MANUFACTURING ACCIDENTS COST ESTIMATION MODEL

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ABSTRACT: In this study, manufacturing accident cost model is proposed. The cost of each class of accidents (C_i) was developed in terms of probability of accident occurrence (ρ_{ai}), degree of fatality (f_i), establishment average annual salary (γ), establishment maximum allowable service year (z), human severity for the class i (H_i), equipment damages (E_{qi}), service life of the equipment (L), usage life of equipment (T), interest rate (t), acquisition cost of machine (N), machine hour rate (MHR), machine down time (θ_i), economic implication cost (E_{ci}), value of goods (Q_i), total hour lost (β_i) and establishment's overall hourly cost of production (α). Data were collected from eleven textile industries in Nigeria on accidents occurrence and cost of consequences of accidents. Three classes of accidents were identified as: fatal, serious and minor. The collected were used to estimate the model parameters. The unit cost of each class of accidents was estimated to be fatal: ₦2,665,360.00, serious: ₦232,750.00 and minor: ₦56,000.00.

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1. Introduction

When accidents occur, the victims suffer a great agony. There is a gross loss in the level of productivity and medical bills payable. The Insurance cover also takes the impact in form of compensations of the victims, while the organizations profit suffers from the down time and reduced workforce. Putting cost of accident will draw the attention of the worker and the management on the need for organized safety programme. This will allow them to compare the actual cost being incurred by the management on accidents occurrence as well as organizing safety programme. Several accident estimation models are reported in the literatures (Charles-Owaba and Adebiyi, 2001); Adebiyi, 2002; Ozbay et al, 2001; Fayad et al; 2003 and National Safety Council 2003).

An agreed model for evaluating the loss due to different classes of accident has not been reported to the knowledge of the authors. However, National Safety Council (2003) stated that the best approach is to estimate the costs which are a measure of money spent and income not received due to accidents, injures and fatalities.

The problem is in the qualification of human life. But the price tag on human life is in no way related to the amount of life insurance that a person may have. Thus, it depends upon the country and circumstances. For example, in United States of America (USA), the cost of life is estimated as the sum of Average Gross National Product, Average Court Penalty and Insurance Compensation (Harold and Moriarity, 1990). In the United Kingdom (UK), cost of life was estimated as sum of 50% of average salaries and wages of establishment employees and related expenditure on accidents involving life. (Phelps, 1999).

In Nigeria, the cost of fatal accident (involving life) may be estimated as:
Compensation = % of disability x monthly salary x 54% months (Ige, 1999).

Although, a more academic approach is that compensation should be based on loss of earning, taking view that nothing can compensate for the actual loss of life. But different circumstances may not allow that.

Therefore, the focus of this study is to develop a manufacturing accident cost model so as to provide a framework for estimating the cost of accident so as to justify the need for organized safety programme for manufacturing industry.

2. Model Development

When accident occurred, it results into injury, damage, loss and emotion to the initiators of accident, that is, the people, equipment, environment, plant and systems (Barber and Donovan, 1998).

The resultant effects of accidents are basis for developing most accidents estimating models. The existing accidents cost estimating models employ deterministic approach. But the occurrence of accident is probabilistic in nature and also the

associated costs. Therefore, in the current model, the probability of occurrence of accidents and costs of accident consequences are considered. First, the notations used are defined.

Notations

ρ_{ai}= Probability of occurrence of accident class i (Dimensionless)
H_i = Human severity cost for accident class i (₦)
γ = Establishment average annual salary (₦ /year)
z = Establishment maximum allowable service year (year)
f_i = Degree of severity (Dimensionless)
L = Service life of the equipment involved in the accident (Year)
t = Interest rate
N = Acquisition cost of damaged equipment (₦)
MHR = Machine Hour Rate (₦/T)
θ_i= Period of idleness of equipment due to accident $_i$ (T)
Q_i = Value of goods/materials damaged in accident class i (₦)
β_i = Total production down time due to accident class i
α = Establishment's overall hourly cost of production (₦ /T).
i = Counter of class of accidents
G = Number of identified class of accidents
1 = Fatal
2 = Serious
3 = Minor

The unit Cost of Accident Class i (C_i) may be given as:

$$C_i = f(\rho_{ai}, P_c) \quad \ldots\ldots 1$$

Using dimensional consistency,

$$C_i = \rho_{ai} * P_c \quad \ldots\ldots 2$$

However,

$$P_c = f(H_i, E_{qi}, E_{ci}) \quad \ldots\ldots 3$$

Applying dimensional consistency,

$$P_c = \rho_{ai}(H_i + E_{qi} + E_{ci}) \quad \ldots\ldots 4$$

But,

$$H_i = f\gamma z \quad \ldots\ldots 5$$

While

$$E_{qi} = f\left[\frac{(1+t)^{L-T}}{(1+t)^{L-T}-1}\right]N + MHR\theta \quad \ldots\ldots 6$$

Also,

$$E_{ci} = Q_i + \beta_i\alpha \quad \ldots\ldots 7$$

Substitute equations 5, 6 and 7 in equation 4

$$C_i = \left[f\left[\gamma z + N\left[\frac{(1+t)^{L-T}}{(1+t)^{L-T}-1}\right]\right] + MHR\theta + Q_i + \beta_i\alpha\right] \quad \ldots\ldots 8$$

3. Model Application

The model was applied to estimate the coast of accident in textile industries. Data were collected from eleven textile industries in Nigeria. The data include the accident occurrence and other model parameters. As a matter of fact, no single factor can cause an accident. Accident occurrence involves combination of two or more contributory factors and also the cost of potential consequences. Thus consequences of accidents may be categorized into human severity, property damaged and economic implication. The estimate of the model parameters are presented in Table 1.

In estimating the manufacturing accident cost, the data on occurrence of accidents has to evaluate the probability of each class of accidents as: 0.24, 0.35, and 0.32 for fatal, serious and minor accidents respectively. This reflects that serious accidents has greatest probability of occurrence, however, the fatal accident has the greatest economic implication. This was applied to potential consequences of accidents estimates to obtain the manufacturing accidents cost as ₦2,665,360.00, ₦232,750.00 and ₦56,000.00 for fatal, serious and minor accidents, respectively.

Table 1: Estimation of Model Parameter

Parameter	Estimates
γ	₦420,000.00
z	35 years
L	20 years
T	12 years
t	10%
N	₦2,000,000.00
θ_1	10 days
θ_2	8days
θ_3	3 days
MHR	₦5,000.00
α	₦50,000.00
f_1	1
f_2	0
f_3	0
Q_1	₦150,000.00
Q_2	₦75,000.00
Q_3	₦10,000.00
β_1	6 hours
β_2	11 hours
β_3	3 hours
ρ_{a1}	0.24
ρ_{a2}	0.35
ρ_{a3}	0.32

Results and Discussion

Using the parameters, the cost of each of class of accidents is estimated as shown in the below:

Table 2: Cost Estimation

	Class of accident		
	Fatal	Serious	Minor
H_i	₦ 14,700,000	₦ 0	₦ 0
E_{qi}	₦ 1,798,000.00	₦ 40,000.00	₦ 15,000.00
E_c	₦ 450,000.00	₦ 625,000.00	₦ 160,000.00
C_i	₦ 2,665,360.00	₦ 232,750.00	₦ 56,000.00

Conclusions

In this study, the cost estimation model was formulated and applied to the data collected from the eleven textile industries. Although, the inflationary effect was not put into consideration, notwithstanding, the application estimated the costs of fatal, serious and minor accidents as ₦2, 665,360.00, ₦232, 750.00 and ₦56, 000.00 respectively. Based on this, it could be concluded that the fatal accidents have the greatest contribution to adversity, while serious accident has greatest probability of occurrence in textile industry.

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