PAMUKKALE ÜNİVERSİTESİ MÜHENDİSLİK FAKÜLTESİ
PAMUKKALE UNIVERSITY ENGINEERING COLLEGE
MÜHENDİSLİK BİLİMLERİ DERGİSİ
JOURNAL OF ENGINEERING SCIENCES
YIL : 1998
CİLT : 4
SAYI : 3
SAYFA : 743-747

# A RULE-BASED SYSTEM APPROACH FOR SAFETY MANAGEMENT IN HAZARDOUS WORK SYSTEMS

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## ABSTRACT

Developments in technology increased the importance of safety management in work life. These improvements also resulted in a requirement of more investment and assignment on human in work systems. Here we face this problem: Can we make it possible to forecast the possible accidents that workers can face, and prevent these accidents by taking necessary precautions? In this study made, we aimed at developing an rule-based system to forecast the occupational accidents in coming periods at the departments of the facilities in hazardous work systems. The validity of the developed system was proved by implementing it into practice in hazardous work systems in manufacturing industry.

**Key Words :** Ergonomics, Safety engineering, Risk assessment

## TEHLİKELİ İŞ SİSTEMLERİNDEKİ GÜVENLİK YÖNETİMİ İÇİN KURAL-TABANLI BİR SİSTEM YAKLAŞIMI

## ÖZET

Teknolojideki gelişmeler iş sisteminde insana daha fazla değer vermeyi ve daha fazla yatırımı gerekli kılmıştır. Bunun sonucunda karşımıza şu problem çıkmıştır; acaba insanların maruz kalabilecekleri kazaları önceden tahmin edip, alınacak tedbirler ile bu kazaları önlemek mümkün müdür? Yapılan çalışmada, tehlikeli iş sistemlerindeki işletmelerin önündeki dönemler bazında departmanlarında meydana gelebilecek olası iş kazalarının önceden tahmini için bir sistem önerisi geliştirilmiştir. Geliştirilen sistemin geçerliliği üretim endüstrisindeki tehlikeli iş sisteminde uygulanarak ispatlanmıştır.

**Anahtar Kelimeler :** Ergonomi, Güvenlik mühendisliği, Risk analizi

## 1. INTRODUCTION

Developments in industry increased the importance of safety engineering and of necessary precautions against occupational accidents in work systems. The improvements in industry also resulted in high enterprises on safety engineering in manufacturing systems.
There are different definitions of occupational accident. International Labour Organization (ILO, 1983) describes work accident as follows: "work accident is an event, which is unplanned and happens unexpectedly and causes a particular damage or injury".

The basic factors which cause work accidents can be ordered as follows:

- Lack of safety precautions on working machines or not using the existing safety precautions,
- The worker's not been educated in the concept of worker health and work safety,
- Design or assembly mistakes on machines,

- Not supplying the workers with required safety tools, or not using the safety tools,
- Employer has not well-understood the importance of worker health and work safety precautions,
- Uncontrolled working and health conditions in work place.

Human, who are the most valuable function of production systems, basically have the right of being protected against possible accidents during work time. This is quite reasonable since all kinds of products are for human comfort (Dizdar and Kurt, 1996).

The basic principle in preventing accident risk in a work place is, to eliminate the sources accidents. If this is not possible, then isolate the accident source in a closed system. Here we meet this problem: Can estimate the possible accidents that workers can face, and prevent these accidents by taking necessary measures?

Managers who work in safety management can prevent possible accidents by analyzing the past accidents in their facilities and by taking the right precaution in right time. Therefore, in order to avoid or lessen work accidents; first of all; unsafe places where accidents frequently take place should be determined; the reasons of these accidents should be analyzed and with a systematic approach, required precautions should be taken and should be observed seriously.

In this study "a rule based system for safety management" which is a model of prognosis for occupational accidents in manufacturing systems is presented. This serves as a tool to forecast possible accidents, by considering the previous years' accidents statistics and analysis the varieties and properties of these accidents. By evaluating the results obtained from this model, precautions against work accidents could be taken and existence of work accidents in work places could be prevented.

## 2. SAFETY MANAGEMENT AND ERGONOMICS

Traditionally, the manufacturing development practice has been characterized by more or less sequential process with the technology aspects in the forefront and leaving limited attention to organizational and human aspects (Kaebernick and Kayis, 1996).

On the other hand, in order to improve manufacturing systems and to produce high qualities of products and processes, it is not sufficient to take into consideration only the technical parameters that influence system improvement and quality (Zülch and Schüindele, 1996).

Supporting this idea, Kidd (1991) says: "Too often, technology is seen as a panacea for the problem of manufacturing in industry. This is natural, because applying new technologies has worked in the past, and technology is obviously still important. New technology on its own, however is not enough". Instead, one should also consider the factors related to human.

Improving safety and reducing human errors in manufacturing systems are central criteria used by human factors practitioners in designing and evaluating systems. Also the health of the workers is becoming of more and more importance within the production factor (Bauer et al., 1996). In order to preserve and support "health" it is necessary to integrate occupational safety in manufacturing systems to a greater extent.

Ergonomics, being an applied branch of science and presenting the basic scientific conditions of productivity, is about primarily the prevention of occupational accidents and to ensure occupational safety. It has duties such as providing a safe system of work, safe equipment, and adequate training and supervision (Salvendy, 1992; Sanders et al., 1993; Oborne, 1995).

The increasing demands on quality and improvements in the manufacturing system technology have increased the importance of safety management. Together with technical, behavioral and organizational factors, accident possibility in work places may be one of the reasons of production disturbances which cause considerable losses. These losses may arise in terms of lost production, medical and compensation costs, as well as the human suffering from the resulting injuries (Brauer, 1993; Goetsch, 1993).

Additionally, in order to make the employees to exhibit their performance potential to the full, they must be provided with most favorable working conditions including the effective occupational safety precautions. Good safety conditions will have a beneficial effect on their overall performance (Gertman, and Blackman, 1993).

Consequently safety management is not a trivial problem. It needs a complex and reliable study, which considers all the factors effecting accidents and it must be applicable to real manufacturing systems. The purpose of this paper is to present a model of prognosis for occupational accidents in hazardous manufacturing systems by using the past years' accident data statistics.

## 3. AN RULE BASED SYSTEM APPROACH FOR PREVENTING ACCIDENTS

This model provides us information about possible work accidents in future periods, by rationally analyzing the past work accidents which are difficult to foresee.

The occupational accidents that are not easy to foresee can be forecasted by considering the past accident statistics. These procedures can be achieved with some type of statistical forecasting methods. The model forecasts the time, the place, the type and the reason of the possible accidents which could happen in future time, and in order to forecast these values it analysis the past years' accident data. Precautions taken in this manner would be effective to prevent possible accidents.

The algorithm embedded in the proposed rule based system is shown below.

### Step 0

Describe an acceptable lower bound for lost workdays in each month, in each department, for each occurrence type of accident and for each accident reason.

$MLB_i$ Acceptable lower bound for lost workdays in month i (i = 1,...,12)
$DLB_j$ Acceptable lower bound for lost workdays in department j (j = 1,. .,N)
$TLB_k$ Acceptable lower bound for lost workdays for accident type k (k = 1,...,K)
$RLB_l$ Acceptable lower bound for lost workdays for accident reason l (l = 1,....,L)
N Total number of departments
K Total accident occurrence type
L Total accident reason

### Step 1

i. Forecast the value of next year's lost work day in each month
$Mf_i$ (i = 1,2,...,12)

ii. Determine the critical month
$Mc_I$ = Max {$Mf_i$; i = 1,...,12} (z = i)
If $Mc_i < MLB_i$; Stop
If $Mc_i \geq MLB_i$; go to Step 2i

i.i.i. If h≠number of departments; go to Step 2ii.

i.i.i.i. If h = number of departments;
$Mf_z = 0$ (h = 0); go to Step 1ii

### Step 2

i. Forecast the value of next year's lost work day in critical month for each accident department
$Df_j$ (j = 1,...,N)

ii. Determine the critical department in critical month
$Dc_j$=Max {$Df_j$; j =1,...,N} (n = j)
If $Dc_j < DLB_j$; $Df_n = 0$, h = h + 1, go to Step 1iii
If, $Dc_j \geq DLB_j$; go to Step 3i

i.i.i. If g ≠ number of occurrence type; go to Step 2ii

i.i.i.i If g = number of occurrence;
$Df_n = 0$ (g = 0); go to Step 3i

### Step 3

i. Forecast the value of next year's lost work day in critical month, critical department for each accident occurrence type
$Tf_k$ (k = 1,...,K)

ii. Determine the critical occurrence type in critical month in critical department
$Tc_k$ = Max {$Tf_k$; k = 1,...,K} (b = k)
If $Tc_k < TLB_k$; $Tf_b = 0$, g = g + 1 go to Step 2iii
If $Tc_k \geq TLB_k$; go to Step 4i

i.i.i. If m ≠ number of accident reason; go to Step 4ii

i.i.i.i. If m = number of occurrence;
$Tf_b = 0$ (m = 0); go to Step 3ii

### Step 4

i. Forecast the value of next year's lost work day in critical month, critical department, for critical occurrence type for each accident reason
$Rf_l$ (l = 1,....,L)

ii. Determine the critical accident reason in critical month in critical department in critical occurrence type
$Rc_l$ = Max {$Rf_l$; l = 1,...,L} (a = l)
If $Rc_l > RLB_l$; $Rf_a = 0$, m = m + 1, go to Step 3iii
If $Rc_l \geq RLB_l$; $Rf_a$= 0, repeat 4ii

## 4. APPLICATION AND RESULTS

In order to show how applicable the model is, a factory where statistically large number of accidents occur is selected. The basic criteria while choosing the pilot factory were; having statistical data of past years accidents' results and having hazardous work system.

The study was implemented at a factory which produces explosive materials in Kırıkkale.

The first cycle of the application is shown in Table 1- 4.

As shown in Table 1, October is found to be the critical month.

Table 1. First Step of First Cycle ($Mc_i$ = October)

| Months | Forecasted Lost Workdays | Accettable Lower Bounds |
|---|---|---|
| January | 5 | 8 |
| February | 5 | 8 |
| March | 8 | 8 |
| April | 11 | 8 |
| May | 12 | 10 |
| June | 4 | 10 |
| July | 5 | 10 |
| August | 6 | 10 |
| September | 9 | 10 |
| **October** | **15** | **8** |
| November | 12 | 8 |
| December | 7 | 8 |

$Mc_i$ = October

In Table 2 one can see the critical department to be 3rd department in October.

Table 2. Second Step of First Cycle ($Dc_j$ = 3)

| Departments | Forecasted Lost Workdays in October in 3th Department | Accettable Lower Bounds |
|---|---|---|
| 1 | 3 | 2 |
| 2 | 0 | 2 |
| **3** | **7** | **5** |
| 4 | 3 | 5 |
| 5 | 2 | 2 |

$Dc_j$ = 3

In the 3rd department, accident type 4 is found to be the critical accident type (see Table 3).

Table 3. Third Step of First Cycle ($Tc_k$ = 4)

| Accident Types | Forecasted Lost Workdays in October in 3th Department | Accettable Lower Bounds |
|---|---|---|
| 1 | 0 | 2 |
| 2 | 1 | 2 |
| 3 | 0 | 5 |
| **4** | **4** | **5** |
| 5 | 2 | 4 |
| 6 | 0 | 4 |

$Tc_k$ = 4

Finally, in accident type 4, the 1st accident reason is determined to be the critical accident reason.

Table 4. Fourth Step of First Cycle ($Rc_l$ = 1)

| Accident Reasons | Forecasted Lost Workdays in October in 3th Depment in 4th Accident Type | Accettable Lower Bounds |
|---|---|---|
| **1** | **3** | **4** |
| 2 | 1 | 4 |
| 3 | 0 | 4 |

$Rc_l$ = 1

As seen in first cycle above, if precautions are taken against accident type 4, in department 3, in month October, these accidents could be avoided.

The algorithm continues to solve the other cycles.

## 5. CONCLUSIONS AND FUTURE WORKS

With the application of rule based system, which forecasts the future years' accident types and specifications by using the past years' accident data; it becomes easier to foresee the possible accidents in a workplace. Therefore, by taking necessary precautions, these foreseen possible accidents could be avoided.

Reliability of the model depends on the past years' accident data being true, and the validity of the rule based systems' algorithm depends on taking necessary precautions in cycles.

This model can be expanded to include the types of accidents, size of management with respect to time and departments.

Nevertheless, it is noteworthy that increasing branches results in decreasing the reliability of solution.

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