SAFETY IN INTELLIGENT MANUFACTURING

Jeremy Hadall

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BACKGROUND

- Opened in 2011
- Independent RTO
- To bridge the valley of death
- Prove innovative manufacturing ideas
- Manufacturing system solutions
- Training
WE’RE BRINGING SOLUTIONS TO LIFE

- Large scale projects converting ideas into viable processes, that are transferred into industry
- Working with project partners to access research and development funding via European, national and local government
- Improving UK productivity
ROBOTICS AND AUTONOMOUS SYSTEMS

- Specialise in the automation of manufacturing processes in a novel and collaborative way
- Development of advanced technologies including robotic manipulators, sensing technologies, adaptability, and the ability to think and act autonomously
- World-class equipment ranging from state-of-the-art robotic and automation systems, through to industrial scale manufacturing cells
INDUSTRIAL ROBOTS
WHAT IS A ROBOT?
A MECHANICAL OR VIRTUAL AGENT

- Can be autonomous or semi-autonomous

- The word was first termed by a Czech playwright in 1921

- But there have been accounts of ‘automata’ dating back to ancient civilisation

- Can take many forms from Honda’s ASMIO to industrial robots to ‘Big Dog’
A LITTLE BIT OF HISTORY…

- The first recognised industrial robot
  - Invented in 1938
  - Powered by a single motor
  - Controlled by punch tape
40 YEARS OF DEVELOPMENT

- 1956 – UNIMATION, USA
  - World’s first hydraulic, programmable robot

- 1974 – ASEA, SWEDEN
  - First commercially available all-electric microprocessor controlled robot
HUMAN FRIENDLY ROBOTS
I AM A FRIENDLY ROBOT.

T-BONE

100% recycled fiber with a minimum of 60% post-consumer material, processed chlorine free, and printed with water based inks.
A NEW GENERATION OF ROBOTS
PERCEIVED ADVANTAGES & CHALLENGES

- Human Robot Collaboration
- Productivity
- Flexibility
- Low Running Costs

- Collaboration vs Risk
  - Complicated Safety Cases
- Scaling
  - Everything we’ve seen so far is small...
- Economic Costs
  - Purchase & Ownership
- Achieving Productivity
  - Making the most of humans & robots working together
- Application Design
  - Ergonomics, ease of use, etc.
SAFETY APPROACHES
SAFETY FUNCTIONS OF INDUSTRIAL ROBOTS

- E-Stop’s
- Protective Stop’s
- Operating Modes
  - Automatic/Manual High Speed/Manual
- Pendant Controls
  - ‘Dead Man’ Handle
  - Start/Restart
  - Hold to Run
- Limit Switches
- Muting Functions

- ALL GOVERNED BY ISO 10218
QUICK QUIZ

Which of these is a ‘collaborative’ robot?

a) The industrial robot?
b) The force/torque limited robot?
c) Both?
d) Neither?

THE CORRECT ANSWER IS…

c) Both!!
# TYPES OF COLLABORATIVE OPERATION

According to ISO 10218-1

<table>
<thead>
<tr>
<th>ISO10218-1 Clause</th>
<th>Type of Collaborative Operation</th>
<th>Main Means of Risk Reduction</th>
<th>Pictogram (ISO 10218-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.10.2</td>
<td>Safety-rated monitored stop (Example: manual loading station)</td>
<td>No robot motion when operator is in collaborative work space</td>
<td><img src="image1" alt="Pictogram" /></td>
</tr>
<tr>
<td>5.10.3</td>
<td>Hand Guiding (Example: operation as assist device)</td>
<td>Robot motion only through direct input of operator</td>
<td><img src="image2" alt="Pictogram" /></td>
</tr>
<tr>
<td>5.10.4</td>
<td>Speed and separation monitoring (Example: replenishing parts containers)</td>
<td>Robot motion only when separation distance above minimum separation distance</td>
<td><img src="image3" alt="Pictogram" /></td>
</tr>
<tr>
<td>5.10.5</td>
<td>Power and force limiting by inherent design or control (Example: ABB YuMi, Kuka iiwa, Universal Robot URx)</td>
<td>In contact events, robot can only impart limited static and dynamics forces</td>
<td><img src="image4" alt="Pictogram" /></td>
</tr>
</tbody>
</table>
COLLABORATIVE ROBOTS

- SO THIS POSES THE QUESTION...
  - Does this mean that robots no longer need guarding?

- Yes and No...
  - It all depends on the process the automation is carrying out and the risk assessment...
SAFETY STANDARDS FOR ROBOTS

A-Level
- IEC 61508 – Functional Safety
- ISO 12100 – Risk Assessment

B-Level
- EN ISO 13849-1:2008
- IEC 62061:2005

C-Level
- ISO11161 – Integrated Manufacturing Systems
- ISO10218-1 - Robot
- ISO 10218-2 – Robot System/Cell

European Machinery Directive 2006/42/EC

Other C-level machinery standards that may be needed
## BIOMECHANICAL LIMIT CRITERIA

**ISO/TS 15066 – Clause 5.44 “Power & Force Limiting”**

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Accessible Parameters in Design or Control</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Impact/transient contact</td>
<td>Effective mass (robot pose, payload)</td>
<td>Pain Threshold</td>
</tr>
<tr>
<td></td>
<td>Speed (relative)</td>
<td>Minor Injury Threshold</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Highest loading level accepted in design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Highest loading level accepted in risk assessment in case of single failure</td>
</tr>
<tr>
<td>Constrained Impact/Quasi-Static</td>
<td>Force (joint torques, pose)</td>
<td>Pain Threshold</td>
</tr>
<tr>
<td>Contact</td>
<td></td>
<td>Minor Injury Threshold</td>
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- **Contact event** is short (<50ms)
- Human body part can recoil
- **Contact duration** is “extended”
- Human body part cannot recoil & is trapped
QUASI-STATIC CONTACT – SEVERITY

Threshold for touch sensation
Threshold for pain sensation
Threshold for low-level injury
Threshold for severe injury
Threshold for non-reversible injury

Adapted from: Industrial Safety Requirements for Collaborative Robots and Applications - Matthias, B – ABB Corporate R&D
## Application Protection Levels

<table>
<thead>
<tr>
<th>Risk Reduction Measures</th>
<th>Level 6</th>
<th>Level 5</th>
<th>Level 4</th>
<th>Level 3</th>
<th>Level 2</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perception-based real-time adjustment to environment</td>
<td>Personal protective equipment</td>
<td>Software-based collision detection, manual back-drivability</td>
<td>Power and speed limitation</td>
<td>Injury-avoiding mechanical design and soft padding</td>
<td>Low payload and low robot inertia</td>
</tr>
</tbody>
</table>

### Robot System – Mechanical Hazards

Adapted from: Industrial Safety Requirements for Collaborative Robots and Applications - Matthias, B – ABB Corporate R&D
USE CASES
All the robots that are currently marketed as ‘collaborative’ are small
  - This generally makes them safer

But industry needs bigger payloads and working ranges

So how do we go from this…
SCALING

- All the robots that are currently marketed as ‘collaborative’ are small
  - This generally makes them safer

- But industry needs bigger payloads and working ranges

- So how do we go from this…
  - …to this?
COLLABORATIVE WORKSPACES
CURRENT MTC RESEARCH

- To break the barriers between robots, humans and the environment so that we can have a truly collaborative workspace between humans and machines

- To overcome technical safety and security challenges to achieve the above

- To provide a platform for universities to research on and industry to exploit

- To provide advise and scientific data and results to regulatory bodies leading to recognised industrial standards
COLLABORATIVE WORKER
ECONOMIC MOTIVATION

DO YOU REALLY NEED COLLABORATION?

- Mass customisation
  - Increasing product variants
  - Shorter product lifetimes

- Competition from low cost economies

- Product flexibility

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