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Meat trimming hand tool:

Initial ergonomics evaluation

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1 Project Brief

OHS Hand Tool Evaluation, with reference to Milestone 2 (Develop body housing and controls) and Milestone 5 (Develop a range of interchangeable heads).

1. Conduct an initial ergonomics evaluation of the body housing, controls, and interchangeable heads of the IBEX concept meat processing trimming hand tool.

2. Report the findings of the evaluation tests to MLA / IBEX, and provide recommendations to improve the physical and functional acceptability of the concept design (where applicable), to be tested through the operational user trials.

2 Methodology

Our findings and recommendations are based on the information collected during the following stages:

- COHFE were initially approached on 17/3/04 by Kerrie Abba (MLA). Following a meeting with Kerrie and Jonathon Engle (IBEX) on 28/4/04 a proposal was sent to MLA & IBEX. Agreement with both MLA and IBEX for conducting the work systems assessment on was reached on 4/6/04.
- A prototype trimming tool unit was sent to COHFE on 14/6/04 (110mm blade and excluding the motor) and Stage 1 of the evaluation was conducted at this point. This process involved evaluation of the prototype with reference to tool-hand interface characteristics. Design characteristics and checklists that were used in this evaluation included:
    - Anthropometric data (Adultdata, 1998)
    - Handtool design principles and guidelines (Cacha 1999, Dababneh & Waters 1999, Kadefors et al 1993, Smith 1997, ILO 1996, Frievalds 1999).
- Stage 2 of the evaluation occurred on site with an operational prototype at the Richmond Te Aroha plant on 9/7/04. The prototype had been operating on site for one week. The evaluation process involved:
    - Briefing and debriefing meetings with the Site Engineer.
    - Task observation and familiarisation – slaughter floor (excess fat trimming), boning room (vertebrae trimming area) (mock-up)
    - Application of hand tool design checklists
    - Semi-structured interviews conducted with five staff (1 engineer, 2 fitters, 2 trimmers), covering: task suitability, ease of use, efficiency of use, safety, hygiene, blade changing, durability, design improvements.
    - Collection of video footage and photographs of the tasks and equipment for later observation and analysis
    - Measurement of the range of tool/head dimensions and weights.

3 Main findings

3.1 Introduction

The main injury risk factors reported in the literature that have been associated with hand tool use in general are as follows:

- Awkward wrist postures causing overloading of the structures running through the carpal tunnel.
- Tissue compression from holding / applying force to the tool.
- Static muscle loading from prolonged control activation (especially trigger finger(s)) or applying force as a task requirement or in reaction to torque in power tools.
- Excessive grip span to hold and activate the hand tool.
- Heat / cold extremes affecting the ability to hold and control the hand tool.
- Insufficient guarding leading to injury through inadvertent contact with the active tool component or power source.
- Vibration – which can lead to gradual onset conditions and vibration-induced white finger syndrome.

Clearly, other non-design work system factors such as workspace design, task organisation and training also have a significant impact on injury risk.

The following list of hand tool design principles are derived from research conducted with the aims of reducing injury risk through powered hand tool use, in particular gradual onset conditions which are the most prevalent problems resulting. The prototype trimming tool is assessed against each of these design principles in addition to three further areas for consideration (hygiene/cleaning considerations, ease of head changing, other observations).

- Grip surface (non-slip, low thermal and electrical conductivity, slightly compressible)
- Size of handle cross section (minimise gripping effort to do the task)
- Shape of handle cross-section (fit, prevent rotating inside the hand, provide a sense of orientation)
- Size of handle cross section (minimise gripping effort to do the task)
- Control activation force (turning on, maintaining power to tool)
- Angle of the handle (keeping a straight wrist and upper arms/elbows close to the body during use)
- Tool weight (minimise carrying effort, optimal weight for force exerted)
- Tool balance
- Handedness
- Colour (easy to identify and locate)
- Absence of pinch/pressure points and sharp edges
- Vibration
- Hygiene / cleaning considerations
- Ease of head changing

There are limitations to the application of these guidelines. Firstly, they were not written specifically for the trimming tool to which they have been applied. Secondly, they are based on research findings using different populations and performing different tasks to those who will be using the tool. Thirdly, the guidelines are largely based on one component of the work system, while task design, organisational design and individual experience levels are not always included. These will all affect how the prototype trimming tool is used.

3.2 Stage 1 – Hand and Hand Tool Design Guidelines (In-lab)

3.2.1 Grip surface (non-slip, low thermal and electrical conductivity, slightly compressible)

- The grip surface of the prototype appeared to provide good slip resistance with both cylindrical grooves to reduce slipping through the hand and deeper, wider grooves along the handle to reduce rotation in the hand (1mm deep). This grip pattern does not extend the full length of the handle however.
- The trigger strip is smooth metal, although this is offset by the length of the strip and the likely grip configuration to use the tool. The degree of slip resistance these configurations would provide under operating conditions with contaminants and glove use would need to be determined in the user trials.
- The conductivity of the handle is unknown but is likely to be low given its composition. As the trigger strip is metal, its conductivity will be much higher.
- Neither the handle or the trigger strip are compressible.

3.2.2 Size of handle cross section (minimise gripping effort to do the task)

- At 37mm the diameter of the main handle area is within the recommended 31-45mm (in theory) and is likely to comfortably accommodate both female and male users, assuming tool precision is required over power and that the hand anthropometry of users is similar to European profiles on which this recommendation is based.
- The handle tapers down to a diameter of 30mm just below the cutting head attachment, providing a thumb rest area, further resistance to slipping through the hand when the tool is in use and enabling grip reconfiguration for more precision. The extent to which these occur could be tested in user trialing.

3.2.3 Shape of handle cross-section (fit, prevent rotating inside the hand, provide a sense of orientation)

- The ideal cross-section for tools of this nature is an oval shape as it fits inside the palm better than round shapes such as the prototype handle, help prevent rotation inside the grip, and provide a sense of tool orientation. User trialing would be required to evaluate the usability and comfort of the prototype trimming tool handle.

3.2.4 Grip length (long enough to allow a power grip / diagonal precision grip)

- At an overall length (base to head attachment) of approximately 177mm, the handle is sufficiently long to enable full palm contact of large gloved hands.
- The potential for the handle to hit the wrist during specific tasks, particularly where the tool is being held further up the handle for greater precision, should be checked through user trials.

3.2.5 Control activation force (turning on, maintaining power to tool)

- The trigger switch was not difficult to activate or maintain in place, due to its length and the ability to change its position in the palmar grip by moving the orientation of the trimming head.
- Difficulties associated with turning on and maintaining power to the tool as it ages are unknown and could be part of an operational user trial. Problems could arise through: additional force required to activate due to contamination in the switch mechanism, inadvertent switching off with wear between the metal switch and plastic body, resulting in compromise hand positions to prevent this occurring.

3.2.6 Angle of the handle (keeping a straight wrist and upper arms/elbows close to the body during use)

- This is dependent on many aspects outside the tool design. However, the potential for angling the handle to maintain wrist movement (especially radial and ulnar deviation) within acceptable ranges during frequently performed or repetitive tasks could be investigated.

3.2.7 Tool weight (minimise carrying effort, optimal weight for force exerted)

- The weights of between 589 – 744 gms (35 – 128mm heads) are just over the recommended weight at which tools used repetitively should be counterbalanced (500gm).

3.2.8 Tool balance (well balanced for the task during intended use)

- This could not be evaluated at stage 1 as the prototype did not have a motor or all 3 trimming heads.

3.2.9 Handedness (equally suited to either left or right hand use)

- The prototype can be used by either hand.

3.2.10 Colour (easy to identify and locate)

- A different coloured body (rather than black) would make the tool easier to identify and locate.

3.2.11 Absence of pinch/pressure points and sharp edges

- There are no significant pressure points or sharp edges on the prototype handle. Less significant edges are present on the locking collar at the top of the handle, given that this is where the thumb is likely to rest and any downward force applied.

3.2.12 Hygiene / cleaning considerations

- There appear to be many places in the handle and head which could fill with trimming debris and may be difficult to clean (nuts, screw holes, switch mechanism).
- Unsure to what extent the switch end of the tool is waterproof and whether this is an issue in cleaning/sterilising the tool.

3.2.13 Ease of head changing

- Attaching / detaching trimming heads to the body requires a lot of handling of the head and increases the risk of finger/thumb contact with the blade.
- The durability of the thread may become a problem over the design life of the tool, as it is plastic, has a fine thread and will be frequently used when repositioning the head or when changing heads.

3.2.14 Vibration

- This could not be evaluated. It should however be considered as part of the operational user trials.

3.2.15 Other Observations

- There appears to be the potential for the rigidity of the power cable to affect tool balance, hand positioning, and the application of force when using the tool. This needs further investigation in user trialing.
- The long-term durability of the collar needs to be tested, particularly whether as it wears the trimming head will move when pressure is applied to it during use.

3.3 Stage 2 – Operational Prototype Appraisal (on-site)

The following comments are based on: observations made on site by the researchers, comments and responses from those people interviewed, and the application of the same hand tool design checklist as for Stage 1 (where applicable).

3.3.1 Grip surface

- No adverse comment specifically reported for both gloved and non-gloved use.

- Extending the grip pattern along the length of the handle and providing a slightly compressible surface are likely to improve the grip characteristics further.

3.3.2 Size of handle cross section

- Handle diameter appears suitable for gloved and non-gloved use.
- A larger thumb-rest / tang before the blade was mentioned as a potential improvement, both in safety and task efficiency.

3.3.3 Shape of handle cross-section

- An oval shaped handle was mentioned as being preferable to achieve a better fit within the palm.

3.3.4 Grip length

- Longer handle was very much preferred, providing a better grip surface and a larger lever for applying force when required.

3.3.5 Tool balance

- The balance appeared to be significantly affected by cable drag, which in turn appeared to be function of work position in relation to cable attachment to the wall and its overall length. When the tool is required to work with the cutting head in a horizontal position or pointing downwards, this drag may adversely affect muscle effort and wrist postures required to overcome this force.

3.3.6 Ease of head changing

- There were concerns about durability of the relatively fine thread for head attachment.
- Would prefer coarser threads so that attachment / detachment required less turns (and less time) – assuming propensity to undo itself was not increased.

3.3.7 Vibration

- Stated as being less than that of the current models used.

These findings are limited by the following factors:

- The relatively short time spent observing tasks.
- The relatively small sample of people interviewed.
- Not all tasks on all species were observed.
- Our presence will have biased the response made to us in interviews in some way (positively or negatively).

4 Recommendations

The following recommendations are categorised using the hand tool design checklist from section 3. It is important that a thorough operational user trial and evaluation process occurs to arrive at the best solution for each recommendation that is implemented.

4.1 Grip surface

- Extend the final grip pattern along the full length of the handle.
- Test slip resistance of the current grip pattern with contaminants and glove use under operating conditions.
- Consider covering the trigger switch with layer of non-conductive material to insulate against temperature extremes.
- Consider trialing a handle with a slightly compressible surface that still meets hygiene and durability requirements.

4.2 Shape of handle cross-section

- Consider trialing an oval shaped handle instead of round to provide better fit in the users palm.
- Trial a larger tang (encircling the handle) and more defined thumb/finger rest areas to reduce run-through risk and provide a more definite surface to grip for precision accuracy.

4.3 Grip length

- Check whether handle hits the wrist during precision task user trials.

4.4 Control activation force

- Conduct specific user trialing of the activation switch mechanism to test force requirements as the tool wears, existence of pressure points with repeated activations, and whether inadvertent switching off occurs as the tool wears.

4.5 Angle of the handle

- Evaluate wrist movements during operational user trialing for the range of commonly performed trimming tasks. Determine whether placing the trimming head at an angle to the handle would result in reducing the exposure of the wrist and hand to constrained wrist positions during use, without adversely affecting task vision.

4.6 Tool weight

- Investigate the potential to further reduce overall weight given that the tool may be used for long periods without counterbalancing.

- Consider making the option of counterbalancing feasible for those who want to do it (providing a place for cable attachment, taking into consideration tool balance, effects on hand placement and task vision).

4.7 Tool balance

- Determine to what extent cable length influences tool balance and task efficiency through user trialing.
- Consider the feasibility of increasing the freedom of movement as the cable attaches to the handle so that tool movement is not restricted by cable rigidity.

4.8 Handedness

- Any change to handle shape, head orientation, or switch configuration should continue to enable both left and right handed use.

4.9 Colour

- Consider the feasibility of a different coloured body to enable rapid tool identification.

4.10 Hygiene / cleaning considerations

- Investigate whether existing debris traps are a critical hygiene issue (MAF), and whether waterproofness is a durability issue.

4.11 Ease of head changing

- Provide a more robust threading system so that the head and body can be quickly coupled and secured with less hand contact of the trimming head, and one that is more durable than the existing system.
- Consider other forms of attachment that are quicker and require less handling of the trimming head.

4.12 Vibration

- Test the level of vibration that occurs during operational use to determine whether they pose a safety risk to users.
- User trials should also consider accelerated aging of the trimming tool to check vibration levels during its design life.

5 Operational User Trial Considerations

- Ensure a representative sample of users are involved (gender, experience levels, handedness, hand size, gloved/non-gloved, height).
- Consider range of tasks to involve in the user trialling (boning, slaughter, species, temperature, etc).
- Consider a range of work environments for conducting the trials (rail / table boning, chain designs, etc).
- Consider data collection methods to use (interviews, checklists, focus groups, measurements, etc).

- Direct measurements could be conducted on:
  - vibration
  - torque
  - grip force requirements (clean, during use)
  - posture (wrist/hand, upper limb, whole body)
  - thermal/electrical conductivity in use

- Subjective measurements could be conducted on:
  - grip surface / shape effectiveness
  - discomfort / pressure points
  - ease of use – all aspects of tool design and use
  - tool balance – cable drag
  - effect of grease chamber on sight lines

- Cycle testing could be conducted on:
  - activation switch durability and ease of use
  - thread durability for changing trimming heads
  - vibration

- Other variables to consider in designing and conducting operational user trials:
  - task duration, repetition
  - training in tool use / familiarity
  - tool use with different glove ensembles
  - unintended activities
  - inspection and maintenance
  - blade sharpness

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