Designing Jobs in Manufacturing: Rest Allowances

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Toronto
Ergonomics contributes to company strategies...

How Human and System Effects are connected

How Human and System Effects are connected

- Fatigue
- ?

Patrick Neumann & Linda Rose, 2012
How can employee fatigue affect your operational goals?
Effects of the working environment - visible and hidden effects

[Flowchart showing the relationship between operational systems, working environment, human effects, system effects, and financial outcomes.]

[Rose et al., In press]

Patrick Neumann & Linda Rose, 2012
Concept Mapping

- Used to tap into Executives strategic thinking
- An interview process
- Concepts are linked by hand on a ‘map’
- Maps are then combined for an Exec. Team (n=7)
- Results are analysed for trends and linkages

- Technique applied to a team of Engineering Managers in electronics manufacturing

- Focus on: How can HF help you reach your strategic goals?

Patrick Neumann & Linda Rose, 2012
31 Reduce control and dexterity demands
30 Reduced physical forces
32 Reduced worker pain and fatigue
38 Improve work-rest recovery
39 Reduce short cycle jobs
51 Improved psychosocial factors
36 Increase variety with workstation level changes
46 Reduce awkward postures

Sample Concept Linkages for Fatigue

Patrick Neumann & Linda Rose, 2012
### Merged Map on Quality: Central Concepts

<table>
<thead>
<tr>
<th>Concept</th>
<th>Score</th>
<th>#Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase quality</td>
<td>110</td>
<td>198</td>
</tr>
<tr>
<td>Improve systems design</td>
<td>100</td>
<td>191</td>
</tr>
<tr>
<td>Reduce injury and/or fatigue</td>
<td>91</td>
<td>186</td>
</tr>
<tr>
<td>Increase understanding of how to do the task</td>
<td>87</td>
<td>186</td>
</tr>
<tr>
<td>Improve service to design teams</td>
<td>83</td>
<td>188</td>
</tr>
<tr>
<td>Reduce repetitive activities</td>
<td>78</td>
<td>166</td>
</tr>
<tr>
<td>Increase motivation</td>
<td>77</td>
<td>178</td>
</tr>
<tr>
<td>Improve repeatability</td>
<td>77</td>
<td>184</td>
</tr>
<tr>
<td>Improve layout of process on mfg floor</td>
<td>75</td>
<td>175</td>
</tr>
<tr>
<td>Build process from point of view of operator</td>
<td>74</td>
<td>160</td>
</tr>
<tr>
<td>Improve lessons learned (quality)</td>
<td>71</td>
<td>169</td>
</tr>
</tbody>
</table>

Patrick Neumann & Linda Rose, 2012
Reduce Injury and/or Fatigue

Patrick Neumann & Linda Rose, 2012
Quotes from Engineering Managers

• “fatigue and quality seem to go hand-in-hand, and that fatigue is not only the root cause of our quality problems, but one of the biggest factors”

• “fatigue seems to sum it up”
IE’s are used to thinking about Allowances

- Allowances account for unavoidable (normal) delays
- Allowable delays may depend on company policy

• Table 11.8

Niebel/Freivalds, 2009

Patrick Neumann & Linda Rose, 2012
\% REST = \frac{(W-5.33)}{(W-1.33)}
Ergo-Index:
Assessing recovery need in manual work

Patrick Neumann & Linda Rose, 2012
Background

• Fatigue and Injury compromise strategic goals

• MSDs
  • Recovery
    • Load level
    • Performance

• Possible to combine assessment of ‘ergonomics’ and production economics?

Patrick Neumann & Linda Rose, 2012
Different ways to analyse work

Chiselling/drilling in concrete wall

I: No support   II: With support

[Glimskär et al.]

Patrick Neumann & Linda Rose, 2012
Traditional comparison

UNIT TIME

ERGONOMICS

ECONOMICS

Minutes/hole

SEK/hole

Cost for support

Cost for drilling

[Glimskär et al.]

Would you invest in alternative II?

Patrick Neumann & Linda Rose, 2012
Ergo-Index rationale

**PRODUCTION TIME**

<table>
<thead>
<tr>
<th>Minutes/hole</th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Chisseling</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**ECONOMICS**

<table>
<thead>
<tr>
<th>SEK/hole</th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost for drilling</td>
<td>5.85</td>
<td></td>
</tr>
<tr>
<td>Cost for support</td>
<td>3.50</td>
<td></td>
</tr>
</tbody>
</table>

Would you invest in alternative II?

Patrick Neumann & Linda Rose, 2012
Ergo-Index

A model to evaluate job tasks regarding load level, time aspects and risk of injury, to be able to choose the “best” alternative from both ergonomic and production economics aspects.

1980s: Model based on literature and experimental studies

1990-2001: Further developed

2004: Call from industry
GM in North America among the users

Current project: Focus on:
1. Endurance time and Resumption time modelling
2. Repeated loading situations
3. Rating of Perceived Discomfort

Subjective assessment of recovery need

Patrick Neumann & Linda Rose, 2012
Quotes about use of the Ergo-Index

• “It is used both proactively (design) and reactively “

• “It is used to make determinations about recovery time in jobs and if there is insufficient recovery time then the job is changed. “

[GM]

Patrick Neumann & Linda Rose, 2012
An applied example
Assembling windows at a construction site

Manually:

With robot:

At first glance:

“Heavier, but faster”

“Easier, but slower”

Patrick Neumann & Linda Rose, 2012
### Ergo-Index input data sheet (model version 2012.1.0_English)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working distance:</td>
<td>0-40 cm, 40-60 cm, 60-80 cm</td>
</tr>
<tr>
<td>Working height:</td>
<td>foot-knuckle, knuckle-shoulder, shoulder-head, above head</td>
</tr>
<tr>
<td>Type of work:</td>
<td>lifting, pulling, pushing</td>
</tr>
<tr>
<td>Exerted force [N]:</td>
<td>375</td>
</tr>
<tr>
<td>Loading time [s]:</td>
<td>15</td>
</tr>
</tbody>
</table>

**Give a name to this case:** Manual window transportation
This load level is assessed to lead to a high risk of MSD-problems!

### Input data:
- Working distance [cm]: 0-40
- Working height: knuckle-shoulder
- Type of work: lifting
- Exerted force [N]: 375
- Loading time [s]: 15

### Results
- Loading time: 15 s
- Resumption time: 52 s
- Total time: 67 s
- Load level: 83 %
Robot window transportation 1(2)

Ergo-Index Input data sheet (model version 2012.1.0_English)

**Working distance:**
- [ ] 0-40 cm
- [ ] 40-60 cm
- [ ] 60-80 cm

**Working height:**
- [ ] foot-knuckle
- [ ] knuckle-shoulder
- [ ] shoulder-head
- [ ] above head

**Type of work:**
- [ ] lifting
- [ ] pulling
- [ ] pushing

**Exerted force [N]:** 80

**Loading time [s]:** 20

**Give a name to this case:** Robot window transportation

Patrick Neumann & Linda Rose, 2012
Robot window transportation

Results from the Ergo-Index analysis (model version 2012.1.0_English)

Case: Robot window transportation

Loading time and resumption time

<table>
<thead>
<tr>
<th>Seconds</th>
<th>Loading time</th>
<th>Resumption time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>34%</td>
<td>66%</td>
</tr>
<tr>
<td>10-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Load level [% of max]

- 42%

Input data:
- Working distance [cm]: 60-80
- Working height: knuckle-shoulder
- Type of work: pushing
- Exerted force [N]: 80
- Loading time [s]: 20

Results
- Loading time: 20 s
- Resumption time: 39 s
- Total time: 59 s
- Load level: 42 %

Patrick Neumann & Linda Rose, 2012
Ergo-Index summary

Patrick Neumann & Linda Rose, 2012
Ergo-Index summary

Borg’s CR-10 & body map

Discomfort rating: 6

Patrick Neumann & Linda Rose, 2012
Perceived discomfort prediction model

Example: Same load level, same loading time

Short pause in work cycle:

- Rapid increase in discomfort
- Probably production & health issues

Longer pause in work cycle:

- “Steady state” discomfort
- Probably less production & health issues

Patrick Neumann & Linda Rose, 2012
5 Key Points

1. Fatigue affects system performance
2. Engineering Managers ‘get’ that fatigue compromises quality etc.
3. Engineering Directors don’t think about 'ergonomics‘, but about fatigue
4. Higher loads need higher rest allowances
5. Rest allowance models allow you to balance fatigue & productivity concerns

Patrick Neumann & Linda Rose, 2012
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Patrick Neumann & Linda Rose, 2012