CONDUCTING MOCK UPS IN THE WORKPLACE: PROCESS, CASE STUDIES AND LESSONS LEARNED

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Abstract
A mock up is a trial of an idea, typically performed in an off-line setting, using real workers who are familiar with the job and the project. Mock ups are used to investigate the feasibility of a proposed recommendation, to identify an "ideal" workstation layout in the design phase, to fine tune recommendations, to develop design specifications prior to implementation and to seek buy-in from operators who will be the end users of the proposed changes (Pheasant and Steenbekkers, 2005; Pheasant and Haslegrave, 2006). Mock ups are essential when it is not possible to easily predict the outcome of a proposed change, or when there are no existing ergonomics "guidelines" to provide specifications for a particular project. This paper provides a process for conducting mock ups, and tips to facilitate successful mock ups. Six case studies from a variety of industries are presented. The lessons learned and outcome of each case study are also discussed.

Key words: mock up, design, case study

RÉALISATION D'UN MODÈLE FICTIF EN MILIEU DE TRAVAIL : LA DÉMARCHE, LES ÉTUDES DE CAS ET LES LEÇONS RETENUES

Résumé
Un modèle fictif est l'essai d'une idée, habituellement réalisée dans un environnement hors ligne, à l'aide de vrais employés qui connaissent bien le travail et le projet. Les modèles fictifs servent à examiner la faisabilité de la recommandation proposée, déterminer un aménagement de poste de travail « idéal » dans la phase de conception, adapter les recommandations, élaborer des spécifications de conception avant la mise en œuvre et chercher à rallier les opérateurs qui seront les utilisateurs finaux des modifications proposées (Pheasant et Steenbekkers, 2005; Pheasant et Haslegrave, 2006). Ces modèles sont essentiels lorsqu'il n'est pas possible de prédire facilement le résultat d'une modification proposée, ou lorsqu'il n'existe aucune « ligne directrice » ergonomique en place pour fournir les spécifications relatives à un projet donné. Le présent article fournit une démarche pour réaliser des modèles fictifs et offre des conseils pour faciliter leur réussite. Six études de cas provenant de divers secteurs sont présentées. Les leçons retenues et les résultats de chaque étude de cas font également l'objet de discussion.

Mots clés : modèle fictif, conception, étude de cas

INTRODUCTION

Generally speaking, a mock up, also called a fitting trial, is a scale or full-size non-functional model of a structure or device, used for teaching, demonstration, testing a design, etc, (Pheasant and Steenbekkers, 2005; Pheasant and Haslegrave, 2006). This paper explores the benefits of using mock ups in the development of solutions for ergonomics concerns. With respect to ergonomics, a mock up is a trial of an idea, typically performed in an off-line setting, using real workers who are familiar with the job and the project. Mock ups are used to evaluate the feasibility of a proposed solution, to determine if an idea is worth pursuing, to dismiss a potential solution as ineffective, or to confirm that the proposed solution achieves the desired impact. Mock ups can provide the information needed to further fine-tune recommendations, to identify optimum working heights, work flow or product orientation. Additionally, mock ups present an opportunity to seek buy-in from operators who will be the end users of the proposed workstation changes.

Mock ups should be done whenever the impact of a proposed solution can not be easily predicted. They are critical in situations where a change will be irreversible (for example, raising the height of a long conveyor belt with multiple infeeds). By contrast, changing the jobs within a rotation sequence can be easily trialed and reversed if the results are not favourable and a formal mock up is not warranted. Almost all ergonomic changes warrant some type of mock up or trial period. The “best” mock ups involve considerable time and effort to simulate the recommended working conditions and to obtain quantitative and qualitative feedback and data. When it is not feasible to complete a “full” mock up, due to a lack of time or resources, a simple, quick mock up can provide valuable information, as illustrated by some of the case studies in this paper.

PROCESS AND TIPS FOR CONDUCTING MOCK UPS

Secure approval

Approval for time, space, equipment and people to conduct the mock up is essential. Mock ups will require experienced operators who are familiar with the job to be relieved from regular production duties. Depending on the fidelity of the mock up, planning and approval may be required to secure parts, equipment and/or production materials.

Gather materials

To facilitate a successful mock up, all the materials should be gathered well in advance of requesting relief for operators to leave the line. The materials required will vary with each project but could include tools, boxes, parts, cardboard, or a forklift to allow the ergonomist to raise and lower objects to determine appropriate heights (Pheasant and Haslegrave, 2006). The safety coordinator or a JHSC member should confirm that the mock up will not present any safety hazards. Once the mock up has been set up, the ergonomist should try the mock up to ensure that it can be used by a worker, and to identify any potential issues with the mock up.

Make the mock up as realistic as possible

The mock workstation should be as similar as possible to the actual proposed layout. Where possible, the use of “real” tools, equipment and parts will help the worker to imagine how s/he would function in the proposed workstation. However, inexpensive cardboard, pallet strapping and paper cutouts can also be used successfully. In setting up the mock up, the ergonomist needs to do as much as possible to help the worker to visualize the proposed layout and how s/he would interact during “regular” production.

Prepare for data collection

Prepare to collect as much information as possible in a short period of time. Ideally a second person, who is responsible for data collection, should be present during the mock up while the first person facilitates. The mock up goes quickly, and unless sufficient data is recorded, it may not be possible to explain why one design is preferred over another, or why a taller worker preferred the mocked up workstation, while coworkers of average and smaller stature provided less positive feedback.

Ideally the data collected should include:

- Video of the workstation and tasks being completed by a representative sample of workers (ideally "small", "average", "tall", and left and right hand dominant workers) (Pheasant and Steenbekkers, 2005; Pheasant and Haslegrave, 2006).
- Photos taken from different angles, capturing the joints or body parts of interest, as well as "big picture" photos of the worker in the workstation.
- Qualitative comments from the worker. Ask the worker to provide written feedback, and ensure that verbal feedback is documented during the mock up.
- The worker's rating of the mock workstation, and (dis)comfort using a Borg-style scale. Scale anchors for rating the mock workstation could include "better", "the same", or "worse" than the existing workstation.
- Worker heights and feedback must be correlated to the appropriate photos (for example, if the work surface is too high for a worker in a photo, but the worker's height was not recorded, the mock up data will be less valuable).

A survey or feedback data collection form ensures that all required information is collected.

Conduct the mock up expediently

The following steps should be followed to facilitate a successful mockup.

- When the worker arrives, explain the purpose of the mock up and the task(s) that they will be asked to complete.
- Ask the worker to complete at least one full cycle of the task. For short cycle tasks, the worker should to complete multiple task cycles (Pheasant and Haslegrave, 2006).
- Make adjustments as required based on observations of the worker and informal feedback.
- Repeat the task(s) as required to gather additional data for multiple variables (e.g. work surface height, location of a tool or part, etc.).
- Ask the worker to provide feedback regarding the acceptability of the mock workstation (Pheasant and Haslegrave, 2006). Feedback includes scoring the mock workstation, providing written feedback and rating the level of (dis)comfort.
- Thank the workers for their involvement and feedback.

If the mock up is not running smoothly, abort the trial and set it up again for another day after the issues that caused problems with the first attempt have been resolved.

MOCK UP CASE STUDIES AND LESSONS LEARNED

The following case studies are taken from client facilities in a variety of industries. Mock ups were conducted after an ergonomics concern was identified with an existing task, or as part of the design review process for new workstations. The outcome of each case study and the lessons learned are discussed.

Mock up reveals two new concerns

Above shoulder reaching, to remove a door from a machine to gain access for cleaning, was identified as a concern (figures 1 and 2). A platform was proposed to allow the operator to remove the door with more neutral shoulder postures. A mock up of the proposed working

height was conducted, confirming that the height change would address the shoulder concern (figure 3). However, the mock up also identified two new potential ergonomics issues. A potential back bending issue was introduced when lowering the door to its hanging position (which was below the height of the platform) (figure 4). Further, the operator was required to squat to lower the door (figure 4) which required greater horizontal clearance than standing upright to lower the door (figure 2). This clearance was not available, when the doors on the adjacent machine were also lowered, (figure 4). Simple calculations of working heights identified the appropriate height for a new platform; however the back bending and clearance issues would have been missed without the mock up. Completing the mock up facilitated discussions regarding process changes that would also be required in addition to the proposed height change (A. Alpaugh-Bishop, personal communication May 22, 2009).

Figure 1: Shoulder postures required to grasp the door

Figure 2: Positioning the door in its lowered position

Figure 3: Mock up of working on platform to grasp the door

Figure 4: Mock up of working on platform to lower door

Identifying an ideal viewing angle for all

A drawing of a new workstation was provided for ergonomics review and sign-off (figure 5). Operators were required to transfer product from an incoming conveyor to a pan on the scale, until the target weight was reached. The proposed location of a red/green display (approximately the size of a credit card), which indicated when the target weight was reached, was identified as a concern. A mock up was conducted to illustrate the degree of neck twisting required to view the display in the proposed location, and to provide operators with the opportunity to identify a preferred location for the display. An envelope attached to an overhead bin represented the incoming conveyor, a box on the desk represented the scale surface, and a business card taped to the overhead bin represented the display (figure 6). Operators were asked to work at the workstation, and to provide feedback on neck postures and viewing angle required (figure 7). Operators were asked to reposition the display to the height and lateral distance that would enable them to view it with neutral neck postures. Prior to recommending a new display location to the engineer, associates of tall, average and small stature were asked to confirm that they could view the display with neutral neck postures. The display was positioned to minimize the awkward neck postures for operators of all statures.

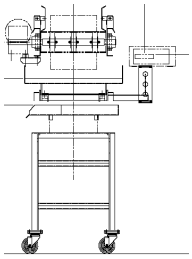

Figure 5: Drawing of proposed workstation

Figure 6: Mock up of proposed workstation

Figure 7: Operator working at mock up of proposed workstation

Forklift used for cart mock up

Awkward back postures required to transfer parts from an outgoing conveyor to the bottom layers of a cart were identified as a concern. A forklift was used to raise the cart during a mock up of loading parts into a modified, taller, cart (figure 8). The mock up confirmed that the back bending concern would be addressed by raising the cart. However a mock up of the full cycle of loading the cart was not conducted, and when a taller prototype cart was constructed, shoulder concerns were identified while loading parts in the top layers of the cart (figure 9). A biomechanical assessment demonstrated that regardless of the height of the cart, loading the top or bottom layers of the cart would create issues for either the shoulders or back, as long as the current cart capacity was maintained. The value of completing a full cycle of the task was reinforced in this mock up (D. Van Winckle, personal communication May 22, 2009).

Figure 8: Mock up of loading parts into the first layer of the raised cart

Figure 9: New shoulder concerns to load top layer of prototype cart

Mock ups to validate biomechanical modeling

Static, awkward shoulder postures were required to complete a meat trimming task. Larger males were required to work with the hands at or slightly above shoulder height (figure 10), while “average” females worked with the hands at or slightly above head height (figure 11). To reduce the shoulder demands, operators of smaller stature were often observed to stand on the kick plate on the front edge of the existing work platform. 3D Static Strength Prediction Program (University of Michigan, 2008) was used to determine the “ideal” height for a new platform, and a mock up was conducted to confirm the results of the analysis. A small step ladder was placed on the existing work platform, and operators stood on the bottom step of the ladder and mocked up the demands of working on a raised work platform, while the line was down during a break. This mock up verified that raising the platform by 30 cm (recommended by the working height calculations and 3D output) would improve shoulder postures. However, the mock up also identified that substantially raising the platform would introduce wrist concerns while trimming. As an interim solution, several pieces of platform grating were “zip tied” to the existing work platform at an intermediate height to improve shoulder postures. Operators provided positive feedback regarding the interim, quick-fix change. In this case, the mock up prevented the implementation of a change that could have increased the risk of wrist injury.

Figure 10: Static awkward shoulder postures required to trim (tall male)

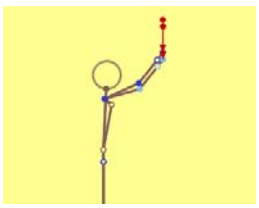

Figure 11: Static awkward shoulder postures required to trim (average female)

Pallet strapping used to identify cutout dimensions

An engineering drawing of a proposed workstation was provided for ergonomics review and sign off. The workstation needed to incorporate two “cut outs”; one for “bad” trim and one for “good” product. A mock up was conducted with several experienced operators to determine the preferred location and dimensions of cut outs in the work surface. Pallet strapping was stapled to form rectangles and circles of various sizes, and placed on the work surface to represent the cut outs and the “drop zone” for incoming product. The operators worked at the mock up of the proposed workstation and provided feedback on the preferred location and dimensions of the cut outs and the “drop zone” (figure 12). The recommendations were forwarded to the engineer and were incorporated into the final design of the new workstation (A. Alpaugh-Bishop, personal communication May 22, 2009).

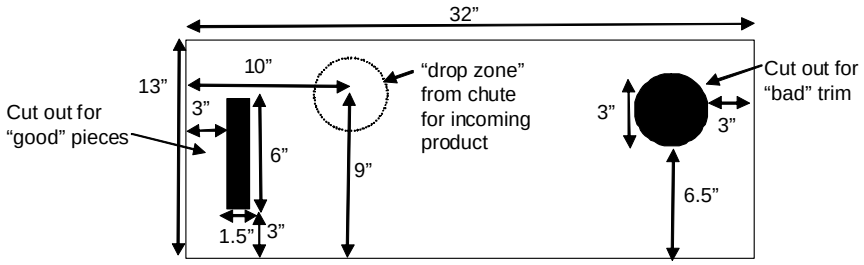

Figure 12: Ideal layout of proposed workstation

2x4 ergonomics mock up

An operator identified concerns regarding the working heights required to work on sub-assembly components in the vise at a work bench. The operator also handled larger components on the work bench without the use of the vise, and did not have concerns regarding the height of the bench for the larger pieces. A scrap piece of lumber placed in the vise was used to mock up the working height change (figure 13). This process represents a quick, low cost method to mock up a proposed height change (A. Barnwell, personal communication May 22, 2009).

Figure 13: 2x4 used to mock up the preferred height of the vise

CONCLUSIONS

As illustrated by these case studies, mock ups can provide valuable information regarding proposed changes or the layout of new work stations. Often the information gained during the mock up could not be attained through ergonomics evaluation tools (e.g. working height calculations, biomechanical modeling, etc.). The cost to conduct a mock up is typically low and these costs are easily offset by any retrofits that are avoided.

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