Identification of Worker Errors by Cognitive Ergonomics Approach Using CREAM Methods

Nataya Charoonsri Rizani[1], Mithia Ulfa[2], Winnie Septiani[3]
[1,3] Lecturer of Industrial Engineering Department, Trisakti University
[2] Alumnae of Industrial Engineering Department, Trisakti University
Jl.Kyai Tapa No.1 Jakarta, Indonesia 11440
Email : nataya@trisakti.ac.id,nat_riz@yahoo.com

ABSTRACT

Errors during working recorded by PT X were believed by the company as one of the source operational failure and work accident. Based on accident report, there were noted that 53 accidents related with human failure as the cause. The preliminary survey result showed respondents mostly stated that accidents caused by unsafe action. This finding led to relation with cognitive activity of human.
This research was aimed to identify human error during work which has potentiality becoming accident. The used method was part of *Cognitive Reliability and Error Analysis Method* (CREAM), a method for identifying error based on cognitive activity. First step was determining common performance condition (CPC) by questionnaire consisted of nine aspects which were *adequacy of organisation, working condition, adequacy of man-machine interface and operational support, adequacy of procedure / plans, number of simultaneous goals, available time, time of day, adequacy of training and experience and crew collaboration quality*. The next step was constructing hierarchical task and defining the error. Valuation of error was becoming the next step with making relation between cognitive activity (coordinate, diagnose, communicate, execute, etc) and cognitive function consisted of observation, interpretation, planning and execution. The last step was determining the failure of cognitive function for each activity. From four cognitive function, based on analysis, the failure were dominated by observation and execution and the strategy should be implemented was tactical control.

Keywords : work accident, human error, cognitive activity, cognitive function

1. Preliminary

1.1 Background of Research

Errors during working were believed by the PT X as one of the source operational failure and work accident. Based on accident report 2007-2008, as depicted on figure 1, there were noted that 53 accidents. Based on preliminary study by interview, observation and questionnaire were concluded that the main problem for operational (production) failure and accident was related with human failure as the cause. Human failure which led to human error was caused by lack of cognition and safety awareness.The cause led to human failure were identified as negligency,workload, and stress.

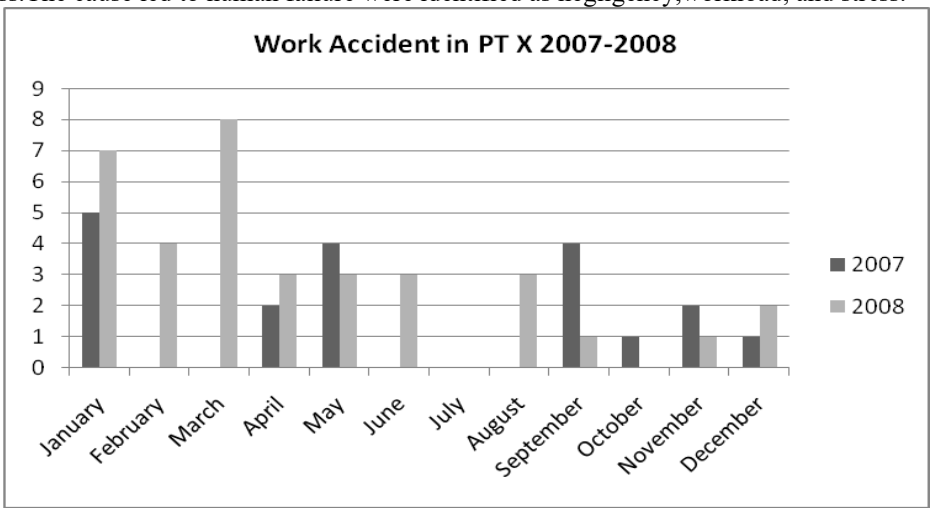

Figure 1 Work Accident Number

Based on preliminary questionnaire given to 30 workers, it can be concluded that most of the accident cause was unsafe act which is related to human like depicted in figure 2.

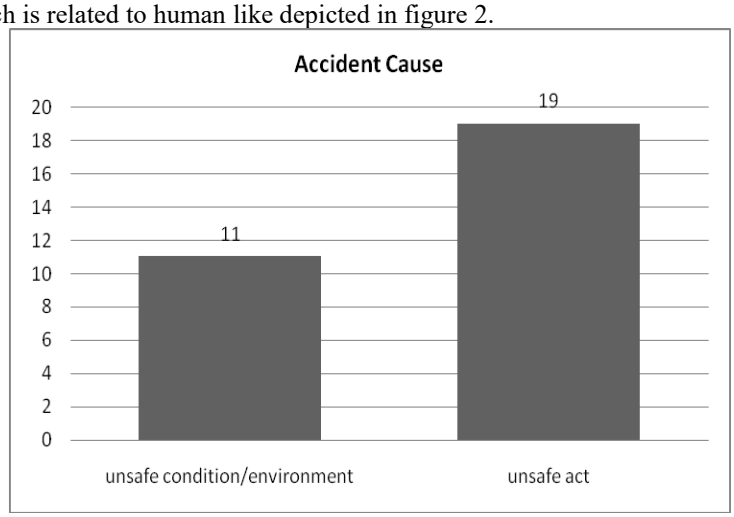

Figure 2 Accident Cause

This research was executed to identify error (human) while working in several activity which has potentiality becoming accident using *Cognitive Reliability and Error Analysis Method* (CREAM) in Gathering Station of Oil State Company in Indonesia. CREAM is used in *Human Reliability Assessment* (HRA) field which aims to evaluate probability for human error during finishing spesific (Hollnagel,1998). After analysis of identification step, the next step is improving, implementing and evaluating the idea of ergonomics intervention so that can reduce the error rate.

1.2 Research's Object

This research was aimed toidentify human error during work which has potentiality becoming accident by method that was part of *Cognitive Reliability and Error Analysis Method* (CREAM).

2. CREAM Method (Hollnagel, 1998)

CREAM or Cognitive Reliability Error Analysis Method, a method developed by Erik Hollnagel, is a tools for human reliability analysis (HRA). There are two types of HRA approaches which are first generation and second generation. CREAM,second generation of HRA, consists of two version analysis technique which are basic and extended. CREAM was developed from analysis principle which contain method clasification scheme dan a model. The main aim of CREAM is giving practical approach to performance analysis and prediction. The three main area of CREAM are task analysis, opportunites for error reduction, considering human performance on overall system safety.

The basic method consists of the following three steps (figure 3):

1. Desribe the task or task segment to be analysed. The first step of an HRA must be a task analysis or another type of systematic task description. Unless the task is known, it is impossible to appreciate the consequences of individual task steps and actions.
2. Assess the common performance conditions (CPCs). The CPCs are used to characterize the overall nature of task , and characterization is expressed by means a combined of CPC score.
3. Determine the probable control mode. The probable control mode is a central concept of underlying Cognitive Control Model (COCOM). The probable control model is determined from the combined CPC score. It is assumed that a control mode correspondens to a region or interval of action failure probability.

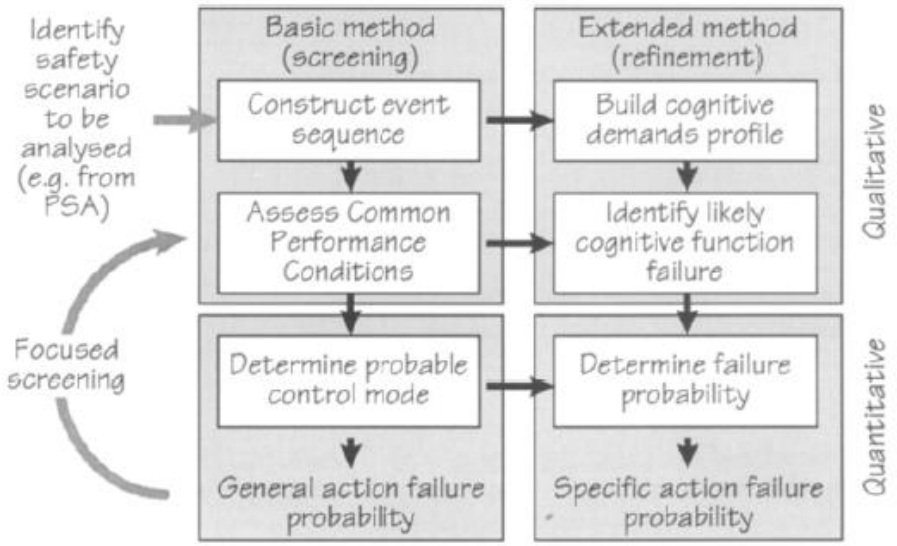

Figure 3 CREAM-Basic and Extended Methods (Hollnagel, 1998)

Table 1 explained about the relation between CPC and performance reliability which can be used to decide what kind of selected control mode. There are 4 main controls mode which are :

1. **Scrambled,** implemented in situation choice of next action haphazard, little or no thinking involved, task demands high, loss of situational awareness
2. **Opportunistic,**implemented in situation choice of action based on present conditions, little planning or anticipation
3. **Tactical**,implemented in situation planning based,follows procedures/rules
4. **Strategic**,implemented in situation considers the global context or "bigger picture"

Table 1 Relation of CPC and Performance Reliability

CPC Name	Level / Description	Performance Reliability
Adequacy of organisation	Very efficient	Improved
	Efficient	Not significant
	Inefficient	Reduced
	Deficient	Reduced
Working Condition	Advantegeous	Improved
	Compatible	Not significant
	Incompatible	Reduced
Adequacy of man-machine interface and operational support	Supportive	Improved
	Adequate	Not significant
	Tolerable	Not significant
	Inappropriate	Reduced
Adequacy of procedure / plans	Appropriate	Improved
	Acceptable	Not significant
	Inappropriate	Reduced
Number of simultaneous goals	Fewer than capacity	Not significant
	Matching current capacity	Not significant
	More than capacity	Reduced
Available time	Adequate	Improved
	Temporarily inadequate	Not significant
	Continuously inadequate	Reduced
Time of Day	Day time (adjusted	Not significant
	Night time (unadjusted)	Reduced
Adequacy of training and experience	Adequate, high experience	Improved
	Adequate, limited experience	Not significant

	Inadequate	Reduced
Crew collaboration quality	Very efficient	Improved
	Efficient	Not significant
	Inefficient	Not significant
	Deficient	Reduced

COCOM consists of several classified function based on cognitive activity like explained in table 2.

Table 2 Cognitive Activity

Activity Type	COCOM Function			
	Observation (O)	Interpretation (I)	Planning (P)	Execution (E)
Coordinate			■	■
Communicate				■
Compare		■		
Diagnose		■	■	
Evaluate		■	■	
Execute				■
Identify		■		
Maintain			■	■
Monitor	■	■		
Observe	■			
Plan			■	
Record		■		■
Regulate	■			■
Scan	■			
Verify	■			

3. Data Collection and Analysis

- Making the *hierarchical task analysis* (HTA), depicted in figure 4.
- Context Description by questionnaire CPC, explained in table 3.

Table 3 CPC for Gathering Station

CPC Name	**Level/Evaluation**	**Effect on Performance Realiability**
Adequacy of Organisation Descriptor	Quality of role and responsibility team member , communication system supporting, health and safety system, instruction and display of activity, role of outside reperesentative,etc	Reduced
	Very efficient / *Efficient* / ***Inefficient*** / *Deficient*	
Working Condition Descriptor	Basically related with physical work environment such as lighting, temperature, noise,glare, etc	Not significant
	Advantageous / ***Compatible*** / *Incompatible*	
Adequacy of man-machine interface and operational support Descriptor	General man-machine relation, including provided information of control board, computerized work station, specific designed supporting operational	improved
	Supportive / *Adequate* / *Tolerable* / *Inappropriate*	
Availability of procedure/plans Descriptor	Rule and plans including emergency operation and procedure, common known reaction, habit, etc	
	Appropriate / *Acceptable* / ***Inappropriate***	reduced

Number of simultaneous Goals	Several task from worker needed to continue or follow in same time	
Descriptor	*Fewer than capacity* / ***Matching current capacity*** / *More than capacity*	Not significant
Available Time	Availability of time to finish task and suite how the task executed with dynamic process.	improved
Descriptor	***Adequate*** / *Temporarily inadequate* / *Continuously inadequate*	
Work Time	Day and night time when task is finished.Example : shiftwork	Not significant
Descriptor	***Day-time (adjusted)*** / *Night-time (unadjusted)*	
Adequacy of training and experience	Level and quality of training to recognize new technology, refresh existing skill, etc. This is also related with operational experience.	Not significant
Descriptor	*Adequate, high experience* / ***Adequate, limited experience*** / *Inadequate*	
Crew Collaboration Quality	Quality of collaboration among crew, including appropriateness formal and informal structure, level of trust, etc.	improved
Descriptor	*Very efficient* / *Efficient* / ***Inefficient*** / *Deficient*	

- Error Identification
  Example of process error identification is explained by table 4.

Table 4 Example of Process Error Identification

Station	Task	Description	Error Description
Gathering Station	1. Chemical Injection	1.1.Taking chemical from chemical storage	Object error
		1.2.Transporting chemical to injection place	Unadequate action
		1.3.Moving and filling chemical fluida with hand pump	Unprocedural action
		1.4.Checking lube oil from chemical pump	Uncomplete inspection
		1.5. Checking the standard	Uncomplete inspection

- Cognitive Demand Profile
  Example of cognitive demand profile is explained in table 5. All tasks depicted in figure 3 were interpretated to cognitive demand profile.
  Table 5 Example of Cognitive Demand Profile

Station	Task	Description	Cognitive Activity	Cognitive Function			
				O	I	P	E
Gathering Station	1. Chemical Injection	1.1.Taking chemical from chemical storage	Execute				■
		1.2.Transporting chemical to injection place	Execute				■

		1.3.Moving and filling chemical fluida with hand pump	Execute				■
		1.4.Checking lube oil from chemical pump	Evaluate		■	■	
		1.5. Checking the standard	Observe	■			
			Evaluate		■	■	

- Failure Cognitive Function
  Example of failure cognitive function is explained in table 6

Table 6 Failure of Cognitive function

Step	Cognitive Activity	Observation			Interpretation			Planning		Execution				
		O1	O2	O3	I1	I2	I3	P1	P2	E1	E2	E3	E4	E5
1.1	execute		●									●		
1.2	execute		●											●
1.3	execute									●				
1.4	Evaluate					●			●					
1.5	Monitor			●										
	Evaluate					●								
Total			**2**	**1**		**2**			**1**	**1**		**1**		**1**

Summary of failure of cognitive function from all activites in gathering station can be seen in figure 5

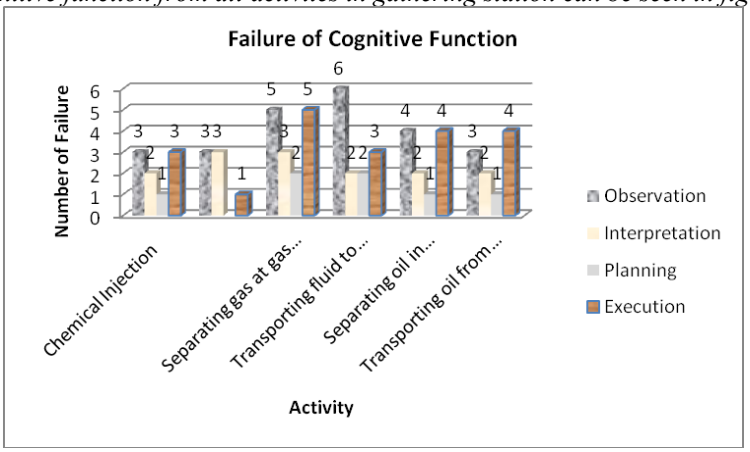

Figure 5 Summary Failure Of Cognitive Function

4. Result and Conclusion

- Based on CPC analysis in table 3, it was found the effect to company which are *improved*, *not significant*, and *reduced*. These effects constructed triplet score [$\sum$ reduced, $\sum$ not significant, $\sum$ improved]which are [3, 4, 2]. Based figure 6, the appropriate control mode was tactical control.

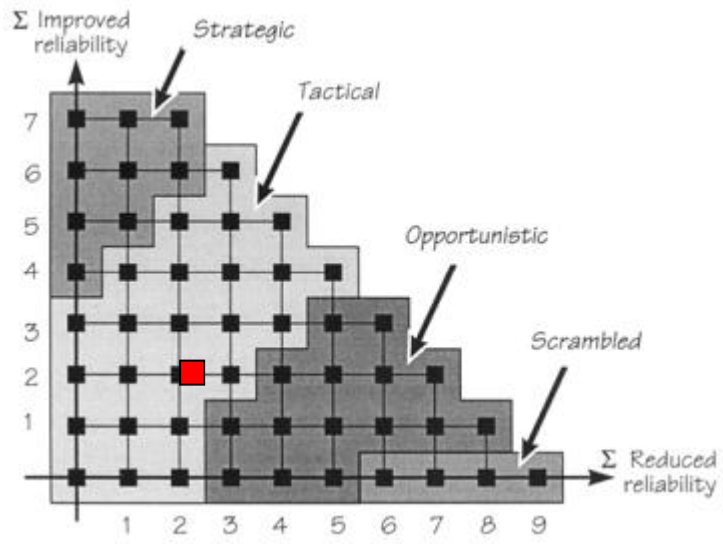

Figure 6 Relation between CPC and Control Mode

- From four cognitive function, based on analysis, the failure or error in gathering station were dominated by observation and execution.

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