
Comfortable earth moving machinery

Knowledge and experiences from the Eurocabin project

Editors

F. Krause

R.E. Bronkhorst

M.P. de Looze

This publication can be ordered at:

TNO Work and Employment

P.O. Box 718

2130 AS HOOFFDORP

The Netherlands

Fax: +31 23 554 93 94

E-mail: receptie@arbeid.tno.nl

Price: EUR 20 excl. VAT

ISBN 90-6743-977-0

© 2003 TNO Work and Employment

© Figures 16.2 and 16.3 Hans Rakhorst and Figures 16.4 and 16.5 Lodewijk Vormer

Editors:

Frank Krause, Robin E. Bronkhorst, Michiel P. de Looze

Print:

PlantijnCasparie Heerhugowaard

No parts of this manuscript may be reproduced in any form, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, or otherwise, without prior written permission from the publisher.

16 Future cabins

Hans Rakhorst, Lodewijk Vormer

TNO Work and Employment, Hoofddorp, The Netherlands

16.1 Intuitive control

Hans Rakhorst

All modern hydraulic excavators are nowadays joystick operated. This has reduced the physical exertion necessary to operate machines of the former generation. Though this may easily be regarded as an improvement - as do all operators - it does not necessarily mean that it is without health risks. As in other professions repetitive strain injuries (RSI) are also present among operators. The transition to joystick operation has led to a working posture, in which only small movements of the arms are required. Furthermore as movement ranges have become smaller, the need for precise muscle activity has become larger. This requires adequate armrests not only to support the arms and alleviate shoulder muscles, but also to stabilize the arm when precision is required.

Excavator seats do not yet meet the requirements to provide this arm support to a large population of users. The seats often lack arm support. This is then supplied by an armrest connected to the console, in which the joystick is mounted. Their adjustment ranges are mostly limited. This was described in chapter 7.

Present joystick design may not necessarily be the most suitable to the various tasks an excavator operator performs. The precision requirements lead several operators to move the joystick by fingers as they are not able to reach the necessary level of precision while gripping the joystick with the full hand. This finger operating technique leads to joint positions, that are far from optimal (see figure 16.1).

The above mentioned conditions are known to be a risk for RSI. This study aimed at improving the adjustability of the operator's control position and at improving the joystick's position relative to the operator to reduce the risk of musculoskeletal disorders. This has lead to an idea for a very adjustable workstation, in which also the joystick's form can also be adjusted to suit the operator's preferred working technique (see figure 16.2).



Figure 16.1 Extreme joint angle in joystick operation

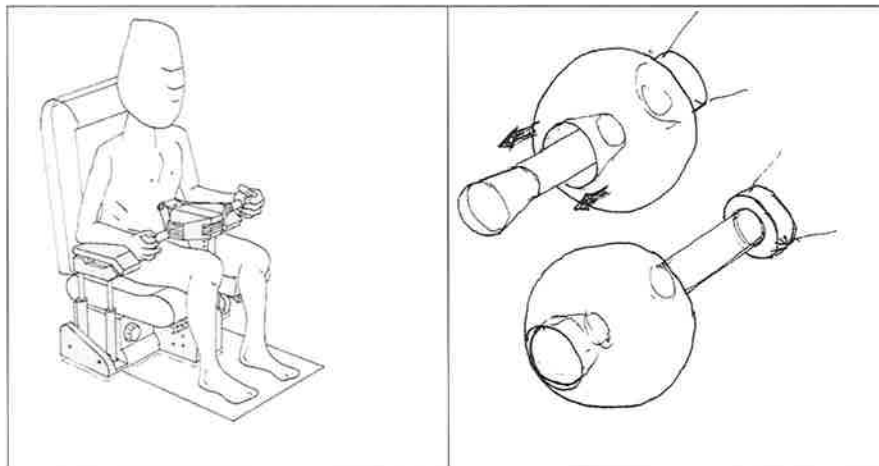


Figure 16.2 New ways of joystick controlling

We have also looked at new ways of operating the excavator without using a joystick. The result is an idea for an alternative control. The new control requires larger movements of the hands and arms. The machine can be controlled bi-manually and with one hand. By doing so the load on hands and arms is varied. This reduces the risk for overuse injuries. Besides wanting to reduce the risk factors we have looked for a very intuitive way of controlling the machine. This may reduce the time necessary for an operator to learn the trade, which in some countries is important because of the difficulties companies may have in finding suitable personnel.

The result is the shown in figure 16.3. At the time of writing this book the presented control still only exists as a three dimensional rendering. It would be interesting to build such a control and to have operators test it under realistic conditions to see, whether this innovative control can live up to its expectations and be of value to future operators.

Comfortable earth moving machinery

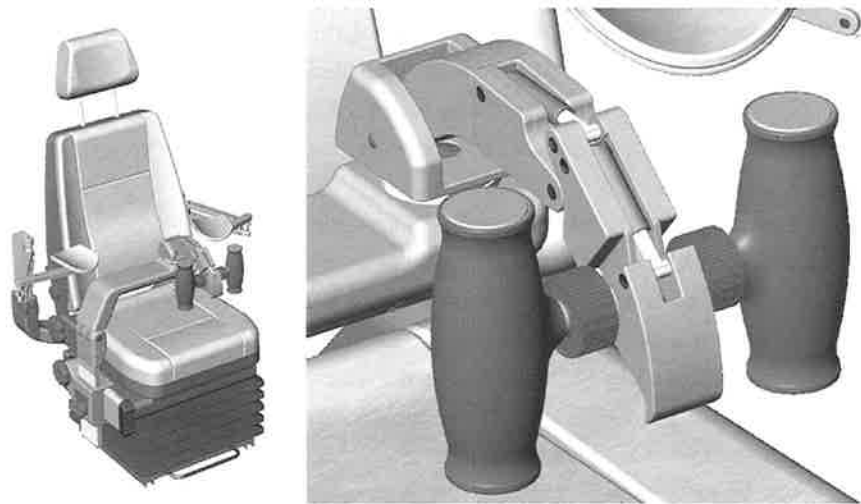


Figure 16.3 An intuitive control system

16.2 I see, I see what you cannot see

Lodewijk Vormer

The purpose of the project was the development of a conceptual cabin design for future excavators. The project's main goal was the improvement of the outside view from within the operator's cab. The project focused on excavator models ranging from 10 to 50 tons and concerned both crawlers and wheeled excavator models.

Based on an extensive analysis of existing excavators, excavator cabins and its users, potential problems concerning the visibility have been charted. These problems have been sub-divided into three areas. First and most important there are restrictions in the operator's view of the direct working area. The downward view is limited and the view on the reaching area of the hydraulic arm is interrupted by the cabin frame. Second the view of the area surrounding the working area is restricted. To the right the view is obstructed by the boom and the downward rear view is limited. Lastly the view of the vehicle's sides should be mentioned. There is little or no view of the vehicle's right side, the right rear corner and the back of the vehicle.

Additionally, problems directly concerning the windows also play an important role in aggravating the restricted visibility of the outside. Curved windows can

lead to reflections and distortion of the view. Glazed windows provide very little protection against glare and the heat of the sun. Windows become soiled, yet not every window is equipped with windshield wipers and washers.

Quite different from these problems nevertheless, something that may also reduce productivity is the fact that windows are also prone to vandalism.

Trends and developments in the field of operator view

When trying to find solutions to these problems, it is important to take a close look at trends and developments regarding this matter. With respect to glazing there is still an increase in glass surface of the cab. For solutions to the problems connected to large glass surfaces the glazing industry can provide solutions. Laminated glass with coatings or incorporated films can make operator life behind the window a lot more comfortable. E.g. with electro-chromatic glass the transmission of light and heat can be adjusted, thus reducing glare or heat build-up. By using self cleaning coatings containing titanium dioxide combined with a hydrophobic surface, soil and rain will have less influence on the outside view.

Legislation requires cars to have glass front and side windows. However, synthetic materials are rapidly evolving into good and in some ways even better alternatives to glass, including their scratchproofness. In cars there are already synthetic back and roof windows. It is a matter of time and these materials will have found their way to all kinds of cabins with their advantages of being light, relatively cheap and easy to mould.

Rather different are the developments towards a moveable cab. A few excavator manufacturers offer the opportunity of mounting a cab of which the vertical position can be adjusted. Several manufacturers of mobile cranes have a tiltable cab installed to improve upward visibility.

With respect to indirect viewing and alternative means of viewing there are also many developments. Already mirrors are being replaced by cameras offering large flexibility regarding camera positions, display positions and the operator's choice of what is to be displayed. By using GPS⁵ in combination with several sensors (radar, sonar, heat, etc.) it will be possible to create a computerized image of reality giving the operator a see-through view of the earth he is excavating. The images might either be projected on the front window or even on a screen in a separate working place from where the operator controls his machine.

⁵ Global Positioning by Satellite.

The 'Turtleneck' concept

Based on the existing trends and developments, in an attempt to further enhance the operator's direct view of his work, solutions have been sought on four different levels:

- the location/position of the cabin;
- the location/position of the driver;
- the cabin exterior;
- the cabin interior.

A multitude of ideas generated in the course of this project have led to several concepts. These concepts were in turn used to compose a single final concept: the 'Turtleneck' concept of which a three-dimensional computer model was built. The 'Turtleneck' concept boasts the following qualities:

- the moving cabin allows repositioning in order to achieve the best possible view. This cabin can be elevated to look over obstacles. It can be moved forward to look down over the undercarriage. The cabin can also be tilted forwards and backwards to optimize view through the front windscreen of the working range of the hydraulic arm (see figure 16.4)

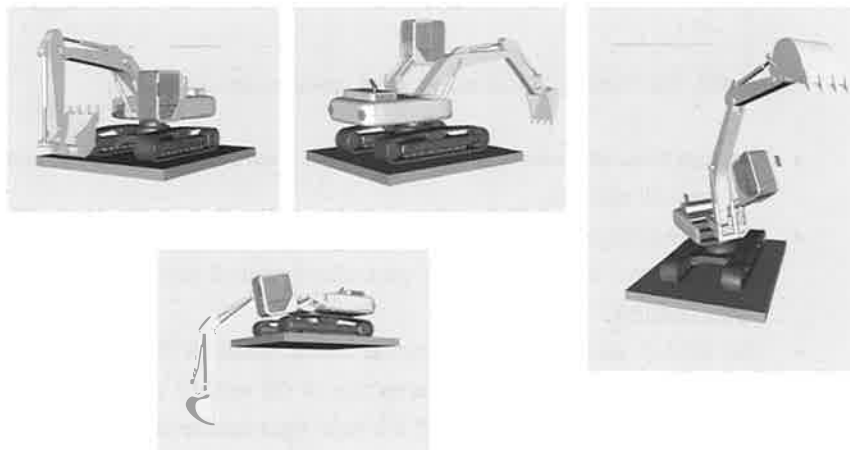


Figure 16.4 Renderings of the 'Turtleneck' concept showing the movements of the cab

- the front windscreen of the cabin is enlarged by integrating front, top and a bottom window affording more view on the working range of the hydraulic arm;
- a sliding floor panel can be uncovered to reveal a window underneath, thus enabling a direct downwards view;

- the cabin's main door is a sliding door and can thus be easily be opened and shut by the driver in a seated position. Because the door can be set in different positions of closure, adjustable ventilation is also achieved;
- the driver's seat can be adjusted to support the driver's body in multiple positions (see figure 16.5);

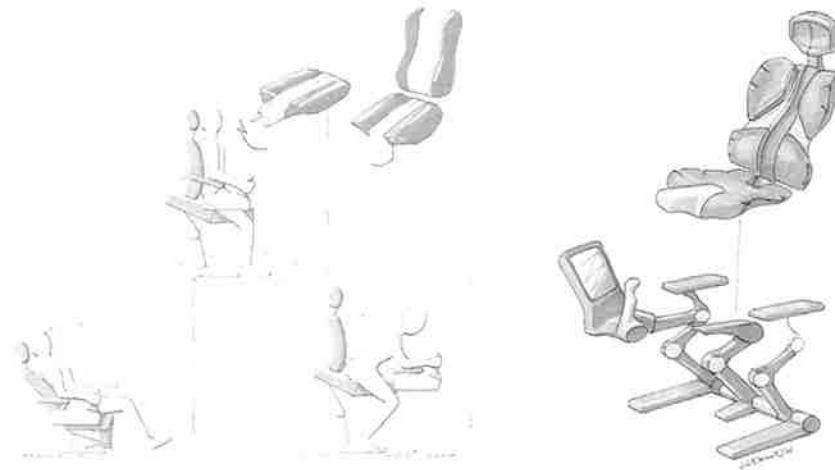


Figure 16.5 The 'Turtleneck' seat adapts to the operator's chosen posture

- the functions of steering wheel and travel levers have been incorporated in the joystick controls;
- all the control panels have been substituted by a single touch-screen display, providing the driver with easy centralised control and overview of all the cabin features;
- the display also provides additional views obtained through cameras and sensors mounted on the upper structure of the vehicle. In this manner views to the right, the right flank, and the back right corner of the vehicle are provided.

Compared with contemporary cabin design, the view of the outside provided by this new cabin design has been improved significantly.