The use of an analytical method to evaluate safety and ergonomics in service of forest machinery

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Background

- Forestry work is accident-prone, and many accidents occur at the service of forestry machines
- Effort to improve environment work is often based on the occurrence of accidents and the result is often new routines and rules
- How the design of the machine may have contributed to dangerous actions is seldom investigated

Incidents due to Bad Design

- A physician treating an infant with oxygen set the flow knob between 1 and 2 L/min and then later noticed that the infant was not receiving any oxygen. Even though the knob rotated smoothly, the device was designed to deliver oxygen only when the knob was set on a number, not between numbers.

- A nurse tried to program an infusion pump to deliver 130.1 ml/h of a drug, but inadvertently programmed the pump to deliver 1301 ml/h, because the decimal point on the pump was designed to operate for numbers no greater than 99.9. When the nurse pressed “1 3 0 . 1” the device ignored the decimal point key-press.

Sawyer D, Aziz KJ, Backinger CL, Beers ET, Lowery A, Sykes SM, et al. Do it by Design: An Introduction to Human Factors in Medical Devices. US Department of Health and Human Services, Public Health Service, Food and Drug Administration, Center for Devices and Radiological Health; 1996

Propose

- To purposefully and intentionally work with this approach, there is a need for a methodology that systematically reviews the relationship between accidents, machine design and use

- This presentation introduce such a framework for evaluation, called CCPE (Combined Cognitive and Physical Evaluation) and its usage in safety work with forest machinery

Basic idea - Combined Cognitive and Physical Evaluation

- By predicting human behavior, it is possible to design machines that are more effective and safer
- Human behavior is effected by a mismatch in the interaction between human, machine, task and environment
- Basic idea is to study two parts of the mismatch
  - Error - Deviation from the intended way of interacting
  - Problem - Properties of the machine which contributes to the mismatch
- Also, combine and integrate evaluation of cognitive and physical ergonomics
  - Achieve overall assessment
  - Cost-effective compared to separate evaluation methods

Basic idea - Combined Cognitive and Physical Evaluation

- Include underlying factors
  - The parts of the human machine system
  - Mental and physical workload
- Provide information useful to improve the design of the machine
  - Connect miss matches to the machine's design
- Large focus on risk and safety
  - Find the missmatches that can cause most harm
  - Ensure that no serious mismatches are unidentified

Procedure CCPE

1. Definition of evaluation
2. Human-machine system description
   - Use profile, task analysis, context description, interaction description
3. Work load analysis
   - Task demands, mental workload, physical workload
4. Interaction analysis
   - Usability problems and use errors

4. Interaction analysis
Procedure

- Performed by a single analyst or by a group of analysts
  - E.g designers, software developers, mechanical engineers, marketing staff, ergonomics and human factors experts, as well as users
- Most importantly is that knowledge about the users and the use are present
- The analysts will act users (think like) and try to predict the user's behavior

4. Interaction analysis
Question process

- For every action in the handling sequence, questions are asked to identifying possible mismatches between human and machine.
- The question process tries to simulate how the user interacts with the machine
- The questions in the interaction analysis are adapted to the purpose of the evaluation

4. Interaction analysis
Questions usability problems

- Can the action be performed in a in a safe and ergonomically good way?
- Does the machine give any information (cues) about how the action can be performed in a safe and ergonomically good way?
- Does the user know how the action can be performed in a safe and ergonomically good way?
- Will the user try to perform the action in a safe and ergonomically good way?

4. Interaction analysis
Questions use errors

- How can the action be performed in an unsafe or non-ergonomic way?
- Which are the possible causes of the ergonomic error?
- Which are the consequences for the user?
- Is the machine designed to prevent the ergonomic error?

Example:
Front window washing

Front window washing

Operation: Front window washing	Y/N	Why?
1. Can the action be performed in a in a safe and ergonomically good way?	No	Need to stand on plastic casing or hand rail to reach, imbalance
2. Does the machine give any information (cues) about how the action can be performed in a safe and ergonomically good way?	May be	Hand rails on the right side and some machines have on the left side as well
3. Does the user know how the action can be performed in a safe and ergonomically good way?	May be	Probably knows not to work in imbalance
4. Will the user try to perform the action in a safe and ergonomically good way?	May be	Depends on the person; size and attitude

5. Error How can the action be performed in an unsafe or non-ergonomic way?	**6. Cause** Which are the possible causes of the ergonomic error?	**7. Consequence** Which are the consequences for the user?	**8. Prevention** Is the machine designed to prevent the ergonomic error?
Stand on plastic casing or hand rail	To reach	May fall down	No
Not using hand rail	To use both hand when cleaning	May fall down	No
Extend to imbalance	To reach	May fall down	No

Example:
Moving around machine

Moving around machine

Operation: Moving around machine	Y/N	Why?
1. Can the action be performed in a in a safe and ergonomically good way?	No	Only if you have long legs
2. Does the machine give any information (cues) about how the action can be performed in a safe and ergonomically good way?	Yes	There is hand rails and platforms
3. Does the user know how the action can be performed in a safe and ergonomically good way?	May be	Depends on experience and training
4. Will the user try to perform the action in a safe and ergonomically good way?	May be	Depends on the person; size and attitude

5. Error How can the action be performed in an unsafe or non-ergonomic way?	**6. Cause** Which are the possible causes of the ergonomic error?	**7. Consequence** Which are the consequences for the user?	**8. Prevention** Is the machine designed to prevent the ergonomic error?
To swing around corner	Do not reach, must go around a corner	Not in balance, not full control -> easier to fall	No
Jumping	Do not reach, do not understand how to move	Not in balance, not full control -> easier to fall	No
Not using hand rail	Need to "crawl" to get around	Less control of movment	No (more than existing hand rails)

Summery

- The CCPE-methodology works well and generated an overview of hazards with maintenance and repair work of forest machinery
- Many of the hazardous situations identified with CCPE in the study were due to the fact that operators could not physically perform their duties in a safer manner, i.e. the machine is not designed to fit human anthropometry
- The results could then be used to find counter-measures and to write instruction for safer use

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Thanks from us!

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