Determination of Maximum Recommended Weight Limit for Manual Lifting Task in Industry through Taguchi Parametric Optimization Technique

Ajay Bangar, Manoj joshi, Ganesh Pal Singh Jadon, Rajan Sharma
Mechanical Engineering Department, Maharana Pratap College of Technology,
Gwalior, Madhya Pradesh, India.
E-mail:abangar1000000@gmail.com,manojjoshi53@yahoo.in,ganeshjadon00@gmail.com,
rjnsharma@rediffmail.com

Abstract: ***In this paper Authors have tried to calculate the maximum Recommended Weight Limit (RWL) for manual lifting task in industry on the basis of revised Load constant (LC), Horizontal Multiplier (HM), Vertical Multiplier (VM), which are calculated according to the collected data from industry. The purpose of this paper is to efficiently determine the optimum combination of those three factors to achieve the maximum recommended weight limit. In the order to meet the purpose in term of Recommended Weight Limit (RWL), author has applied the taguchi parametric optimization technique. The base of this study is NIOSH lifting equation, in this equation the recommended weight is calculated by the multiplication of seven factors, authors have worked only three factors i.e. LC, HM, VM respectively.***

Keyword: Recommended Weight Limit (RWL), Horizontal Multiplier (HM), Vertical Multiplier (VM), Load Lifting, Safe Weight, Load Constant (LC), taguchi methodology.

I.INTRODUCTION

A. Literature History:

The NIOSH (National institute for occupational safety &health) lifting equation was designed to evaluate RWL to avoid the risk of lifting task with respect to low back injury (water, puts, Anderson, Gargandfine 1993). The equation is widely accepted and used through out in industry insetting acceptable lift limits for workers. It was revised in 1991.

RWL=LC× HM×VM× DM× AM× FM× CM

This equation is used for calculating the value of RWL

Here

DM = Distance Multiplier
AM = Asymmetric Multiplier
FM = Frequency Multiplier
CM= Coupling Multiplier

The values of LC, HM, VM is find out from the reference papers [4]

B. For Load constant (LC)

Age (year)	Load Const.(LC) in kg		
	Low capacity (lc) = 23	Medium capacity (mc) = 28	High capacity (hc) = 33
20	10	13.48	17.97
25	15	17.97	21.59
30	20	21.59	26.35
35	15	17.97	21.57
40	10	13.48	17.97
45	5	8.07	13.48
50	5	8.07	13.48

TABLE I
load constant

C. For Horizontal Multiplier (HM)

TABLE II
Horizontal Multiplier

Distance From C.G. (inches) H	Horizontal Multiplier(HM)										
	Waist (inches)										
	30	32	34	36	38	40	42	44	46	48	50
≤10	1.00	.93	.88	.83	.78	.75	.71	.68	.65	.62	.60
11	.90	.85	.81	.76	.73	.69	.66	.63	.61	.58	.56
12	.83	.78	.75	.71	.68	.65	.62	.60	.57	.55	.53
13	.76	.73	.69	.66	.63	.61	.58	.56	.54	.52	.50
14	.71	.68	.65	.62	.60	.57	.55	.53	.51	.50	.48
15	.66	.63	.61	.58	.56	.54	.52	.50	.49	.47	.46

D. For Vertical Multiplier (VM)

TABLE III
Vertical Multiplier

Vertical distance (inches) V	Vertical Multiplier(VM)			
	Height ≤66	66<Height ≤68	68<Height ≤70	70<Height ≤72
0	.78	.76	.76	.75
5	.81	.80	.79	.79
10	.85	.84	.83	.82
15	.89	.88	.87	.86
20	.93	.92	.91	.90
25	.96	.95	.94	.94
30	1.00	.99	.98	.97
35	.96	.96	.97	.98
40	.93	.93	.93	.94
45	.89	.89	.90	.90
50	.85	.85	.86	.86
55	.81	.81	.82	.83
60	.78	.78	.78	.79
65	.74	.74	.75	.75
70	.70	.70	.71	.72
>70	0.00	0.00	0.00	0.00

II. DATA ANALYSIS

S.No	Name	Age (Yr.)	Weight (Kg)	Height (CMs)	Job Weight (Kg)	Distance Of Weight (Horizontal) (Inches) H	Ht. Of Job from Ground (Inches) V	Vertical distance (inches) D
01	MAHESH CHAWLE	44	64.8	158	10.7	11	40	≥10
02	BALRAM	50	60	169	5.8	13	42	≥10
03	RAJENDRA	30	77	177	6.1	14	45	≥10
04	SHIVDAYAL	38	61	163	10.5	12	39	≥10
05	S.M. SHARMA	47	64.8	166	13.4	11	42	≥10
06	RAM PRASAD	36	76.4	177	12.7	13	39	≥10
07	M.L.DALAL	45	68.7	166	8.9	12	38	≥10
08	MAHESH	48	60.3	170	11.5	15	39	≥10
09	P. CHAND	43	68	170	13.4	15	54	≥10
10	AJAY	32	64	164	14.2	14	39	≥10
11	VIKRAM	35	63	169	3.1	13	39	≥10
12	C.S.CHAUHAN	34	79.7	163	2.9	11	39	≥10
13	SANDEEP SINGH	35	67	173	2.9	13	39	≥10
14	MANGILAL	24	65	175	6.1	14	39	≥10
15	VASANT	23	61	165	7.5	12	42	≥10

A. Data Collection

TABLE IV
The Data Collected From The Company, GAJRA GEAR Ltd.

III. TAGUCHI OPTIMIZATION TECHNIQUE

A. Introduction

AS per the Taguchi Technique the Quality characteristic utilized in the work is **higher the Better**. Authors have calculated Mean recommended weight limit (MRWL) ,Mean Slandered Deviation(MSD) of MLT and Signal To Noise Ratio (S/N)

$$MLT(\text{in }\%) = (1/Y_1 + 1/Y_2 + 1/Y_3)/3$$

$$MSD = (1/Y1^2 + 1/Y2^2 + 1/Y3^2) / 3$$

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

Here Y1, Y2, Y3 are the recommended weight limit of each group respectively.

IV. CASE STUDY

Following are parameters and their levels

TABLE V :
Process Parameters and their Levels

Symbol	Controllable factors	Level 1 lower	Level 2 medium	Level 2 higher
A	**LOAD CONSTANT**	(5-11)	(12-18)	(19-26)
B	**HORIZONTAL MULTIPLIER**	(.46-.60)	(.61-.73)	(.74-1)
C	**VERTICAL MULTIPLIER**	(.70-.80)	(.81-.90)	(.91-1)

TABLE VI
For mean recommended weight limit (MRWL), Mean Standard Deviation (MSD) and Signal to Noise Ratio (S/N) of each group

Group no	Load constant	Horizontal multiplier	Vertical multiplier	Mean recommended weight limit	MSD	S/N ratio
1	L	L	L	3.23	.176	7.55
2	L	M	M	5.17	.0710	11.48
3	L	H	H	7.12	.033	14.76
4	M	L	H	7.28	.022	16.73
5	M	M	L	9.10	.017	18.67
6	M	H	M	10.92	.0095	20.25
7	H	L	M	11.53	.0089	20.50
8	H	M	H	13.96	.0067	22.16
9	H	H	L	15.78	.0047	23.22

A. Mean recommended weight limit (MRWL)

The analysis of each controllable factor is studied and the main effect of the same is obtained in the table main effect of each factor at individual level i.e. at 1,2,3 levels is equal to the mean of recommended weight limit of all the experiments with the factor at individual level.
For example

The main effect of the load constant on recommended weight limit at various level is calculated as follows
L= (3.27+5.22+8.13)/3 = 5.54
M= (7.22+9.03+10.72)/3=8.99
V = (11.66+14.12+15.96)/3= 13.91

The main effect of the HORIZONTAL MULTIPLIER recommended weight limit at various level
L= (3,27+7.22+11.66)/3= 7.38
M = (5.22+9.03+14.12)/3 =9.45
H = (8.13+10.72+15.96)/3 = 11.60

The main effect of the VERTICAL MULTIPLIER recommended weight limit at various level

L = (3.27+9.03+15.96)/3= 9.42
M= (5.22+10.72+11.66)/3= 9.2
H= (8.13+7.22+14.12)/3=9.82

TABLE VII
Factors recommended weight limit

Symbol	Controllable factors	Level 1 lower	Level 2 medium	Level 2 higher
A	**LOAD CONSTANT**	5.54	8.99	**13.91**
B	**HORIZONTAL MULTIPLIER**	7.38	9.45	**9.41**
C	**VERTICAL MULTIPLIER**	9.42	9.2	**9.82**

Symbol	Controllable factors	Level 1 lower	Level 2 medium	Level 2 higher
A	LOAD CONSTANT	11.26 (A1)	13.19 (A2)	**21. 96 (A3)**
B	HORIZONTAL MULTIPLIER	14.84 (B1)	17.43 (B2)	**19. 41 (B3)**
C	VERTICAL MULTIPLIER	16.48 (C1)	17.41 (C2)	**17. 88 (C3)**

From the table the values in bold show the higher the better criteriaas proposed by taguchi method.

GRAPH I

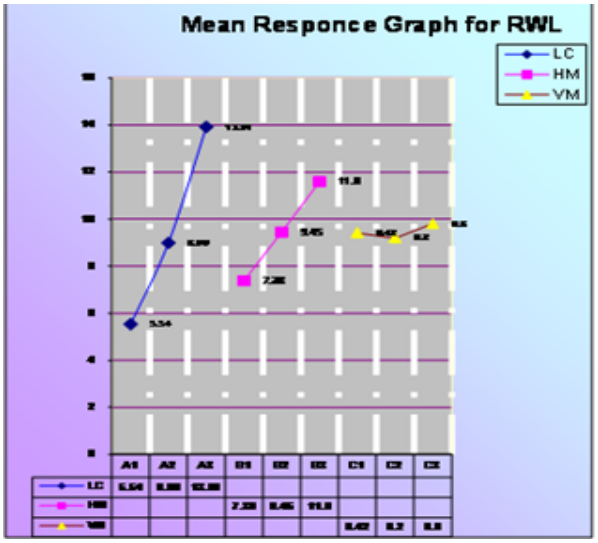
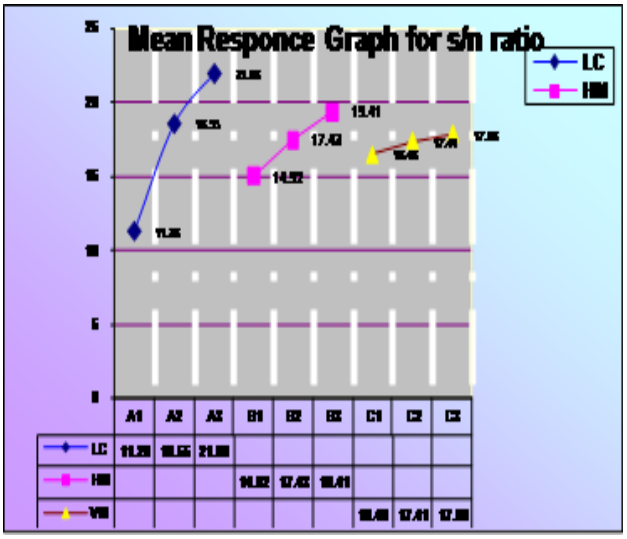


Table represents the signal to noise ratio based on design of experiments and table shows the mean effect of s/n ratio corresponding to chosen parameters for maximum recommended weight limit for manual lifting task in industry.

TABLE VIII
Effect of S/N,corresponding to chosen parameters

From the table the values in bold show the higher the better criteriaas proposed by taguchi method.

GRAPH II



V. RESULT

For calculating the maximum recommended weight for safe lifting or lowering in manual material handling the value of LC, HM, VM is take as value shows in bold font in table VII.

ACKNOWLEDGEMENT

We gratefully acknowledge the inspiration provided by Dr. Sanjeev Jain Director MITS, Dr Manish Sagar MITS, Professor Sanjay Goyal, and Professor A.K. Saxena, Professor Ashish Shastri, Professor Neetu of M.P.C.T.Gwalior to complete this research. Partial support for this research from the GAJARA GEAR Ltd. is deeply appreciated.
At last but not least we are very thankful to God who has blessed us to accomplish this work.

REFERENCES

[1] T.R. Waters, Putz- V. Anderson, A. Garg, Applications manual for the revised NIOSH lifting equation, DHHS (NIOSH) Publication No. 94-110, NIOSH, Cincinnati, 1994.

[2] M.M. Ayoub, N.J. Bethea, S. Deivanayagam, S.S. Asfour, G.M.Bakken, D Liles, Determination and modeling of lifting capacity, Final report, DHHS (NIOSH) Grant No. 5-R01-0H-00545-02, NIOSH,Cincinnati (1978).

[3] Ajay Bangar, K.C. Arora, Vikrant Joshi, Neetu, Evaluation of acceptable weight for manual lifting task in industry: A Fuzzy Logic Approach, ICAM, Agra, India, PP 1099, 2011.

[4] Ajay Bangar, K.C. Arora, Vikrant Joshi, Neetu, Analysis of recommended weight limit to mitigate thelower back pain in manual material handling task. Paper published in IJMIE journal ainterscience open acess journal voi. 2.

[5] M.M. Ayoub, J.L. Selan, B.C. Jiang A mini-guide for lifting, Texas Tech University, Texas. (1983)

[6] S.M. Hsiang, M.M. Ayoub, Development of methodology in biomechanical simulation of manual lifting. Int. J. Ind Ergon 13, 271 88, 1994.

[7] Kackar N. Raghu, (1985), "Off-line Quality Control Parameter Design & Taguchi Method" Journal of Quality Technology, Vol. 17, No. 4, pp. 176-188.

[8] Stanley, D.O. and R.Unal, (1992), "Application of Taguchi methods to dual mixture ration propulsion system optimization for SSTO Vehicles". 30th Aero Space Sciences meeting and exhibit, Jan. 6-9, Reno, Nevada

[9] Nicolo Belavendram, (2001), "Quality by Design- Taguchi Technique for Industrial Experimentation, Prentice Hall, Great Britain".

[10] Sathiya, P & Abdul Jaleel, (2010), "Grey based Taguchi method for

◈◈◈