# Cost – Effective Solution for Twist Free Chassis Design of Three Wheeler Vehicles

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**Abstract - This paper presents studies and analysis for designing the solution against chassis twist in three wheelers. It covers all comprehensive aspects of chassis twist, measurement, causes and effects of twist, stresses; energy consumption ,manpower cost etc.The project also covers the designing of standard operating procedure for quality production, statistical quality control approach, and also designing the manufacturing process for higher productivity and quality.**

**The mechanism of twist in chassis and analysis in terms of twist repair, manpower cost, electrical energy consumption, stresses is analyzed. The manpower cost reduction is by 48.34 %, whereas the electrical energy cost is reduced by 42.69 %.**

**By designing the SOP. (Standard operating procedure) at work stations leads to increase in awareness for quality and decrease of rework rate by 75 % at work stage, where main beam subassembly is produced.**

**The statistical quality control approach can be implemented for the quality aspects and its control. The cost saving up to 66.49 % can be achieved by implementing new method for the chassis going to CED paint shop as part for productivity improvement. Also the cost saving is by Rs. 12.80 per chassis by implementing new method.**

**Keywards: chassis, chassis twist, stress analysis, standard operating procedure, statistical quality control, Productivity, quality, cost, brazing**

## I. INTRODUCTION

The motor vehicles, both passenger car and goods truck, are generally considered to be made up of two major assemblies 1) chassis 2) Body. Chassis is a French term and was initially used to denote the frame or the main structure of vehicle. It is now extensively used to denote the completely vehicle except the body for the heavy vehicle having a separate body. In case of light vehicles of monoconstruction, it denotes the whole body except the additional fittings in the body.

### A. Objectives of study

1. To design for the solution of chassis twist for three wheelers.
2. To increase the quality rate for the production of three wheelers chassis as a product.
3. To increase the customer satisfaction level by decreasing defects in chassis of three wheelers as a product.
4. To design the manufacturing process for higher productivity and quality in three wheelers without twist.

### B. Twist in chassis

- Twist in chassis is specified as a) dome twist b) Rear or overall twist.
- The height difference between left and right side measured at front dome area of chassis is called as dome twist.

- The height difference between left and right long member measured at rear side is called as rear or overall twist.
- The causes and effects of twist in chassis are given and comprehensive aspects of twist mechanism to be analyzed

*C. The causes for twist in chassis*

1. Clamping pressure low- The certain assemblies are produced on the fixture with pneumatic clamping system.
2. The blocks of the fixture wear out or the loose. Dome frontal pin location not ok.
3. The intermediate box wrongly fitted to the long member.
4. BS2 / BS3 model changeover not done at work stage where long member and cross member assembly are joined.
5. Main frame assembly angle variation or unsymmetrical welding of front parts.
6. The work stages operators are not of qualified skill or lack of technical training for the work.
7. The dimensional variation in the incoming materials. Scarcity of measuring gauges and working fixtures preventive maintenance adherence.

*Effects of twist in chassis*

1) Aesthetic design considerations affected.

2) The wear of tyre surfaces is excess.

3) It needs excess physical efforts and energy, time and the resources for rectification of twist in chassis.

4) The vehicle may get skid due to uneven forces.

5) The rubber shock springs get unevenly deflected.

6) The rapid failure of chassis and customer dissatisfaction increases.

7) The dimensional variation occurs tending to mismatches of parts during production of chassis, the dimensional accuracy not achieved. The cost associated with repair of chassis is increased.

Table 1 Dome twist data for period

| Sr.No. | Month | Average twist | Power cost (Rs) |
|--------|-------|---------------|-----------------|
| 1) | January 2014 | 11.7 | 9.0 |
| 2) | Feb. 2014 | 9.4 | 7.23 |
| 3) | March 2014 | 7.7 | 5.93 |
| 4) | April 2014 | 6 | 4.62 |
| 5) | May 2014 | 5 | 3.85 |

## II. PRPPOSED METHODOLOGY

*A .Controlling Of Twist InChassis*

*A1.ParallismControlled By Pneumatic Cylinder Mechanism*

The pneumatic cylinder mechanism is provided for controlling parallism of front parts. It is working on pneumatic operating pressure of 6 bar .The clamping force = 1061.1 N.

The calculation is given as below.

Pneumatic piston force, $F = A * P - R$      (1)

$F = P*10*d^2*3.14 /4 - R$      (2)

Where A = Piston area (cm$^2$), P= Operating pressure (bar), R = Friction force = 10 % (N)

Piston area A = 3.14*d$^2$/4, d = piston diameter = 50 mm = 5 cm.

Hence ,A = 19.625 cm$^2$

F = 6*10*5*5*3.14/4 – 106.1

= 1177.5 -117.8

= 1059.7 N



Pneumatic cylinder

Figgure 1.Parallism controlled by pneumatic cylinder mechanism
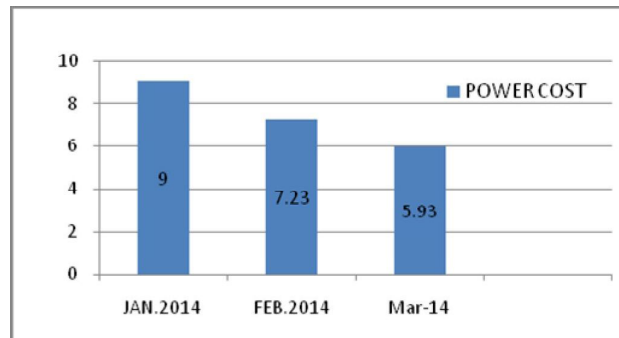
## III. EXPERIMENTATION AND RESULT

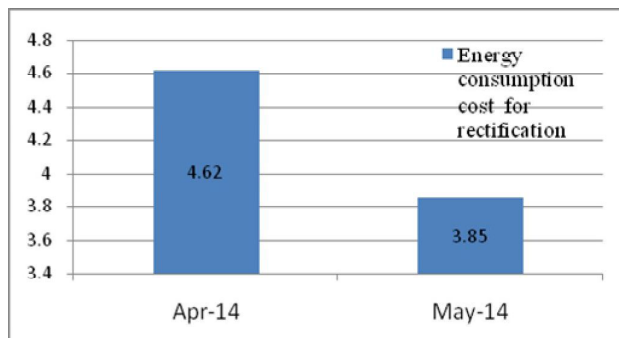A. Kaizen Implementation For Holding Cup On bracket:



Clamp Miler for holding cup knob

Figure 2. Kaizen implementation for holding cup on bracket

Graph 1 Energy consumption cost for rectification (a), (before controlling)4/13



Graph 2 Energy cost for rectification (b), (after controlling)



*B.Manpower Cost Analysis*
The observations show that the operator time required for twist rectification is about 5 min. The salary paid to operator is of Rs 7500 per month. The following tabulated data is given here for the cost.
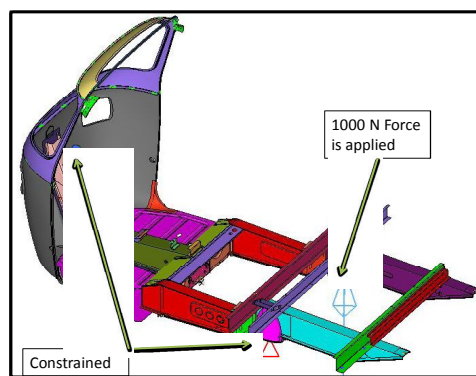
Table 2 manpower cost analysis

| Sr no. | Month | Avg. twist | Total time(Min.) | Manpower cost(Rs.) |
|--------|-------|------------|------------------|--------------------|
| 1 | Jan.2014 | 11.7 | 58.5 | 30.46 |
| 2 | Feb.2014 | 9.4 | 47 | 24.48 |
| 3 | Mar.2014 | 7.7 | 38.5 | 20.05 |
| 4 | April 2014 | 6.0 | 30 | 15.63 |
| 5 | May 2014 | 3.85 | 19.25 | 10.02 |

Graph 3 Manpower cost for the given period
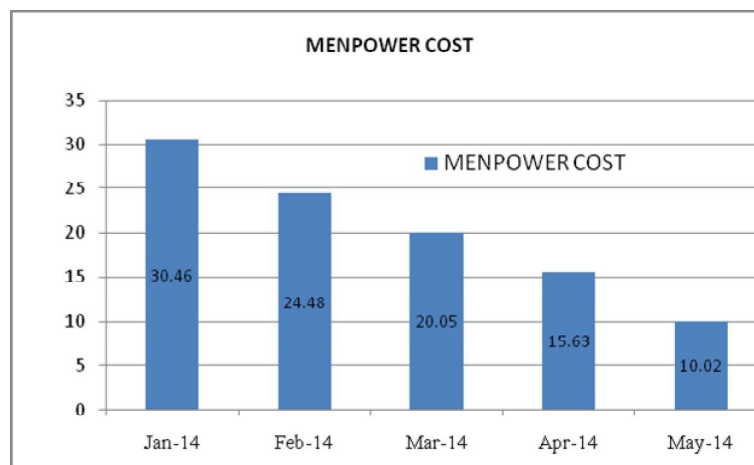
Twisting of chassis.



*C. CAE Analysis of Twisting Of Chassis:*

- For analysing chassis in twisting condition in three wheeler, front end and one of the rear end is fixed
- Force of 1000 N is applied at the rear free end of the 3 wheeler chassis, tempting body to get twisted.
- After applying above condition, results are obtained for the displacement and stressof twisted body of the threeWheeler.
SOFTWARES USED:
1) Modelling: Pro-E   2) FE Modelling: Hyper mesh 12.0
3) Solver and Post Processor: Optistruct and Hyper view
ST 45 MATERIAL PROPERTIES:
1) Young's Modulus: 2.1E5 MPA   6/13
2) Poisson's ratio: 0.3 ,3) Density (Steel) : 7.89e – 6 Kg/ mm$^3$
MESHING PROPERTIES:
1) Element Size – 10 mm  , 2) Element type – trias and quads (2D    Rigid, bars and beams (1D)
*Twisting Of Chassis (Stress Analysis)*
 As shown in below fig. front end and one of rear end is kept fixed and 1000N force is applied on the rear free end of the chassis
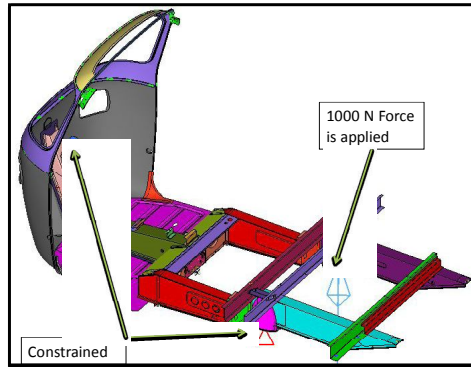
Twisting of chassis.



Figure 3.CAE Analysis (Twisting of chassis)

**Displacement Result:** Displacement of the rear end of the chassis at which force is applied. It is found around 14mm.

**Stress Result:** with application of 1000N force at one of rear end the stresses are found on rear end of vehicle. Max stress found is around 220 MPA which is less than yield limit (230 MPA)
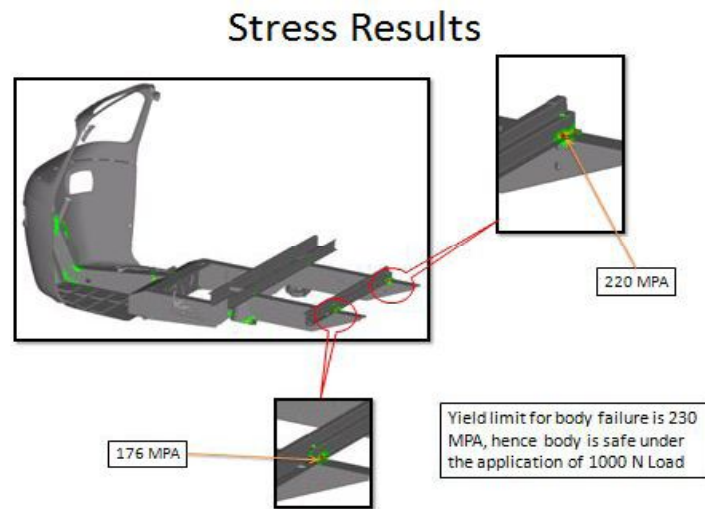
## Displacement Results
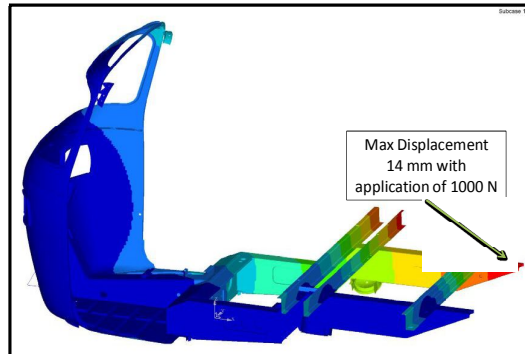
## Stress Results



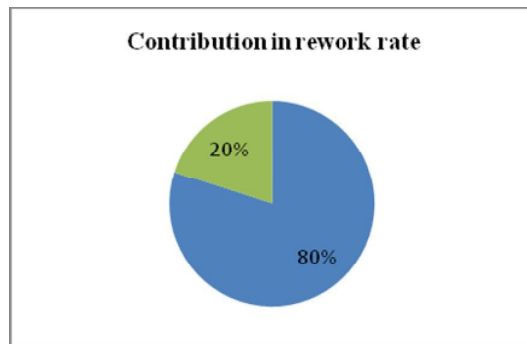Figure. 5 CAE Analysis (stress result )

Table 3 Impact Of Implementation Of S.O.P.(standard operating procedure)

| SR.NO | PARAMET ER | BEFORE IMPLEME - NTATION OF S.O.P. | AFTER IMPLEMENT- ATION OF S.O.P. |
|---|---|---|---|
| 1) | Rework rate ( Qty / week ) | High. Quantity = 4 | Low and Quantity =1. The % decrease in rework rate=75%. Wastage control is achieved. |
| 2) | Quality awareness | Less | More |

Graph 4 Pie chart for analysis of rework rate

Pie chart is used to display the contribution of rework rate before and after implementation of standard operating procedure .From the tabulated data, 1 job /week contributes to 20 % (less rework rate), whereas, 4 jobs / week contributes to 80 % (before implementation of S.O.P.)

Table 4    Production, Defects And % Quality Product Rate

| Sr.No. | shift | production | No. of defective | % defective units | % Quality product rate |
|--------|-------|------------|------------------|-------------------|------------------------|
| 1 | 1 | 167/175 | 40. | 23.95 | 76.04 |
|   | 2 | 73/73 | 12 | 16.44 | 83.56 |
| 2 | 1 | 175/175 | 16 | 9.14 | 90.86 |
|   | 2 | 70/73 | 5 | 7.14 | 92.86 |
| 3 | 1 | 175/175 | 14 | 8.0 | 92.0 |
|   | 2 | 65/73 | 12 | 18.46 | 81.54 |
| 4 | 1 | 175/175 | 18 | 10.28 | 89.72 |
|   | 2 | 73/73 | 4 | 5.48 | 94.52 |
| 5 | 1 | 175/175 | 23 | 13.14 | 86.86 |
|   | 2 | 73/73 | 6 | 8.22 | 91.78 |
| 6 | 1 | 175/175 | 9 | 5.14 | 94.86 |
|   | 2 | 70/70 | 5 | 7.14 | 92.86 |

## FORMULAE  FOR P- CHART

1) $UCL = \bar{p} + 3\sqrt{\dfrac{\bar{p}.q}{N}}$

2) $LCL = \bar{p} - 3\sqrt{\dfrac{\bar{p}.q}{N}}$

3) $\bar{p} + q = 1$

4) $\bar{p} = \dfrac{\sum p_i}{n}$

Notations have usual meaning as below:

1) UCL= upper control limit
2) LCL =lower control limit
3) N = average lot size
4) n = no. of lots.

Table 5 Lot wise Defect And U.CL. , L.C.L. Data

|  | A | B | C | D | E |
|---|---|---|---|---|---|
| LOT1 | 240 | 52 | 0.22 | 0.1823 | 0.05763 |
| LOT2 | 245 | 21 | 0.09 | 0.1823 | 0.05763 |
| LOT3 | 240 | 26 | 0.11 | 0.1823 | 0.05763 |
| LOT4 | 248 | 22 | 0.09 | 0.1823 | 0.05763 |
| LOT5 | 248 | 29 | 0.12 | 0.1823 | 0.05763 |
| LOT6 | 245 | 14 | 0.06 | 0.1823 | 0.05763 |
| Total | 1466 | 164 | 0.67 | 0.1823 | 0.05763 |

In table 5, following notations are used.

A = PRODUCTION ,

B = DEFECTS    ,

C = % DEFECTS  ,

D = U.C.L.   (UPPER CONTROL

LIMIT)

E = L.C.L.   (LOWER CONTROL

LIMIT |)

Graph 5   P- Chart For Variable Lot Size:

Table 6 Brazing Alloy Consumption And Cost Analysis

| SR. NO | PARAMETER | PREVIOUS METHOD (A) | NEW METHOD (B) |
|---|---|---|---|
| 1 | Material used | Brazing filler alloy. | Brazing filler alloy with thumb grade sealer. |
| 2 | Cost | RS. 770/kg | sealant cost = Rs 160/kg |
| 3 | Consumption analysis | 4 Rods = 5 Chassis | 1 Rod = 5 Chassis |
| | | 5 kg = 158  qty | 20 Rods = 0.63 kg = 100 chassis. |
| | | 80 Rods = 100 Chassis | RS for 0.63 kg= Rs 485 |
| | | Also 80 Rods = 2.53 kg | 20 lines sealant = 1 kg |
| | | | 1 kg sealant = 100 Chassis |
| | | RS = 1925 | Total Cost = 485+160 = RS 645 |
| 4 | Cost for 100 Chassis | Rs.1925 | Rs 645 |
| 5 | Saving | | Rs 1280 |
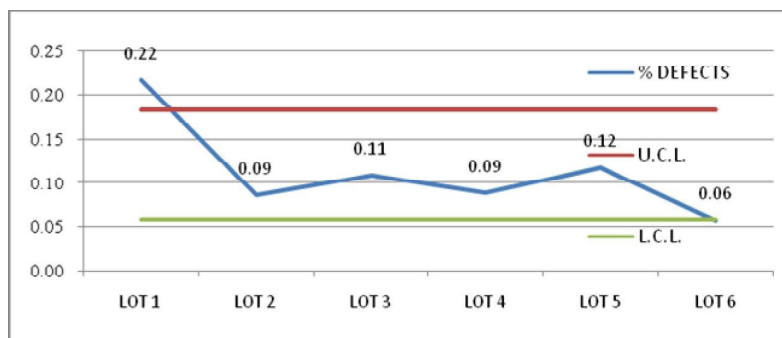


D. Designing TheManufacturing Process For Higher Productivity And Quality Without Twist

Graph 6 Comparison of Consumables Cost
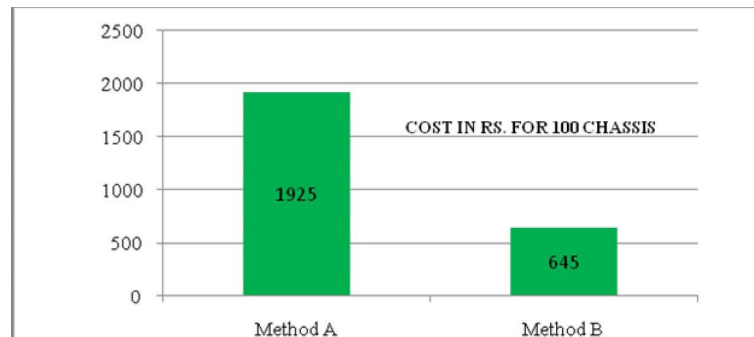




Brazing operation Figurer 6 (Previous Method) Section Of     Chassis Where Brazing

Is Applied



Brazing operation                                    Thumb grade sealer

Figure 7 (New And Implemented Method) Section Of Chassis Where Along With Brazing, Thumb Grade Sealer Is applied.

**Ratio Analysis:** It is important technique to compute percentage saving on Material.

The percentage saving on material cost =

(Total cost by using brazing filler alloy)  -

(Total cost by using brazing filler    along with   thumb grade sealer) *10

_____

(Total cost by using brazing filler alloy)

= 1280/1925 *100

= 66.49 %

## IV.    CONCLUSION

1) The mechanism of twist in chassis and analysis in terms of twist repair, manpower cost, electrical energy consumption, stresses is analyzed. The electrical energy cost reduction is by 42.69   %, where as the manpower cost is reduced by 48.34 %.

 2) By designing the SOP. (Standard operating procedure) at work stations leads to increase in       awareness for quality and decrease of rework rate by 75 % at work stage, where main beam subassembly is produced.

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