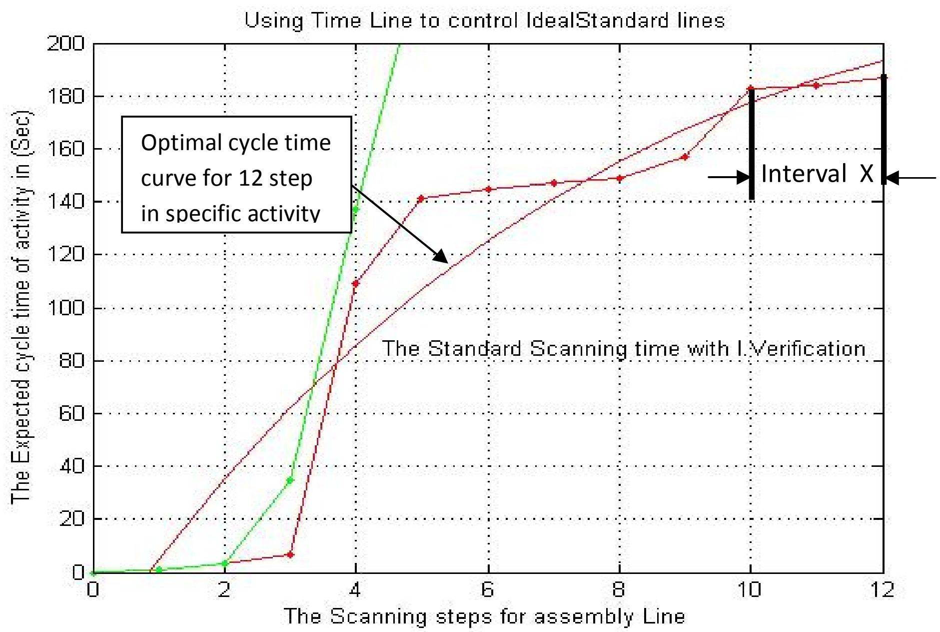


Figure 5. The optimal time curve for the steps executed in specific activity

(Figure 5) illustrates the interval X that match with clock monitor; the machine is stopped automatically by the control system to prevent scrap parts. The next phase applies code between processes to reduce NNVA time.

4.2. Verification code (Step II)

Verification to corrective is the second section in the proposed flowchart, the verification executed by picked sequential images in fixed time domain to decide verification level of the product.

```
using System;
using System.Drawing;
using System.Drawing.Imaging;
using System.Security.Cryptography;

namespace ZagazigUniversity
{
        public class Verification
        {
                public enum Check
                {       Part_Pass,Points_Defect,Size_Defect             };
```

```
        public static Check Compare(Bitmap fileNameBase, Bitmap Produced)
                {
                        Check cr = Check.Part_Pass;
                        if (fileNameBase.Size != Produced.Size)
                                {     cr = Check.Size_Defect;            }
                        else
                        {
System.Drawing.ImageConverter ic = new System.Drawing.ImageConverter( );
                                byte[ ] baseImage1 = new byte[1];
btImage1 = (byte[ ])ic.ConvertTo(fileNameBase, baseImage1.GetType( ));
                                byte[ ] producedimage2 = new byte[1];
btImage2 = (byte[ ])ic.ConvertTo(produced, producedimage2.GetType( ));

            SHA256Managed shaM = new SHA256Managed( );
            byte[ ] hash1 = shaM.ComputeHash(baseImage1);
            byte[ ] hash2 = shaM.ComputeHash(producedimage2);
            for (int i=0; i<hash1.Length && i<hash2.Length && cr==Check.Part_Pass; i++)
                                {
                                  if (hash1[i] != hash2[i])
                                  cr = Check.Points_Defect;
                                }
                        }
                        return cr;
                }
        }
}
```

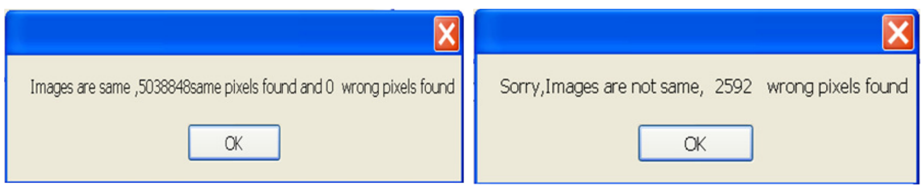


Figure 6. The comparison product process result.

(Figure 6) illustrates the result of comparison among picture which stored in database and every part produced. This result determine the rework percentage the used in mathematical model (phase I).

V. CONCLUSION

The proposed steps is divided into two phases, every phase have two steps that formulate a code that present a future quantity after known days (future state), the first phase based on percentage of reworking and scraping parts during the same tasks of different operations. The starting production point is 1354 parts as shown in (Figure 2) and the best productivity is 1990 or 2500 parts as shown in (Figure 3). The model used to determine best quantity with respect to profits taking into account marketing and inventory costs that appeared if company produce extra product. The unit price is exchange if customer demands difference about company productivity in overproduction case. The ideal situation when customer demand is equal to company productivity.

The second phase illustrates a preventive and corrective system for rapid modeling and manufacturing of objects with contact dimension. The system needs the 2D optical digitizing system and the dimension reconstruction software. The optical digitizer utilized a white-light source for image acquisition that makes this technology cost-effective, fast in image acquisition and portable for various applications. The inspection time (NNVA) was reduced from 1.25 *min* to 0.28 *sec.*

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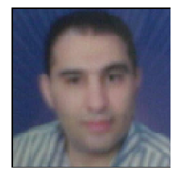

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