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Analysis of "Variation in Non-Uniformity with Runout Temperature of Tyre" Using Taguchi Parametric Optimization Technique

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Abstract

tyre uniformity is a vital property of tyre . The main parameter on which uniformity depends is Radial force, lateral force, and conicity. We have taken value of all three parameter of six hundred tyres and found the relative variation of all with respect to the run out temperature of tyre. We found by the analysis that variation in LC is uneven. And on the other hand variation of RC & CONICITY with in rang. Hence a needful work is required to control the variation of "LC". With all these regration modally has also been done. To get the relation of LC, RC, CONICITY with the run out temperature. We conclude that the parameter varies with the temperature & they can be controlled.

***Keyword*:-** Uniformity, Radial Force Compnent (RC), Lateral force Components (LC), Conicity, Run Out Temperature,

I. Introduction

1.1 What is tire UNIFORMITY?

Actually Its mean is Non Uniformity, A Quantitative Measure within a Tire Usual Variations are in forces and Run Outs. In order to verify that a tire will not have problems on the Customer Vehicle we must measure variation Characteristics (Forces and Run outs).

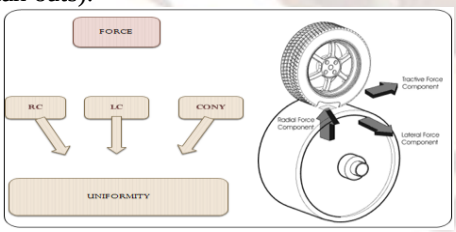


Fig.(1) Forces apply on Tyre uniformity

1.2 Ununiformity Depend On:-

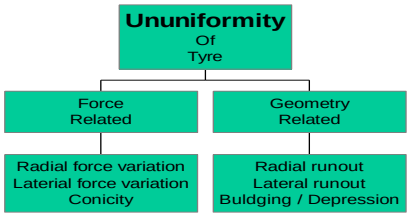


Fig.(2) Basic parameter of uniformity

1.3 Radial Force Variation:-The vertical force between the tire and the road. Radial force variation is caused by tires which are not perfectly round. Passenger will feel riding uncomforted and will travel with a periodic jerk.

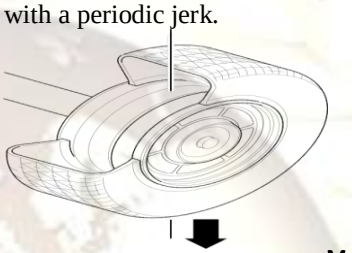


Fig.(3) Radial Force

1.4 Lateral Force Variation :-Lateral force variation is a term which may be explained as a condition where the tyre steer from side to side. Lateral force can be caused by a breaker being applied 'crooked' or 'snaky 'to the tyre

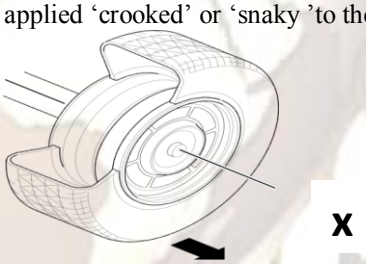


Fig.(4) Lateral Force

1.5 Conicity :-The tendency of a tyre to react like a cone and tries to roll in a circular path.Off center tread or belt application is one of the main reason for conicity generation of the tyre.

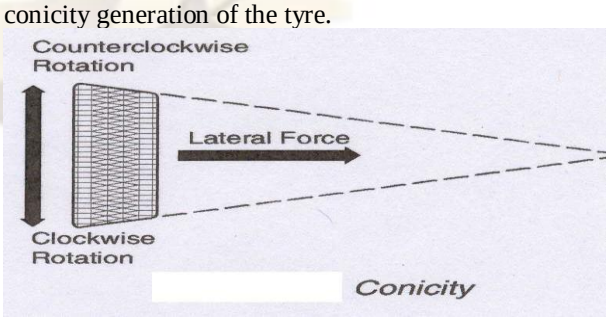


Fig.(5) Conicity.

II. Research Methodology

2.1 Taguchi

Quality control methodology that combines control charts and process control with product and process design to achieve a robust total design. It aims to reduce product variability with a system for developing specifications and designing them into a product or process. Named after its inventor, the Japanese engineer-statistician Dr. Genichi Taguchi who also developed the quality loss function

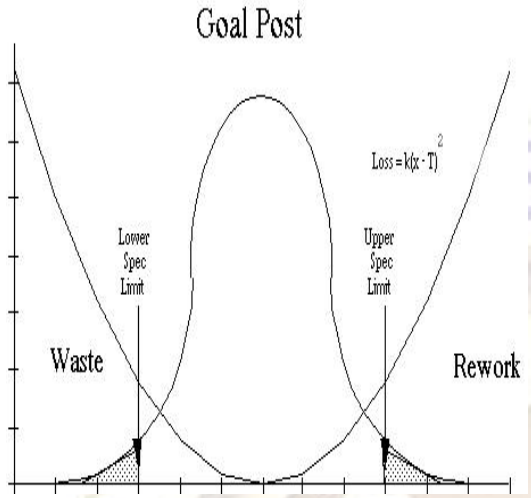


Fig.(6) EPS IN TAGUCHI

2.2 Step use in Taguchi

Step-1: Identify The Main Function, Side Effects, And Failure Mode.

Step-2: Identify The Noise Factors, Testing Conditions, And Quality Characteristics.

Step-3: Identify The Objective Function To Be Optimized.

Step-4: Identify The Control Factors And Their Levels.

Step-5: Select The Orthogonal Array Matrix Experiment.

Step-6: Conduct The Matrix Experiment

Step-7: Analyze The Data, Predict The Optimum Levels And Performance

Step-8: Perform The Verification Experiment And Plan The Future Action

III. Experimental Set Up

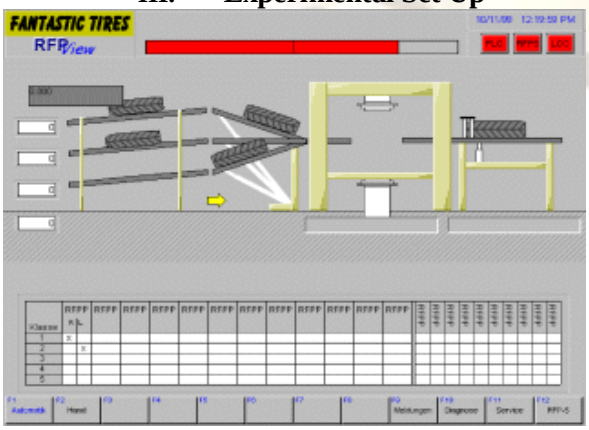


Fig.(7) TUO measuring m/c

IV. Data Analysis

4.1 {ANOVA TECHNIQUE} We take three group of 100 (14_NISSAN) tire result of "RC" used in experiment

CALCULATION:

$\overline{X}_1 = 7.6279$, $\overline{X}_2 = 7.5785$, $\overline{X}_3 = 8.8566$,

$$\overline{\overline{X}} = \frac{\overline{X}_1 + \overline{X}_2 + \overline{X}_3}{3} = 8.021$$

$n_1 = 100$, $n_2 = 100$, $n_3 = 100$, $n = 300$, $k = 3$

SS Between $= n_1\{\overline{X}_1 - \overline{\overline{X}}\}^2 + n_2\{\overline{X}_2 - \overline{\overline{X}}\}^2 + \ldots + nk\{\overline{X}_k - \overline{\overline{X}}\}^2 = 104.85612$

SS With In $= \sum\{X_{1i} - \overline{X}_1\}^2 + \sum\{X_{2i} - \overline{X}_2\}^2 + \ldots + \sum\{X_{ki} - \overline{X}_k\}^2 = 1315.184778$ $i = 1,2,3, \ldots\ldots$

MS between $= \frac{\text{SS Between}}{(k-1)} = 52.42806$

MS Within $= \frac{\text{SS Within}}{(n-k)} = 4.428231$

F –RATIO $= \frac{\text{MS between}}{\text{MS Within}} = 11.839503$

(CALCULATION FOT "RC")

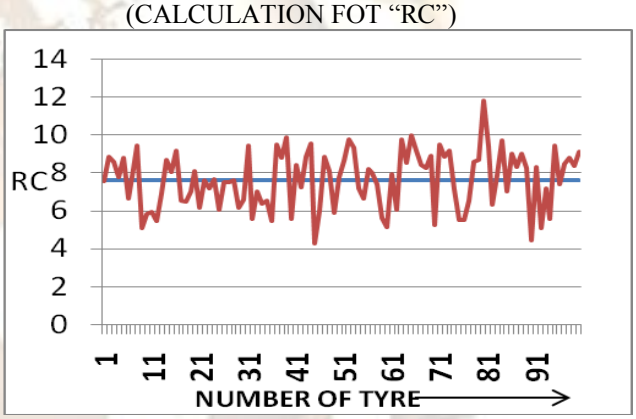


Fig. (8) (Blue line is mean of "RC")

4.2 {ANOVA TECHNIQUE} We take three group of 100 (14_NISSAN) tire result of "LC" used in experiment .

CALCULATION:-

$\overline{X}_1 = 3.7084$, $\overline{X}_2 = 3.5474$, $\overline{X}_3 = 3.4415$,.

$$\overline{\overline{X}} = \frac{\overline{X}_1 + \overline{X}_2 + \overline{X}_3}{3} = \mathbf{3.565766667}$$

$n_1 = 100$, $n_2 = 100$, $n_3 = 100$, $n = 300$, $k = 3$

SS Between $= n_1\{\overline{X}_1 - \overline{\overline{X}}\}^2 + n_2\{\overline{X}_2 - \overline{\overline{X}}\}^2 + \ldots + nk\{\overline{X}_k - \overline{\overline{X}}\}^2 = 3.6122306$

SS With In $= \sum\{X_{1i} - \overline{X}_1\}^2 + \sum\{X_{2i} - \overline{X}_2\}^2 + \ldots + \sum\{X_{ki} - \overline{X}_k\}^2 = 453.4443$ $i = 1,2,3, \ldots\ldots$

MS between $= \frac{\text{SS Between}}{(k-1)} = 1.806115$

MS Within $= \frac{\text{SS Within}}{(n-k)} = 1.526748$

F –RATIO = MS between / MS Within = 1.182982

(CALCULATION FOT "LC")

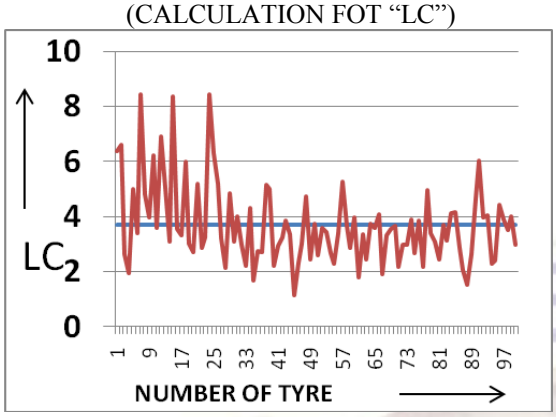


Fig.(9) (Blue line is mean of "LC")

4.3 {ANOVA TECHNIQUE} We take three group of 100 (14_NISSAN) tire result of "Conicity" used in experiment .

CALCULATION: -

$\overline{X}_1 = 1.9687$, $\overline{X}_2 = 2.212$, $\overline{X}_3 = 1.571$,.

$$\frac{\overline{\overline{X}} = \overline{X}_1 + \overline{X}_2 + \overline{X}_3}{3} = 1.917$$

$n_1 = 100$, $n_2 = 100$, $n_3 = 100$, $n = 300$, $k = 3$

SS Between = $n_1\{\overline{X}_1 - \overline{\overline{X}}\}$ ^2+$n_2\{\overline{X}_2 - \overline{\overline{X}}\}$^2+…+nk $\{\overline{X}_k - \overline{\overline{X}}\}$ ^2 = 20.9217795

SS With In = $\sum\{X_{1i} - \overline{X}_1\}$^2 +$\sum\{X_{2i} - \overline{X}_2\}$^2+…+ $\sum\{X_{ki} - \overline{X}_k\}$^2 = 871.17522 i = 1,2,3, ……

MS between = SS Between / (k – 1) = 10.46088975

MS Within = SS Within / (n – K) = 2.933249899

F –RATIO = MS between / MS Within = 3.566313853

(CALCULATION FOT "CONY ")

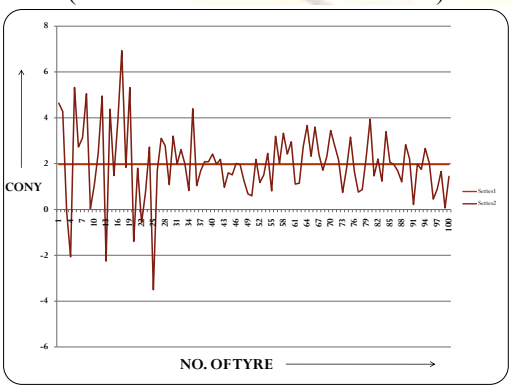


Fig. 10 - (Blue line is mean of "conicity")

4.4 Value measured by TUO/machine (548) "14_NISSAN "tire result (RC, LC, CONY) used in experiment)

TABLE – (600, sample tyre)

S.N.	RC	LC	CONY
1	7.53	6.4	4.65
2	8.81	6.62	4.28
3	8.59	2.65	-0.09
4	7.77	1.96	-2.06
5	8.76	5.01	5.33
6	6.62	3.41	2.73
7	8.21	8.45	3.13
8	9.41	4.83	5.05
9	5.08	3.99	0.040
10	5.82	6.23	1.07
11	5.93	3.6	2.47
12	5.41	6.92	4.96
13	6.91	5.05	-2.25
14	8.65	3.12	4.38
15	8.01	8.37	1.49
16	9.14	3.57	3.89
17	6.51	3.32	6.93
18	6.46	6.01	1.84
19	7.00	3.02	5.33
20	8.08	2.71	-1.40
21	6.13	5.2	1.81
22	7.57	2.87	-0.57
23	7.18	3.27	0.76
24	7.66	8.45	2.73
25	6.01	6.33	-7.59
26	7.46	5.19	1.71
27	7.51	3.24	3.11
28	7.59	2.14	2.79
29	6.14	4.85	1.09
30	6.57	3.11	3.21
31	9.42	4.02	1.99
32	5.57	2.98	2.62
33	7.02	2.24	1.98
34	6.38	4.34	0.83
35	6.51	1.7	4.40
36	5.45	2.77	1.05
37	9.46	2.72	1.69
	Up	**to**	
600	8.89	3.84	1.57

REPEATABILITY - EXPRESSED AS 3 σ

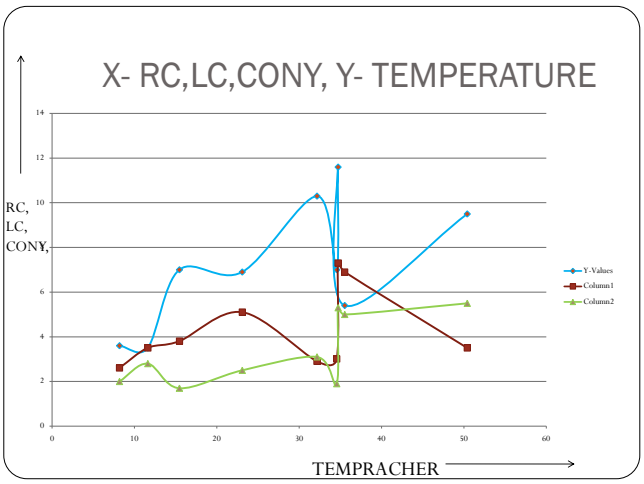
TABLE–(exp. Data given by J.K. TYRE)

TEMP.	RC	LC	CONICITY
77℃	±7.0	± 10.8	± 7.96
44℃	± 6.6	± 4.5	± 6.35
23℃	± 6.4	± 3.3	± 3.35

Y= (RC) ^0.9353 * (LC)^0. 3741* (CONY) ^0.7894

TABLE – 3 (**Taguchi L_9 Orthogonal Array)**

RC	LC	CONY	RC	LC	CONY	TEMP(℃)
L	L	L	3.6	2.6	2	8.188
L	M	M	3.5	3.5	2.8	11.624
L	H	H	5.4	6.9	5	35.529
M	L	H	7	3	5.3	34.725
M	M	L	7	3.8	1.7	15.461
M	H	M	7	3.8	1.7	23.089
H	L	M	10.3	2.9	3.1	32.165
H	M	H	9.5	3.5	5.5	50.401
H	H	L	11.6	7.3	1.9	34.562



Graph – 1(BETWEEN RC, LC, CONICITY & TEMP.)

The Basic Taguchi L_9 Orthogonal Array

The S/N ratio is computed deviation (MSD) by the equations:

$$\textbf{S/N Ratio} = -10 \log_{10} \textbf{(MSD)}$$

For the S/N ratio to be large, MSC must have a value that is small. If smaller is the best quality characteristic;

$$\textbf{MSD} = [(Y_1^2 + Y_2^2 + \text{----------} + Y_n^2)] / N$$

TABLE – (MSD)

MSD	L	M	H
RC	488.17	659.34	1589.83
LC	769.18	971.49	996.67
CONY	500	567.62	1669.51

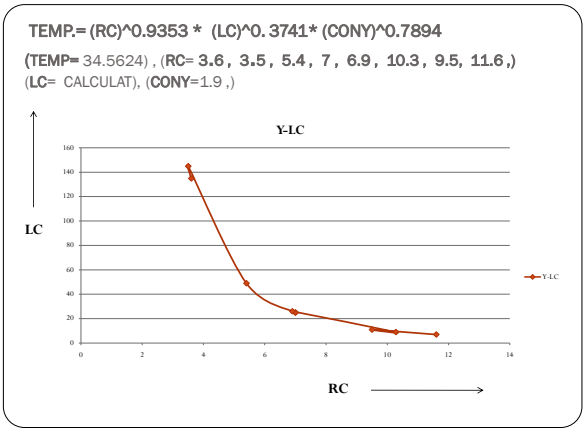
TABLE – (S/N RATIO)

S/N RATIO	L	M	H
RC	- 26.6	- 28.8	- 32.01
LC	- 28.8	- 29.8	- 29.9
CONY	- 26.9	- 27.5	- 32.2

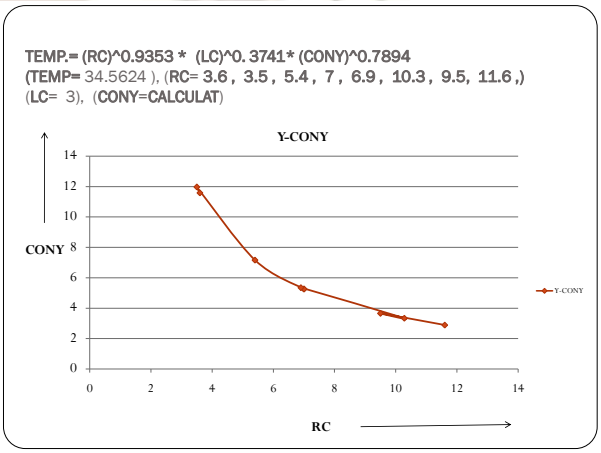
V. Result

All three primitives RC, LC, Conicity varies with temperature the minimum non uniformity is at 11°C while RC, & LC increase with temperature where the conicity decrease with temperature up to 23°C at than 34.7°C sudden change got in RC, LC conicty occur.

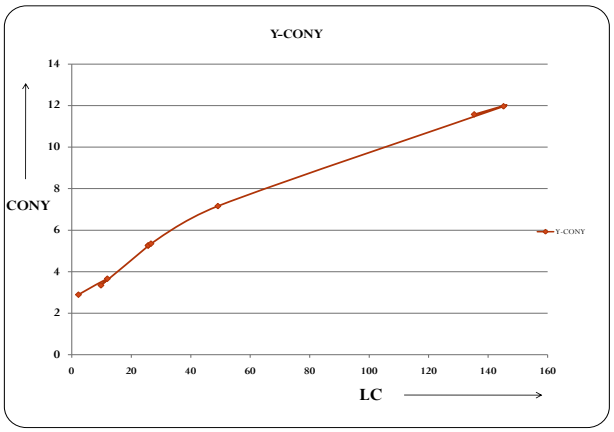
RELATION BETWEEN UNIFORMITY FACTOR (RC , LC, CONICITY)



Graph – 2 (BETWEEN LC & RC)



Graph – 2 (BETWEEN CONICITY & RC)



Graph – 2 (BETWEEN CONICITY & LC)

VI. Conclusion

(1) Non-Uniformity of tire varies the temperature of tire during the Running condition.
(2) Increment of temperature also depend on the type of non- uniformity (RC, LC, CONY).

VII. Acknowledgement

The authors gratefully acknowledge HOD MPCT College & J.K. Tyre, for his esteemed support in arranging and providing all the facilities for the completion of work.

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Net Support

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(c) http://www.freepatentsonline.com/6673184.html
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