Comfortable earth moving machinery

Knowledge and experiences from the Eurocabin project

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11 The Eurocabin project

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11.1 Introduction

The participants in the Eurocabin project were three SME manufacturers of earth moving machinery: the German Hermann Paus Maschinenfabrik GmbH (Paus), the Dutch ETEC Van Vliet bv (ETEC) and the Liechtensteiner KAISER AG Fahrzeugwerk (Kaiser). They manufacture small sized wheel loaders, medium sized excavators and special purpose excavators.

Paus Kaiser ETEC

The company's size limits the investments the company can make in the field of research and development. The European Union provides such SME's the opportunity to obtain funded research. This is created by one of the four thematic programmes of the Fifth RTD Framework Programme, called 'Competitive and Sustainable Growth'. For this purpose the Eurocabin project was started with the goal to collect information on how to create the best possible comfortable cabin and using this information to improve their own cabins.
This section describes how we collected information from the users of these machines as a starting point for further improvements.

11.2 Collecting information

In an ideal situation we would have liked to collect standardized information using different methods, from a great number of users. This means using detailed questionnaires and, while the operator is at work, observing and inter-

viewing him and monitoring parameters such as movement frequencies and joint angles.

However, it was not possible to sit in the cabin while the operator was at work. Observations therefore had to take place outside the cabin or sometimes standing in the door opening. Interviewing the operator in the hours of work also was not easy. Earth moving machinery in The Netherlands, especially excavators, are used very intensively. Operators easily make more than 2,000 machine hours a year. Labour is quite cheap and so companies were initially not very anxious to have us interview the operators for more than 30 minutes.

Because of this we chose to use detailed questionnaires and to visit some of the respondents for a short interview and observations. The manufacturers supplied the companies which we called to ask if they would participate and how many operators would fill in the questionnaire. Whenever possible we also spoke to the operators before sending the forms. This was done to get as much operators as possible to fill in the questionnaires and return them. All together 46 operators received a questionnaire. They worked for two of the three participating manufacturers. Although we also made reminder calls 19 questionnaires were returned by the operators. After this we visited 10 operators at the site they were working. Because we already knew a lot about their opinion, we could go into detail about certain subjects and nonetheless keep the time the operator was not working within acceptable limits. The number of operators that was visited, was mainly based on the operator's availability and his employer's willingness to co-operate.

The third manufacturer in the project preferred to use a different approach. For this client observations and interviews were combined. We shortened the original questionnaire in such a way that it could be used as a basis for a structured interview. Using this we interviewed and observed 12 operators on location. The sales department had prepared our visits. Each interview took between 30 and 45 minutes time. After each interview we asked the operator whether he was inclined to fill in the long questionnaire. If so it was handed to him together with an answering envelope. Half of the operators filled in the questionnaire and by doing so supplied us with extra information. All operators received a small gift as a token of gratitude.

Measurements

In addition to the information collected from interviews, observations and questionnaires, experts performed measurements regarding cab dimensions and control positions, forces necessary to operate the machine and noise levels (see figure 11.1).

Figure 11.1 Measuring the cab

11.3 Information processing

Statistics were used to evaluate the results from the 19 long questionnaires. All other results were brought together and categorized by subject (view, seat, controls, etc.) in which we kept the different sources of information separately. We had specific information on the machines from the manufacturers, the experts and the operators and we had ideas about the trends for the future from sales people, designers and from what operators wanted to have improved and how they wanted it.

We presented the results to the manufacturers. Much of the information was either known to the manufacturer or sounded very familiar, yet was found to be very valuable as their ideas for the future had largely been supported by researchers.

After having presented these results it was then up to the manufacturers to decide which issues would be tackled in the new design. In the decision making process money obviously plays a large role. This is even more the case in the earth moving machines industry as there are so many competitors offering very similar machines at the lowest prizes. As a consequence not all important issues were on the list of adaptations the companies chose to address in the redesign.

11.4 Comparison of the two evaluation methods

The extensive questionnaires and the following statistical analysis did not render more information with respect to the operators' opinion about their machines and what they would like to have changed, compared to the structured interviews and observations used with the third manufacturer. In some ways the second method was advantageous as all interviewed operators were also observed.

This led the expert to form a better opinion of the machines which again is necessary to be able to value the operators' opinions.
The large questionnaires were not necessarily filled in inside the vehicle. Although the operators are very familiar with their machines, filling in a questionnaire e.g. at home may influence the answers given.
However, a distinct advantage of using a questionnaire over interviews is that it will give an objective analysis of the machine, provided enough questionnaires are available. Through statistical analysis scientific information is obtained on how the machine is evaluated by its end-users. This information is obviously very suitable as a basis for redesign. Interviews, even structured, leave more room for influencing operators in the answers they give.

11.5 Redesigning

After having chosen the items the manufacturers would redesign to optimize the cab comfort, they started redesigning these items. TNO supported the manufacturers in the process with technological input. We supplied them with redesign suggestions regarding several points e.g. general design, noise reduction, ingress-egress and the configuration of seat and controls with respect to each other. To investigate what the proper position would be of the seat relative to controls and view, we used an instrument called Ergomix, in which it is possible to mix real persons with drawings of the workplace, in this case an operator's cab (see figure 11.2). In the next section we will describe a few of the improvements that were made to the machines.

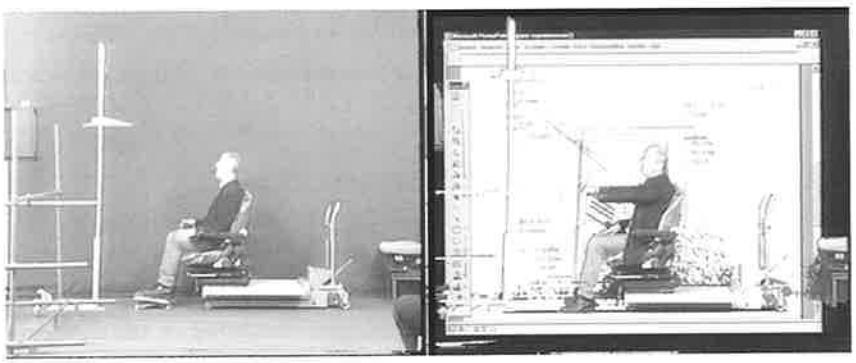

Figure 11.2 Ergomix session: left the filmed operator, right the mix with the cab drawing

11.6 Examples of improvements

Seat positioning relative to view and controls

In two cabins the seat position was changed slightly to increase the cab's suitability for a wide range of operators. We gave measures to the exact positioning of a new steering column (see figure 11.3).

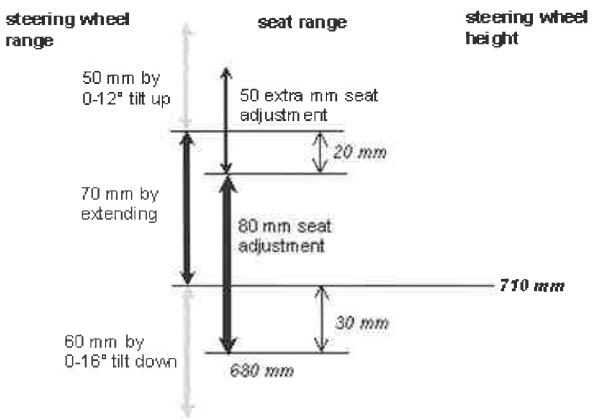

Figure 11.3 Defining the position of the steering column

The seat manufacturer Grammer AG was found willing to co-operate in the project and presented a prototype to one manufacturer. In this prototype the ideas mentioned in chapter 7 were applied. The armrest, that can also serve as a mounting pod for a joystick, is fully adjustable relative to the seat and therefore enables operators to find a perfect position relative to the controls. Because the seat stays in place while armrest and joystick move, it is also easier for the operator to find a proper working position. Unfortunately at the writing of this book the seat was still in a prototype stage, therefore it was agreed to not yet show pictures of this seat.

Noise

General measurements showed for earth moving machinery relative low noise levels. This was somewhat surprising as the technical measures the manufacturers had taken to reduce exterior sound pressure and interior noise level were sub optimal. In some positions where insulation should have been present there was no insulation applied. In two cases the engine mounting was not adequate resulting in materials vibrating and thus producing noise. This noise was not nec-

essarily audible yet caused an unpleasant sensation to the operator in the cab. Measurements revealed the source of this noise. By stiffening the engine and the window suspension the noise was reduced significantly and, equally important, the irritating sensation was taken away. In all machines the sound insulation of the engine compartment and the cab have been improved.

Outside view

Outside view stands on top of the list of important items in the cabin. It was therefore also chosen to perform a specific design study into this subject, the results of which can be found in chapter 16. Outside view is directly connected to comfort because, when view is obstructed, operators need to sit in awkward postures. Through the remarks made by operators improvements were made to the position and shape of certain window sills (see figure 11.4) and to the positioning of mirrors and (extra) lights. On the excavator a camera solves the problem of the boom obstructing the view sideways.

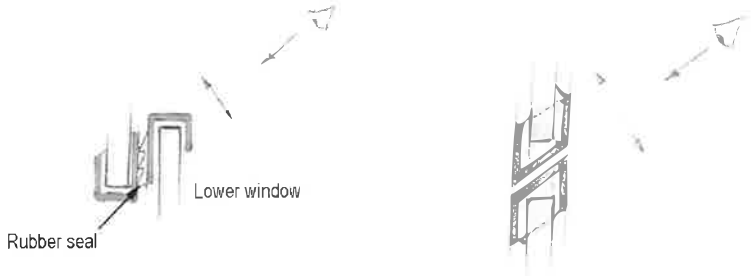

Figure 11.4 Two possible solutions to create a narrower window will between upper and lower excavator front window

Ingress/egress

Ingress/egress may be of less importance when the operator seldom leaves the cabin. In all investigated machines, however, operators estimated the amount of times they went in and out of the cabin up to 50 times a day. This fact makes an easy and safe ingress-egress very important. Therefore in improving the machine comfort much attention was paid to this aspect. Some grips were extended to widen the range at which the operator could reach for a grip. Grip diameter was set at 25 mm for a comfortable grip. On one cab the grips were positioned closer to the cabin, thus reducing the vulnerability of the grips. The distance between the cab and the grips was set at 65 mm to allow an easy grip with gloves.

Next to these changes there were several small items which all together add to a satisfying feeling about the machine:

- repositioning air filters to make servicing easier and by doing so, to reduce fuel consumption;
- being able to fill the windscreen wiper fluid from the outside;
- creating extra storage space; operators gave us several ideas to do so;
- operators on the wheel loader required a gauge giving information on the shovel position. Because operators do not continuously drive the vehicle, they do not have the feel of the machine as e.g. an excavator operator does;
- in one type machine operators mentioned that both feet were not equally heated. This was improved.

Although vibration is known to be a large health problem in earth moving machinery, it was not mentioned by all operators. Nevertheless all manufacturers wished to address this problem, as European guidelines on wholebody vibration are prepared. However, in this project the manufacturers chose not to. Reducing machine vibration would imply doing elaborate research and possibly making large changes to the machines. The required investments would be too great for the manufacturers involved.