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Evaluation of Load Constant of Worker in Industry By Using A Fuzzy Logic Approach

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Abstract: Low back disorders (LBDs) continue to be the most common musculoskeletal problem in the workplace. It affects many workers, is associated with high costs to industry and the individual, and can negatively influence the quality of life for the workers. In this paper researchers work on load constant , which play an important rule for elimination health related problem in industry , for this researcher use the fuzzy logic approach .

Keywords: Manual Material Handling, Load Constant, Fuzzy Logic.

1. Introduction

Material Handling is the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal. There are kinds of injuries and disabilities associated with MMH tasks, among which LBDs represent the most common and most costly musculoskeletal disorder experienced in the workplace. Up to 80% of adults will eventually experience back pain at some time during their life and 4 – 5% of the population has an acute low back pain episode every year (Plante *et al*. 1997). Much of this LBD is associated with occupational factors (Spengler *et al*. 1986) and significantly increases workers compensation costs. For example, LBDs account for 16 - 19% of all worker compensation claims, but 33 - 41% of the total cost of all work compensation costs (Webster and Snook 1994, Spengler *et al*. 1986). Manual material handling (MMH) tasks have been associated with the majority of lower back injuries (Snook *et al*. 1978, Bigos *et al*. 1986). In this MMH area load that lifted by the person is play important role LBD problem. Load is also known as load constant it is load that is lifted by worker without any musculoskeletal problem. The value of load constant (LC) suggested by the NIOSH in 1981 for all age group was 40 kg but this value was not feasible value of load constant. So in 1991 NIOSH is set the value of load constant, which is 23 kg., but researcher are going to find that it may change with age, and strength of worker. In this paper researchers use the fuzzy logic approach for calculating load constant for each group of person for safe handling in Industry.

2. Data Collection

For this research work, researchers visited to S. & H. Gears Dewas (M.P.) and collect data which are require for the research these are shown in Table 1. This data is randomly selected among the workers of company which represent random age group, weight.

Table 1: Data Collected from the Industry

S. No.	Name	Age (Yrs)	Height of Worker (ft)	Weight of worker (Kg)	Lifted weight (Kg)
1.	P.KHADE	48	5' 5"	62	20
2.	C.M.SHARMA	45	5' 7"	56	14

3.	K.SALAME	46	5' 2"	50	12
4.	A.K.SONI	45	5' 2"	63	8
5.	B.G.BARSKER	45	5' 8"	61	9
6.	LOKRAM	50	5' 3"	53	12
7.	P.R.DAMGE	50	5' 5"	50	10
8.	PRAVEEN CHOUDARY	47	5' 2"	46	10
9.	JAI SINGH	48	5' 5"	72	10
10.	DAULAT SINGH	47	5' 3"	57	25
11.	K.K.DEV	50	5' 6"	74	8
12.	PREM NARAYAN	56	5' 5"	70	10
13.	B.K.RAJPOOT	43	5' 5"	56	10

3. Fuzzy Logic Methodology

Fuzzy logic introduced by Zadeh in 1960s. He said that rather than regarding fuzzy theory as a single theory, the process of "fuzzification" should be regarded as a methodology to generalize any specific theory from a crisp (discrete) to a continuous fuzzy form . Fuzzy logic is a powerful problem- solving methodology with many applications in embedded control and information processing. Fuzzy gives a wonderfully simple approach to draw definite conclusions from vague information. In a common sense, fuzzy logic resembles human decision making mechanism with its ability to work from approximate data and get accurate solutions.

Fuzzy algorithms have been successfully applied to a variety of industrial application including automobiles, autonomous, vehicles, chemical process and robotics (T.J. Ross 2004). These successful applications are attributes to the fact that fuzzy system is knowledge based or rule-based system. We have applied this technique to find out the acceptable load for worker working in Industry according to their age and strength. The flow chart of fuzzy logic is shown in figure 1.

3.1 Flow Chart

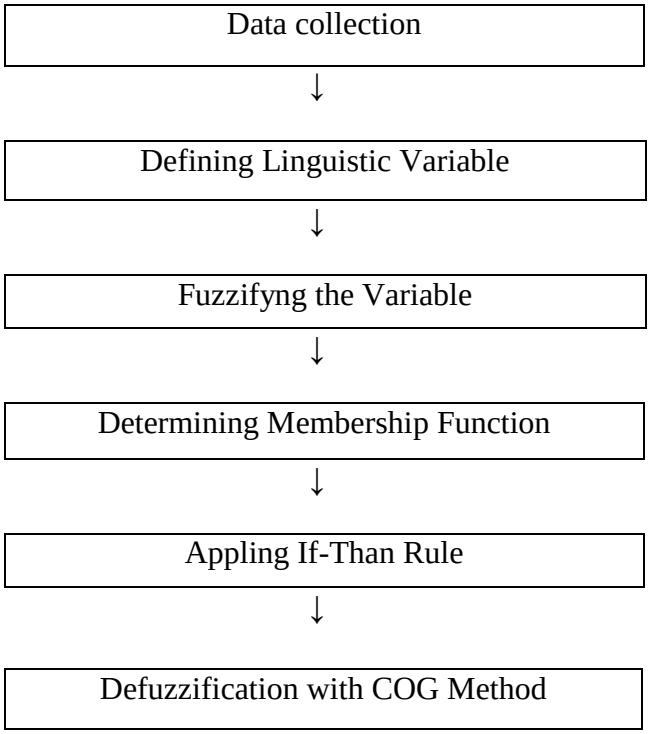

Figure 1: flow chart of fuzzy logic

3.2 Acceptable load constant

For evaluating the acceptable load constant for worker in the industry according to their age and strength, inputs are age and strength in the fuzzy controller then fuzzifing the inputs (developing fuzzy set), applying "if- then" rule and defuzzifuying out put results.

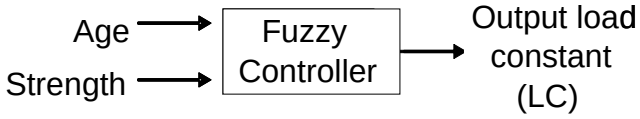

Figure 2: for fuzzy process

3.3 Linguistic Variable:

Worker's age and Strength are interpreted as the linguistic variables which have some of linguistics values as follow.

Age

(VYA, LYA, YA, LMA, MA, UMA, LOA, MOL, UOL, VOA)

[Very Young Age (VYA) <25, Lower Young Age (LYA)(20-30), Young Age (YA) (25-35), Lower Middle Age (LMA) (30-40), Middle Age (MA) (35-45), Upper Middle Age (UMA) (40-50), High (H) (45-55), Upper High (UH) (50-60), Very High(VH)>55]

Strength

(VL, L, M, H, VH)

[(Very Low (VL)<20, Low (L)(15-25), Medium (M)(20-30), High (H)(25-35), Very High (VH) >35)]

Output Load Constant

(VL, L, LM, M, UM, H, UH, VH)

(Very Low (VL)<25, Low (L)(20-30), Lower Medium (LM) (25-35), Medium (M) (30-40), Upper Middle Age UM (35-45), H (40-50), Upper High (UH) (45-55), Very High (VH)>50)

3.4 Fuzzy Sets

Fuzzy sets are prepared between worker age (in yrs) and DOM (degree of membership) which shown in figure 3; Strength (kg) and DOM (degree of membership) which shown in figure 4; Load Constant (kg) and DOM (degree of membership) which shown in figure 5.

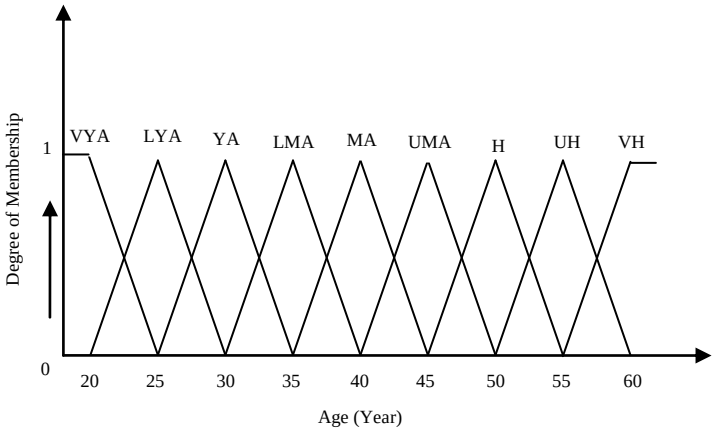

Figure 3: for fuzzy set of age

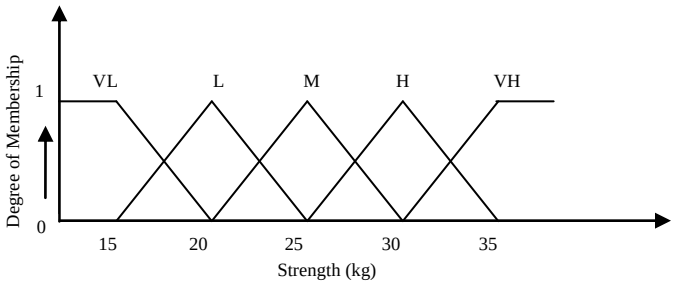

Figure 4: for fuzzy set of capacity

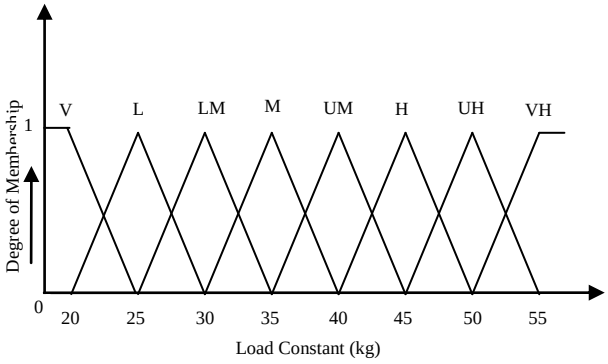

Figure 5: for fuzzy set of load constant

3.5 Fuzzification of Inputs:

Following formula is utilized to compute the membership value of antecedents, this is shown in figure 6.

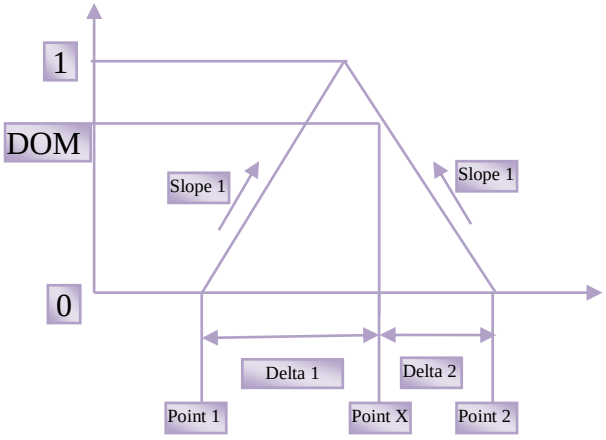

Figure 6: for calculation

Degree of membership for triangle:

$$\mu(X)=\text{Min}\begin{bmatrix} Delta1\times Slope1 \\ Delta2\times Sliope2 \\ Max \end{bmatrix}$$

Where Delta 1 = Point ×–Point 1
And Delta 2 = Point 2 – Point ×
If delta 1 ≤ 0
delta 2 ≤ 0
Then degree of membership = 0

Let normalized value of Age X = 25 yrs then qualifying
Fuzzy set are shown here

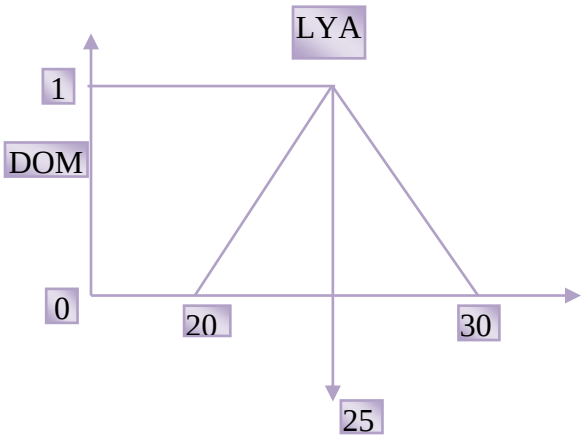

Figure 7: for fuzzy set of 25 year age

Fuzzy membership function of X for L
delta1 = Point X– Point 1
= 25– 20 = 5
delta2 = Point 2 – Point X
= 30 – 25 = 10
Slop 1 = 1/5 = 0.2
Slop 2 = 1/5 = 0.2

There for degree of membership function for LYA

$$\mu(X)_{LYA}=\text{Min}\begin{bmatrix} 5\times 0.2 \\ 5\times 0.2 \\ 1 \end{bmatrix}=1$$

The membership function of x with remaining fuzzy sets namely VYA, YA, LMA, MA, UMA, H, UH, VH, is zero (since value of delta 1 & delta 2 is ve i.e. ≤ 0)

Similarly let the measured normalized value of Strength be x = 17 kg.

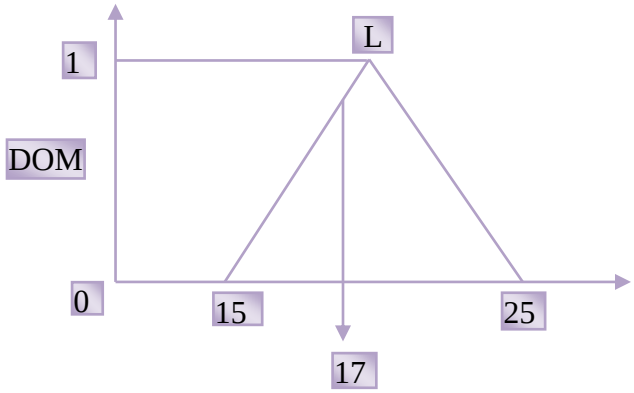

Figure 8: for fuzzy set of Strength 17 kg

Fuzzy membership function x for L

Delta 1 = x–Point 1

= 17– 15 = 2

Delta 2 = Point 2– x

= 25 – 17 = 8

Slop 1 = 1/5 = .2

Slop 2 = 1/5 = .2

There for degree membership function for L

$$\mu(X)_L=\text{Min}\begin{bmatrix} 2\times 0.2 \\ 8\times 0.2 \\ 1 \end{bmatrix}=0.4$$

There for membership function of x with remaining fuzzy sets namely VL, M, H, VH is

zero (Since value of delta 1 & delta 2 is –ve i.e. ≤ 0).

3.6 If than Rule

For LYA

1. If Age is LYA and Strength is L than load constant is LM.
2. If Age is LYA and Strength is M than load constant is M.
3. If Age is LYA and Strength is H then load constant is UM
4. If age is LYA and Strength is VL then load constant is L.
5. If Age is LYA and Strength is VH then load constant is H.

For YA

1. If Age is YA and Strength is L than load constant is M.
2. If Age is YA and Strength is M than load constant is UM.
3. If Age is YA and Strength is H then load constant is H.
4. If age is YA and Strength is VL then load constant is LM.
5. If Age is YA and Strength is VH then load constant UH.

For LMA

1. If Age is LMA and Strength is L than load constant is UM.
2. If Age is LMA and Strength is M than load constant is H.
3. If Age is LMA and Strength is H then load constant is UH.
4. If age is LMA and Strength is VL then load constant is M.
5. If Age is LMA and Strength is VH then load constant VH.

For MA

1. If Age is MA and Strength is L than load constant is M.
2. If Age is MA and Strength is M than load constant is UM.
3. If Age is MA and Strength is H then load constant is H.
4. If age is MA and Strength is VL then load const. is LM.
5. If Age is MA and Strength is VH then load const. UH.

For UM

1. If Age is UM and Strength is L than load constant is LM.
2. If Age is UM and Strength is M than load constant is M.
3. If Age is UM and Strength is H then load constant is UM
4. If age is UM and Strength is VL then load const. is L.
5. If Age is UM and Strength is VH then load const. H.

For H

1. If Age is H and Strength is L than load constant is L.
2. If Age is H and Strength is M than load constant is LM.
3. If Age is H and Strength is H then load constant is M.
4. If age is H and Strength is VL then load const. is VL.
5. If Age is H and Strength is VH then load const.UM.

For UH

1. If Age is UH and Strength is L than load constant is L.
2. If Age is UH and Strength is M than load constant is LM.
3. If Age is UH and Strength is H then load constant is M.
4. If age is UH and Strength is VL then load const. is VL.
5. If Age is UH and Strength is VH then load const.UM

For the measured value of Age be x = 25 year and Strength x = 17 kg. the fuzzy membership values for fuzzified inputs are shown in figure 8.

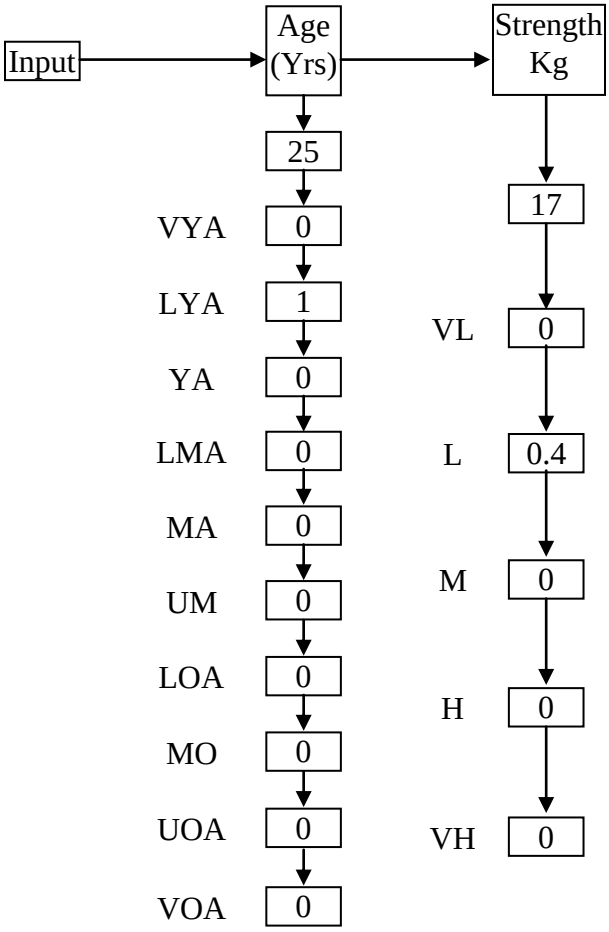

Figure 8: for fuzzification of inputs

Rule Strength Computation:-

Rule strength's are obtained by computing the minimum of the membership function of antecedents.

Rule 1: Min (1, .4) = .4

Rule 2: Min (1, .0) = 0

Rule 3: Min (1, .0) = 0

Rule 4: Min (1, .0) = 0

Rule 5: Min (1, .0) = 0

3.7 Defuzzification:-

Center of gravity method is applied to defuzzify the output figure shows the computation of CG for one competing outputs of rule 1 with strength 0.4 According to rule 1 output is LM. This process shown in figure 9.

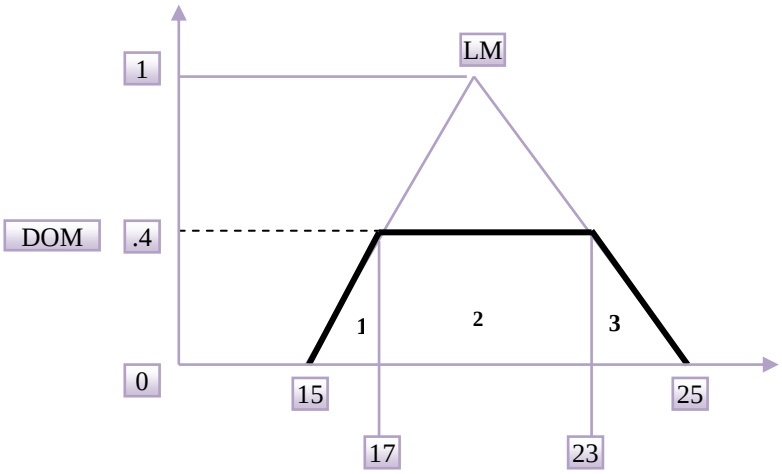

Figure 9: for defuzzification

Table 2 for area & C. G. calculation

Area Segment No.	Area (A)	$\overline{X}$	A $\overline{X}$
1	$\frac{1}{2}\times 2\times 0.4 = 0.4$	16.33	6.53
2	4×.6=2.4	19.5	39
3	$\frac{1}{2}\times 2\times 0.4 = 0.4$	23.66	9.46
	$\sum A = 2.8$		$\sum A\overline{X} = 54.99$

$$X = \frac{\sum A\overline{X}}{\sum A} = \frac{54.99}{2.8} = 19.63kg$$

By Similar process load constant is calculated for different age group at different strength, which are shown in the table 3.

Table 3: Load Constant for different age group

Strength → / ↓ Age	Load Constant (kg)			
	17 kg	**22kg**	**27kg**	**32kg**
25	19.63	22.09	27.09	30
30	24.99	27.09	32.09	35
35	29.99	32.09	37.09	40
40	24.99	27.09	32.09	35
45	19.63	22.09	27.09	30
50	14.99	17.09	22.09	25
55	14.99	17.09	22.09	25

4. Summary:

Finally By apply the fuzzy logic researcher evaluate and draw table which indicate the load constant for different age at different strength . By using this problem of LBD is minimized in the industry where manual material handling is done.

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