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A Pilot study for Determining the Load Constant of Lifting for Indian Population using Fuzzy Logic Approach

Deepak Gupta[1*], Vikas Misra[2], M. L. Meena[3]

[1]*Department of Mechanical Engineering, GIT, Jaipur, Rajasthan*

[2]*Department of Mechanical Engineering, GITS, Udaipur, Rajasthan*

[3]*Department of Mechanical Engineering, MNIT, Jaipur, Rajasthan*

Abstract

Load constant plays an important role for the elimination of problems related to Low Back Disorders (LBDs) in Manual Material Handling. To produce standards for the regulation of MSDs (Musculoskeletal Disorders) resulting from MMH, determination of load constant is important, for working population. Load constant depends on the workers age, strength and the method of lifting like on head or on shoulders etc. This paper is a pilot study for determination of the load constant for Indian population using fuzzy logic approach and only three factors 1.Age of the worker. 2. Strength of the worker. 3. Way of lifting (on head and by both hands) is considered for determining load constant.

Keywords— *Fuzzy Logic Approach, Load Back Disorder, Load Constant, Manual Material Handling, Musculoskeletal Disorders.*

1. Introduction

Manual material handling operations are carried out in most industrial plants. Each handling task poses unique demands on the worker. Material Handling is the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal [1 Ganesh pal, Manish]. LBDs are the most common and costly MSDs experienced in manual material handling. Most of the LBDs are associated with occupational work related disorders [2]. Load constant is a load that is lifted by worker without any musculoskeletal problem. In 1962, ILO recommended a weight limit of 24.5 kg for young male (20-35 y) in occasional lifting task with reduction for age and gender. In the latest ISO draft, the acceptable weight for non-repetitive lifting is less than 25 kg under ideal circumstances. The limits could vary ranged from 20 kg to 100 kg for adult male while considering different lifting conditions (ILO, 1990). There was a tendency in legislation to reduce the limit for further reducing the risk of low back injury. The original NIOSH equation included four lifting factors and a load constant of 40 kg, whereas the revised equation added two more multiplier and reduced the load constant to 23 kg. But this can vary according to many other factors like workers age, strength and the method of lifting like on head or on shoulders etc. The main objective of this paper is to determine a load constant considering the three factors 1.Age of the worker. 2. Strength of the worker. 3. Way of lifting (on head and by both hands). In this paper only three factors are taken into consideration for determining load constant.

1.1 Data Collection

Data regarding anthropometry and strength of the workers are taken from secondary source like previous literature.

TABLE I: DATA COLLECTED

S.No	Age (Years)	Height of worker (ft)	Weight of worker (kg)	Lifted weight (kg)
1.	48	5' 5"	62	20
2.	45	5' 7"	56	14
3.	46	5' 2"	50	12
4.	45	5' 2"	63	8
5.	45	5' 8"	61	9
6.	50	5' 3"	53	12
7.	50	5' 5"	50	10
8.	47	5' 2"	46	10
9.	48	5' 5"	72	10
10.	47	5' 3"	57	25
11.	50	5' 6"	74	8
12.	56	5' 5"	70	10
13.	43	5' 5"	56	10

1.2 Fuzzy logic approach

Fuzzy Logics (FL) provides an appropriate logical mathematical framework to handle problems with such characteristics, since [3]:

- deals with uncertainty and imprecision of reasoning processes;
- allows the modelling of the heuristic knowledge (that cannot be described by traditional mathematical equations);
- allows the computation of linguistic information.

Lotfi Zadeh, in 1965 [4] proposed the concept of fuzzy logic. In which he formulated the fuzzy set in the Fuzzy Set Theory (FST). FST provides a mathematical framework for the systematic treatment of vagueness and imprecision [5]. In the present study fuzzy is applied for determining the load constant according to workers anthropometry and strength. Fig. 1 shows the flow chart of fuzzy logic for determination of load constant and figure 2 is the fuzzy process used.

A. Flow Chart

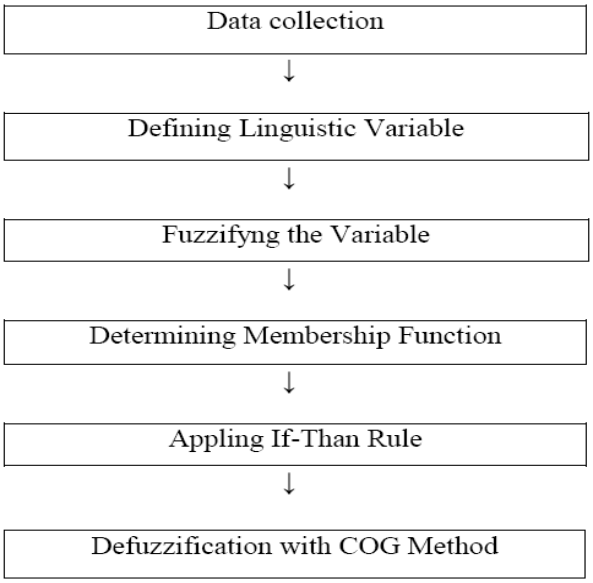

Fig.1. Flow chart of fuzzy logic

B. Acceptable load constant

For evaluating the acceptable load constant for worker in the industry according to their age and strength ,and way of lifting weight (by hands or on head), input variables are age, strength, hands and head in the fuzzy controller then fuzzifing the inputs (developing fuzzy set), applying "if- then" rule and defuzzifuying output results.

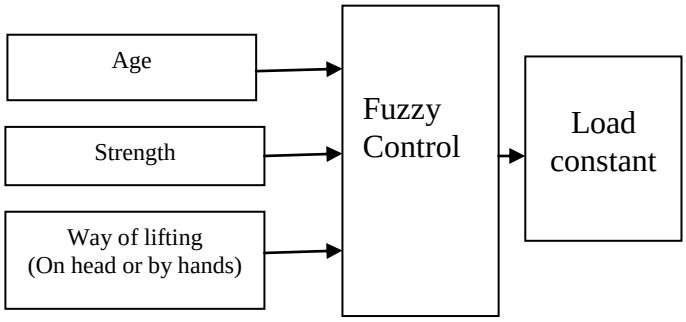

Fig. 2 Fuzzy Process

C. Linguistic Variable:

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

Age (YA, MA, UMA, HA, UHA)

[Very Young Age (VYA) <25, Middle Age (MA) (15-35), Upper Middle Age (UMA) (25- 45), High AGE (HA) (35-55), Upper High (UHA) >45]

Strength (LS, MS, UMS, HS, VHS)

[(Low Strength (LS)<12.5, Medium Strength (MS)(0-25), Upper Middle Strength (UMH)(12.5-37.5), High Strength (HS)(25-50) Very High Strength(VHS) >(37.5)]

Weight lifted by head

[(Low Weight (LW) <12.5, Medium Weight (ML) (0-25), Upper Middle Weight (UMW)(12.5-37.5), High Weight (HW)(25-50) Very High Weight (VHW) >(37.5)]

Weight lifted by hands

[(Low Weight (LW) <7.5, Medium Weight (ML) (0-15), Upper Middle Weight (UMW) (7.5-22.5), High Weight (HW)(15-30) Very High Weight (VHW) >(22.5)]

Weight lifted by head

[(Low Load (LL) <12.5, Medium Load (ML) (0-25), Upper Middle Load (UML) (12.5-37.5), High Load (HL)(25-50) Very High Load (VHL) >(37.5)]

D. Fuzzy Sets

Fuzzy sets are prepared between worker age (in yrs) and DOM (degree of membership) which shown in Fig.3

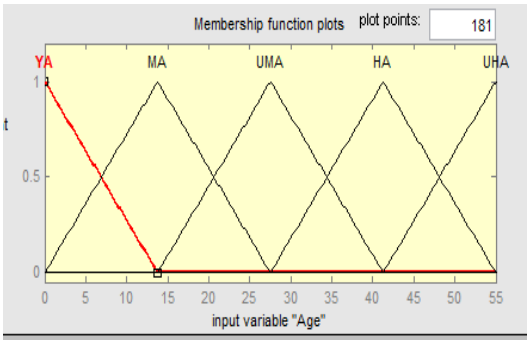

Fig. 3 Fuzzy set for age

Strength (kg) and DOM (degree of membership) which shown in Fig. 4

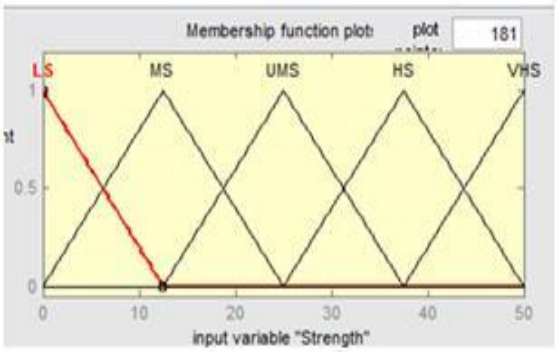

Fig. 4 fuzzy set for strength

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Weight lifted by hands and DOM (degree of membership) which shown in Fig. 5

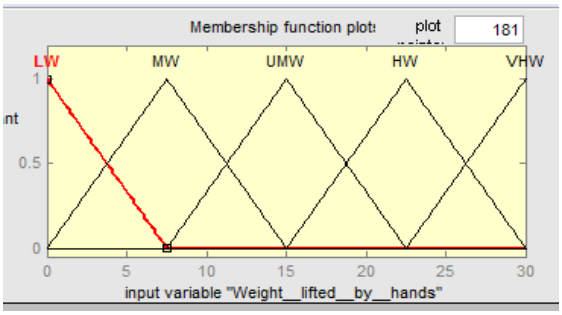

Fig. 5 fuzzy set for way of lifting (on hands)

Weight lifted by head and DOM (degree of membership) which shown in Fig. 6

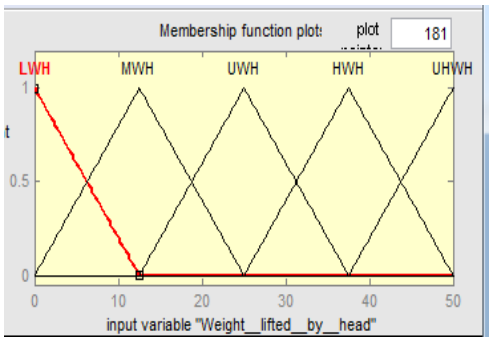

Fig. 6 fuzzy set for way of lifting (on head)

Load Constant (kg) and DOM (degree of membership) which shown in Fig.7

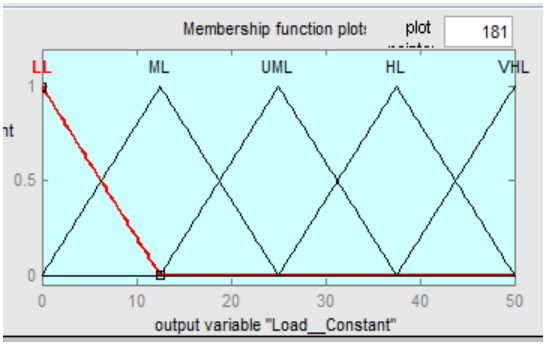

Fig. 7 fuzzy set for load constant

E. If than Rule

For YA

1. If (Age is YA) and (Strength is LS) and (Weight lifted by hands is LW) then (Load Constant is LL) (1)
2. If (Age is YA) and (Strength is MS) and (Weight lifted by hands is MW) then (Load Constant is LL) (1)
3. If (Age is YA) and (Strength is UMS) and (Weight lifted by hands is UMW) then (Load Constant is ML) (1)
4. If (Age is YA) and (Strength is HS) and (Weight lifted by hands is HW) then (Load Constant is ML) (1)
5. If (Age is YA) and (Strength is VHS) and (Weight lifted by hands is VHW) then (Load Constant is UML) (1)
6. If (Age is YA) and (Strength is LS) and (Weight lifted by head is LWH) then (Load Constant is LL) (1)
7. If (Age is YA) and (Strength is MS) and (Weight lifted by head is MWH) then (Load Constant is ML) (1)
8. If (Age is YA) and (Strength is UMS) and (Weight lifted by head is UWH) then (Load Constant is UML) (1)
9. If (Age is YA) and (Strength is HS) and (Weight lifted by head is HWH) then (Load Constant is HL) (1)
10. If (Age is YA) and (Strength is VHS) and (Weight lifted by head is UHWH) then (Load Constant is VHL) (1)

For MA

11. If (Age is MA) and (Strength is LS) and (Weight lifted by hands is LW) then (Load Constant is LL) (1)
12. If (Age is MA) and (Strength is MS) and (Weight lifted by hands is MW) then (Load Constant is LL) (1)
13. If (Age is MA) and (Strength is UMS) and (Weight lifted by hands is UMW) then (Load Constant is ML) (1)
14. If (Age is MA) and (Strength is HS) and (Weight lifted by hands is HW) then (Load Constant is ML) (1)
15. If (Age is MA) and (Strength is VHS) and (Weight lifted by hands is VHW) then (Load Constant is UML) (1)
16. If (Age is MA) and (Strength is LS) and (Weight lifted by head is LWH) then (Load Constant is LL) (1)
17. If (Age is MA) and (Strength is MS) and (Weight lifted by head is MWH) then (Load Constant is ML) (1)
18. If (Age is MA) and (Strength is UMS) and (Weight lifted by head is UWH) then (Load Constant is UML) (1)
19. If (Age is MA) and (Strength is HS) and (Weight lifted by head is HWH) then (Load Constant is HL) (1)
20. If (Age is MA) and (Strength is VHS) and (Weight lifted by head is UHWH) then (Load Constant is VHL) (1)

For UMA

21. If (Age is UMA) and (Strength is LS) and (Weight lifted by hands is LW) then (Load Constant is LL) (1)
22. If (Age is UMA) and (Strength is MS) and (Weight lifted by hands is MW) then (Load Constant is LL) (1)
23. If (Age is UMA) and (Strength is UMS) and (Weight lifted by hands is UMW) then (Load Constant is ML) (1)
24. If (Age is UMA) and (Strength is HS) and (Weight lifted by hands is HW) then (Load Constant is ML) (1)

25. If (Age is UMA) and (Strength is VHS) and (Weight lifted by hands is VHW) then (Load Constant is UML) (1)
26. If (Age is UMA) and (Strength is LS) and (Weight lifted by head is LWH) then (Load Constant is LL) (1)
27. If (Age is UMA) and (Strength is MS) and (Weight lifted by head is MWH) then (Load Constant is ML) (1)
28. If (Age is UMA) and (Strength is UMS) and (Weight lifted by head is UWH) then (Load Constant is UML) (1)
29. If (Age is UMA) and (Strength is HS) and (Weight lifted by head is HWH) then (Load Constant is HL) (1)
30. If (Age is UMA) and (Strength is VHS) and (Weight lifted by head is UHWH) then (Load Constant is VHL) (1)

For HA

31. If (Age is HA) and (Strength is LS) and (Weight lifted by hands is LW) then (Load Constant is LL) (1)
32. If (Age is HA) and (Strength is MS) and (Weight lifted by hands is MW) then (Load Constant is LL) (1)
33. If (Age is HA) and (Strength is UMS) and (Weight lifted by hands is UMW) then (Load Constant is ML) (1)
34. If (Age is HA) and (Strength is HS) and (Weight lifted by hands is HW) then (Load Constant is ML) (1)
35. If (Age is HA) and (Strength is VHS) and (Weight lifted by hands is VHW) then (Load Constant is UML) (1)
36. If (Age is HA) and (Strength is LS) and (Weight lifted by head is LWH) then (Load Constant is LL) (1)
37. If (Age is HA) and (Strength is MS) and (Weight lifted by head is MWH) then (Load Constant is ML) (1)
38. If (Age is HA) and (Strength is UMS) and (Weight lifted by head is UWH) then (Load Constant is UML) (1)
39. If (Age is HA) and (Strength is HS) and (Weight lifted by head is HWH) then (Load Constant is HL) (1)
40. If (Age is HA) and (Strength is VHS) and (Weight lifted by head is UHWH) then (Load Constant is VHL) (1)

For UHA

41. If (Age is UHA) and (Strength is LS) and (Weight lifted by hands is LW) then (Load Constant is LL) (1)
42. If (Age is UHA) and (Strength is MS) and (Weight lifted by hands is MW) then (Load Constant is LL) (1)
43. If (Age is UHA) and (Strength is UMS) and (Weight lifted by hands is UMW) then (Load Constant is ML) (1)
44. If (Age is UHA) and (Strength is HS) and (Weight lifted by hands is HW) then (Load Constant is UML) (1)
45. If (Age is UHA) and (Strength is VHS) and (Weight lifted by hands is VHW) then (Load Constant is UML) (1)
46. If (Age is UHA) and (Strength is LS) and (Weight lifted by head is LWH) then (Load Constant is LL) (1)
47. If (Age is UHA) and (Strength is MS) and (Weight lifted by head is MWH) then (Load Constant is ML) (1)
48. If (Age is UHA) and (Strength is UMS) and (Weight lifted by head is UWH) then (Load Constant is UML) (1)
49. If (Age is UHA) and (Strength is HS) and (Weight lifted by head is HWH) then (Load Constant is HL) (1)

50. If (Age is UHA) and (Strength is VHS) and (Weight lifted by head is UHWH) then (Load Constant is VHL) (1)

F. DEFUZZYFICATION

Defuzzyfication of output is done by Centre of gravity method i.e. load constant is determined for different age group at different strength and way of lifting, which are shown in the table II.

TABLE III: LOAD CONSTANT FOR DIFFERENT AGE, STRENGTH AND WAY OF LIFTING

Age	**Strength (kg)**	**Weight lifted by hands (kg)**	**Weight lifted by head (kg)**	**Load constant (kg)**
25	20	14	0	12.3
30	40	0	48	39.2
35	35	0	40	37.5
40	18	0	21	19.7
45	37	25	0	16.5

II CONCLUSIONS

From the defuzzyfication it can be concluded that the results of load constant varies according to age strength and way of lifting the load which is different from NIOSH load constant (23kg). This variation is due the fact that the load constant depends on various factors like age, strength and way of lifting (on head or by hands) etc. for calculating accurate load constant more factors need to be considered like temperature, relative humidity, lighting, noise, time constraints (e.g., machine–paced work or deadline pressures).

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