Ergonomics of Grab Unloaders for Bulk Materials Handling

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Abstract

An ergonomic study of operator cabs for grab unloaders is presented herein. Our results demonstrated that the drivers adopted poor postures, partially owing to the basic geometry of the situation and partially because they used only the central lower front window for downward vision and control boxes obstructed visio n. These problems have been exacerbated by introducing extremely large bulk carriers that have a wider hold than the previous ships used.

8 Introduction

The bulk unloaders investigated herein have a grab which removes coal from ships moored at a jetty and, then, transfers the coal to hoppers which control the flow onto a conveyor belt. The operators have complained of various aches and pains presuma bly owing to the shortcomings in the cab design. The drivers of the unloaders sit in a cabin which runs along a jib extended out over the ship's hold. The task involves looking almost vertically down into the ship's hold to load the grab and then lift the loaded grab and transfer it to a hopper which is slightly below eye level to the right of the driver. This study evaluated the cab from an ergonomics perspective. Recommendations for improvements are also presented. The unloaders studied herein were instal led about 7 years ago. Courtney and Evans (1993) examined much older grab unloader cabs, concluding that because the drivers inclined the trunk forward up to 40X and the neck up to 70X from the vertical direction, the static loadings on the back and neck were likely to cause problems.

Keywords: bulk materials handling, overhead cab design, ergonomics

1 Method

Information about general operation of the unloaders was obtained from the company. A literature search was also conducted for cranes (Burdorf and Zondervan,1990; Gustafson-Soderman, 1987), seating (A nderson,1986) and posture (Buckle et al.,1986). Sixteen grab unloader operators were interviewed using a questionnaire covering work space, seat, controls, displays, visibility and lighting, postural functional load, thermal environment, noise and vibration, work schedules and general factors. Cab dimensions of the unloaders were recorded permitting reconstruction of the cabin layout, thereby allowing the solutions to be tested without the need for access to the unloader. Geometrical configurations for the unloader and dimensions for the largest ships were combined to define the visual requirements of the task (Figures 1 and 2). In addition. the postures adopted and sequences of operation were recorded by still and video photography. One quarter scale manikins and drawings of existing and proposed cab layout were also used to predict postural reactions to changes in the cab.

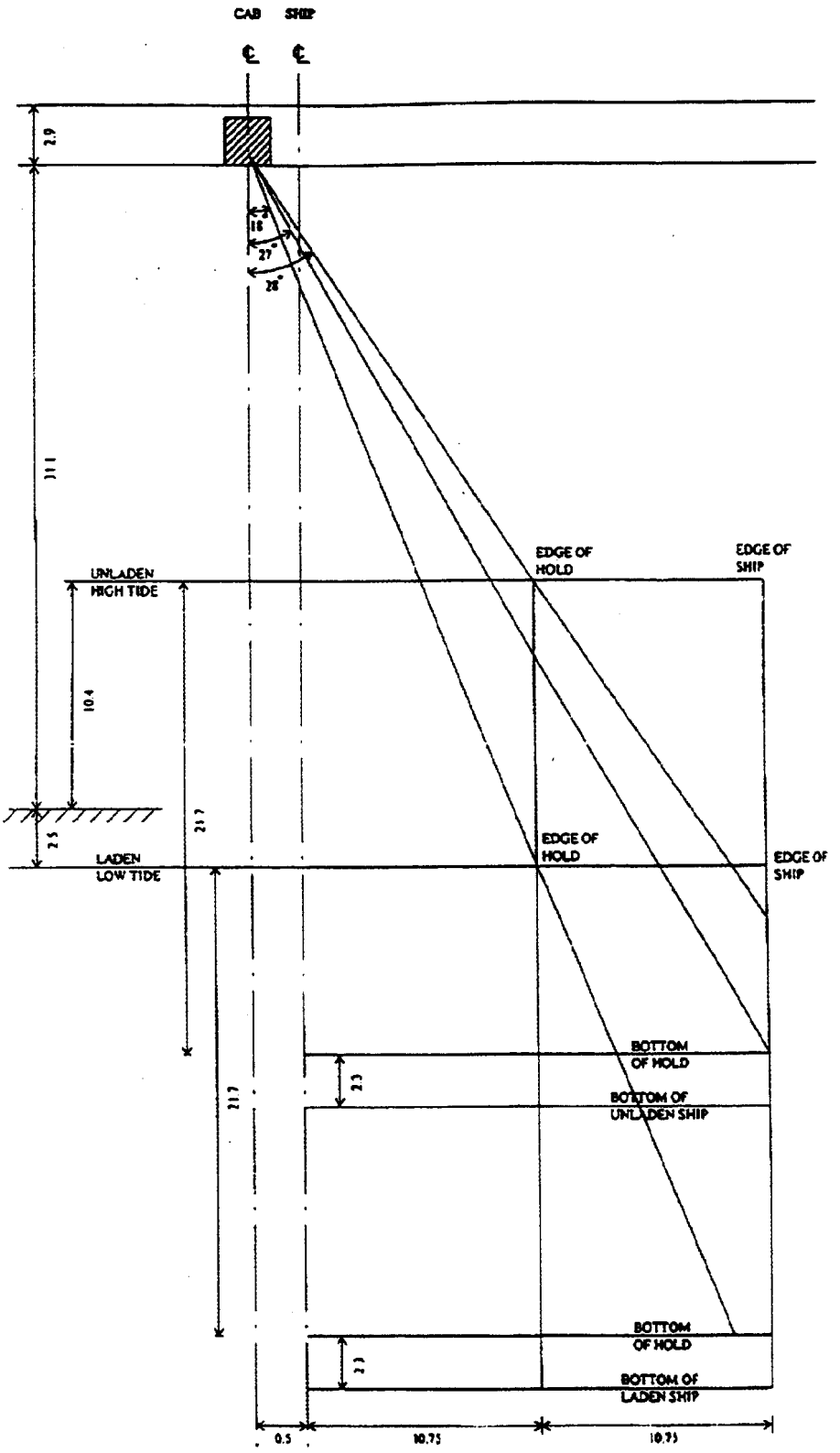
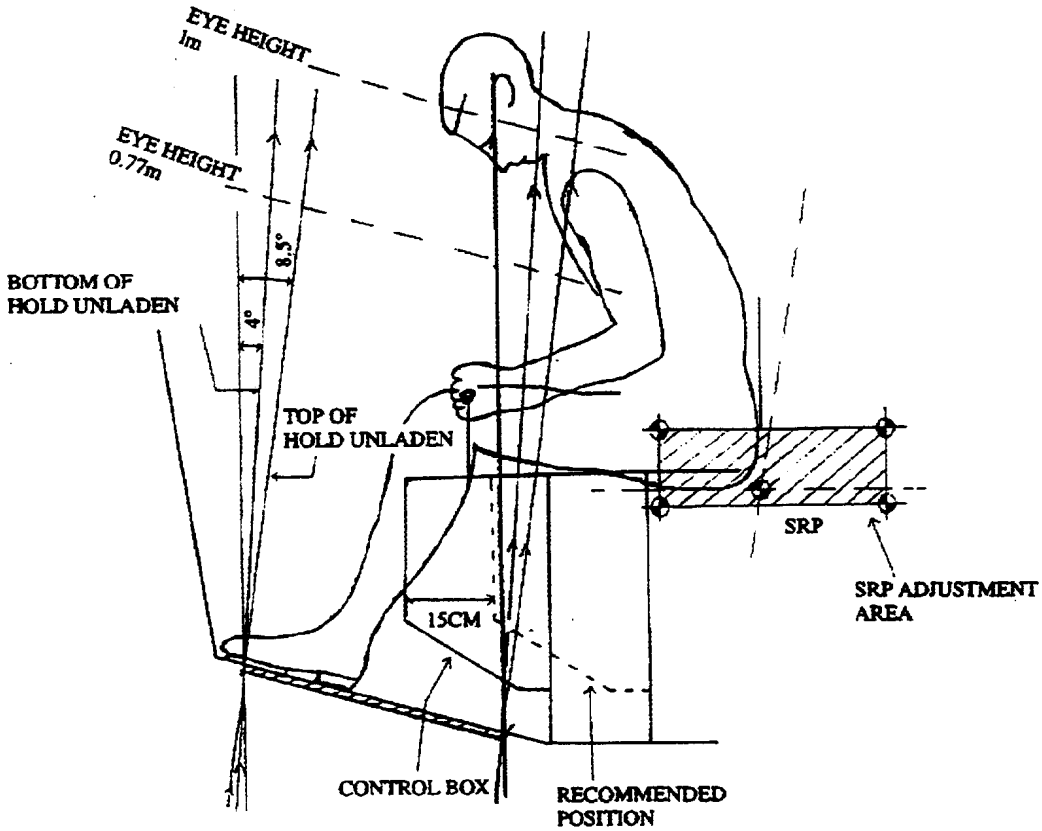


Fig. 1. Geometry associated with the largest ships (dimensions in m).



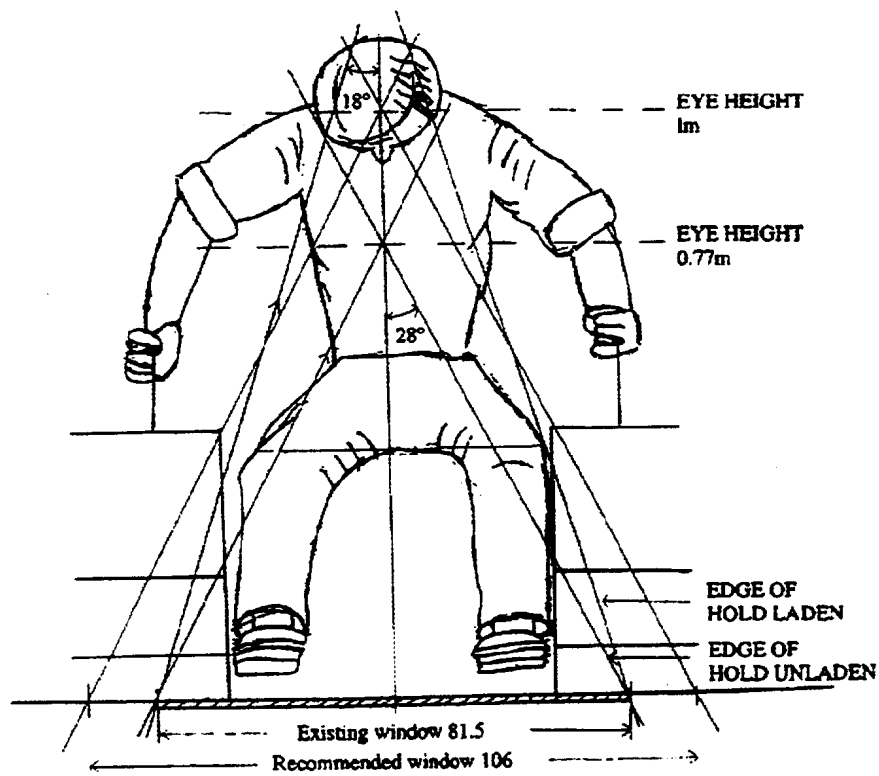


Fig. 2. Eye heights and recommended modifications (dimensions in cm).

2 Results

General layout and detailed drawings of the cab were prepared. The control at the front of the right console opens and closes, as well as raises and lowers the grab. The control at the front of the left console traverses the grab along the jib. Behind this traverse control is a third control that operates the unloader's movement along the jetty (forward and back). The drivers did not complain about the physical layout of the controls. The grab has a semi-automatic system. However, because the drivers found it diffi cult to set up, they preferred using the manual mode. Although the drivers did not complain, it was difficult to get in and out of the seat. The only complaint about the adjustability of the seat was that 31% of the drivers would like some lateral adjustment. One driver thought the seat was too soft; otherwise, all the drivers found the seat satisfactory. Nevertheless 94% of the drivers use some sort of bamboo or plastic seat insert; 70% of them occasionally stand up when working. The lower front window and the right hand window are essential for viewing the hold of the ship and the hopper, respectively. All drivers complained of the inability to clean the windows easily. The lower front windows were especially difficult to clean because to clean the windows, retaining nuts and clips had to be removed and the window lifted out by handles. This procedure was not easy and presented some danger because any of the loose parts, including the entire window, may drop to the ground. Owing to this difficulty, the drivers tended to use only the centre lower window and allow the other lower front windows to become dirty. Another visual problem was that on sunny days, it was difficult to see into the ships hold because of the high contrast between the deck and hold.

All the drivers complained that they had to maintain awkward body positions during normal work and that the entire job involves awkward postures. The main problem areas were neck (81%), shoulders (50%), mid back (50%) and lower back (88%). 56% of the drivers said that they have sought medical advice for these problems. All the drivers questioned operated the old type of cabs reported by Courtney and Evans (1993) and the newer ones reported herein. The complete work cycle was 45 sec and approximately 50% of this time was spent looking nearly vertically down into the hold; most of the other half of the time was spent looking forward or to the right. For 50% of the cycle when the operators were looking down, they adopted a posture with the back 30X to 40X forward and the head inclined forward 30X to 35X. Much the same postures were adopted for inclination of the head and back in both old and new types of unloaders, so as to achieve a posture with the head inclined forward to about 60X to 70X from a vertical position. Some drivers bent the lower back more than others to achieve this angle; other drivers bent the neck more to achieve the same angle. Increasing angle of forward inclination of the head is associated with localized fatigue, the great er the angle the greater the fatigue. The driver must have good downward visibility to guide the grab into the hold without causing damage and to pick up a full load. The distance from the centre line of the grab to the drivers eyes was 3.5 m; the cab floor was 31.1 m above the jetty floor; and only the lower front window was normally used. If the driver wanted to check the movement of the grab relative to the hold or if he wanted to see inside the hold, the geometry of the situation dictated that he must e ither bend forward to 77 cm from the window or bend sideways to 14 cm from the vertical position. Bending forward would decrease the angle between the thigh and trunk. This angle should preferably be not less than 105X for comfort, though the range 85X to 100X is recommended for drivers of heavy vehicles (Courtney and Wong, 1985). This angle ranged from 70X to 90X for most of the work cycle. Bending sideways caused the drivers to adopt awkward postures.

The postures adopted when looking into the hold were superimposed onto one quarter of the scale drawings of the cab using 5th and 95th percentile manikins based on dimensions from Courtney and Wong (1985). With these manikins, a range of seat adjustments using the seat

reference point (SRP) to specify seat locations were tested for 5th and 95th percentile drivers. Seat reference point (SRP) is where the middle of the seat and the backrest intersect. The seat pan should tilt forward to allow the drivers to adopt a more nearly standing pos ture sometimes. Under such a posture, the eye height would increase so that the front lower clean window area must be increased to 1.06m (Figure 2). If we improve driver posture by raising eye height to around one metre, the control boxes must be modified to provide a relatively unobstructed view and permit easier window cleaning. The drivers prefer to sit well forward to obtain a visual field free from obstruction by the control boxes. If we improve driver posture by raising eye height and allow a greater range of postures by making it possible for the drivers sit further back, the control boxes must be modified. There is quite a lot of control equipment in each box so careful study of the electrical layout is required. Much of the space at the bottom of the box is taken up by a bus bar which may be fairly easily relocated. Every effort should be made to reduce the box by cutting away part of the inside edge. A preferable solution would be to move the entire box back 15 cm to give an unobstructed view and pe rmit much easier window cleaning (Figure 2). If this is done, it is highly desired to attempt to reduce the overall length of the box by taking 15 cm or more of the rear of the box to permit easier access to the roll back seat. The window grill acted as a footrest. The present grill attachments are totally inadequate and the windows are removable. If the control boxes are moved back, a hinged window and grill could be fitted to make the window cleaning easier.

3 Conclusions and Recommendations

From the data collected and analysis of postures, static loading of the neck and back apparently occur with the trunk inclined forward to between 30X and 40X and the neck inclined forward about 60X to 70X from vertical to ensure a good line of sight almost vertically downwards. A relatively recent problem has arisen because of the width of the new ships, thereby preventing the drivers from positioning the cab over the centre line of the ship. Therefore they must either twist sideways or bend lower to ob serve the edge of the hold. If the drivers adopt a more vertical position, the working posture should be significantly improved. Any adjustments to achieve a more vertical posture would involve increasing the eye height. Consequently, a wider window clean area for vision than currently provided by the centre window is necessary.

3.1 Short term recommendations

(a) A new seat should be provided. The main design criteria are as follows: range of adjustment should be inc reased; it should be easy to adjust; seat pan depth should not exceed 34 cm so as not to obstruct downward vision; width should be at least 45 cm; seat pan should have an angular adjustment capability from 5 degrees back to 15 degrees; and the back angle should be adjustable from 0X (upright) to 15X back and should provide good lumbar support; seat parts subject to wear such as seat pan, backrest and adjustment bearings, must be easy to replace; the seat padding should be firm; and access/egress should be permitted by a roll back system with easier access than presently.

(b) Drivers should be trained to adjust the new seat to improve their posture.

(c) The front part of the control boxes should be cut-away as much as possible to reduce obstruction to vision and to enable the windows to be more easily cleaned. Cutting away the structure would require reorganizing some of the wiring.

(d) The control box should be moved back 15 cm and shortened by at least the same amount by cutti ng away the rear. The latter modification would maintain the existing clearance

for the roll back seat.

(e) The grill serves a safety function, it protects the glass and acts as a footrest. Lightweight grills with minimum cross section rods consistent with safety should be designed for the lower front windows so as to minimize obstruction to vision. The grill should be hinged in such a manner as to make window cleaning easy and safe. If hinges prove impractical, it should be very easy to remove an d replace. Some means of securing the grill safely but out of the way for window cleaning should be sought.

(f) The lower front windows should be hinged and not totally removable as at present. Moving the control boxes allows the windows to be opened for cleaning. A safe procedure for window cleaning should be devised and the drivers instructed in the procedure.

(g) A programme of regular window cleaning should be implemented to prevent workers from leaving it for the next worker or next shift.

(h) Provision of first rate, properly stored and maintained window cleaning equipment should be made.

(i) The cut away control box should permit easier cleaning of all the lower front windows. Drivers should be instructed of the importance of keeping the lower side windows clean because using them allows for a greater variety of postures and, in particular, allows them to occasionally sit more erect.

(j) The lower front windows should be replaced when they become badly scratched and cause scattering of light.

3.2 Longer term recommendation

View of the hold and work place design can be improved in the long term by modifying the cab structure. These recommendations are not necessarily interlinked.

(a) The length (horizontal dimension) of the front lower window should be increased to as near to 1.1 m as is safe and practical. This increase will enable the operators to observe the lateral movements of the grab w ithout adopting sideways twisting postures.

(b) A seat combined with controls could be considered, allowing the tilting and swivelling and permit a wide variety of postures. Such a seat has been suggested for crane cabs with the objective of alleviating some of the symptoms due to poor posture (Gustafson-Soderman, 1987).

(b) A longer outreach for the cab would allow the drivers to position it over the centre line of the largest ships.

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