Advanced Cabin Design

How to Improve Comfort and Performance by Progressive Cabin Design

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Cover photo:
In co-operation with the public transport enterprise RET in Rotterdam and the manufacturer of the tram, TNO developed a cabin that provides all drivers with a safe and comfortable working environment. This could only be achieved by designing the tram from scratch. The adjustments involve more than just the adjustment of the chair and the range of the controls.

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5 Cabin ergonomics and comfort of compact sweeping machines

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Current developments bring new challenges for the design of compact sweeping machines. In general, there is a growing attention for a healthy working environment. In addition, the operator has more demands with regard to his comfort and the ease of operation of the machine. These demands increasingly affect purchase decisions for new machines. To find opportunities for the future generation of sweeping machines TNO and a main producer of sweeping machines performed a project, addressing the issues of health, comfort and ease of operation. This chapter presents the outcome.

3.1 Present design

Compact sweeping machines are primarily made for the mechanical cleaning of alleys, paths, gutters, streets, market squares and road maintenance. A sweeping machine is in fact a large driving vacuum cleaner: two brushes spinning towards each other collect the muck off the street and move it towards the nozzle of a vacuum unit in the middle front of the machine, under the cabin floor. With great power the street dirt is vacuumed up into a build-in container. On board there is also a water tank from which nozzles spray a water film, to prevent dust getting blown up by the wind, and to bind the dirt in the container. The removed muck contains mainly plastic, paper garbage, leaves, grid, sand and water. An increasing amount of machines are equipped with a third brush, which is mounted in front of the machine. This third brush can be moved sideways and is exceedingly suitable to remove weeds between the pavement, to reach corners and to clean wide paths.

The main task of the machinist is to drive the machine safely, and simultaneously to operate the brushes and vacuum unit. The machinist has to concentrate on the traffic and public movements and on the work that has to be done properly. The tasks of the machinist are complex and demand substantial mental and physical effort. On top of that, the work includes environmental stresses on the machinist when dealing with aggravating circumstances as rain, coldness, (extreme) warmth and darkness.

The driver seat is at the right side in right-driving countries, so they have a good view on the right hand brush when cleaning the gutter at that side of the road and can easily move around the parking cars. For driving, this seat position is on the other side of the vehicle than usual.
Roughly, there are two types of sweeping machines, namely the big truck mounted machine and the compact machine (see Figure 5.1).

Figure 3.1 Truck mounted versus compact sweeping machines

The first is mainly used in the outskirts of cities who have a large scattered working area. The truck has more speed potential than most compact sweepers and is therefore appropriate for long distance driving. The cabin is spacious and is comfortable, dependent on the type of trucks. The container has, generally speaking, a larger capacity than the compact sweeping machine, which is mainly used in the urban areas.
The compact machine is designed mainly for the cleaning of small lanes, public footpaths, gutters, market squares and driving under porches and underpasses. In this machine the machinist has a better view on the working area, the brushes and the environment, and the machine is more manoeuvrable compared to the bigger truck mounted machine. Therefore, the work can be done more accurately, while the risk for any traffic accident is less. For a good view on the right brush, which is mounted just in front of the front wheels, a mirror is installed. By the windows in the front, the door and the cabin floor the operator can have a direct view on the right brush, on the third brush (in front of the machine), on the dirt on the street, and on the vacuum nozzle. Because of its compactness the cabin's inner space is restricted.
This project was aimed at the improvement of the design of the cabin of the compact machine.

5.2 Bottlenecks in present design

What can be improved in the design of the compact machine? How can we create more comfort ánd a good outside view on the tasks and the traffic within the restricted space within the cabin? To find answers we needed a basic investigation into the bottlenecks of the current design. This investigation comprised:

- a study of the documents about the layout of the present concept;
- a demonstration of the compact machine's functions by an instructor;
- interviews with staff members of the manufacturer about their ideas of improvement;
- observations of and interviews with five experienced operators during work (each for several hours) to analyse their working actions and to obtain their experiences and ideas about the functioning and ergonomics of the machine;
- interviews with supervisors of the machine operators and with ergonomic experts/advisors about their ideas of design improvement;
- a categorization of the results into ten main bottlenecks.

One of the main bottlenecks found concerns the static and awkward body postures that are adopted during the work. These postures comprise lateral and forward bending and rotation of the head and trunk. Hence, it is not surprising that the literature mentions neck and back pain as the predominant health problems for operators of sweeping machines (Massaccesi et al., 2003).
The observations showed us a remarkable variation in body posture across the five operators. The adoption of body posture seems to depend largely on individual strategy to perform the job and on individual preferences. For instance, some operators use the mirror to look at the right brush, while others prefer a direct view on the right brush through the window, which has a significant impact on the upper body posture. One of the operators had even an extra mirror fitted to see the right brush, to reduce bending of the neck. Another source of variation is the varying stature of the operators. Finally, the lack of support for the left arm, inviting some of the operators to lean on the steering wheel, leads to variation in posture.
During the interviews the drivers surprisingly did not mention their awkward body postures although clearly occurring frequently and for long periods of time.
From all observations and interviews we categorised the obtained bottlenecks, which resulted in a list of issues. Generally speaking, cabins in this kind of machines are too small in relation to the required tasks performed. There are definitely possibilities and requirements to improve the cabin but this will lead to

contradictions. To name one is more height required in the cabin but the total height of the machine is already at the maximum and lowering the cabin floor is impossible because of the structure and the vacuum equipment.

Examples of the issues leading to unwanted postures are shown in Figure 5.2 and 5.3.

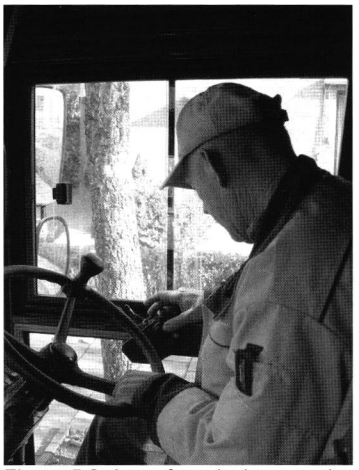

Figure 5.2 A preferred view on the right underbrush leads to an awkward body posture

Figure 5.3 The armrest with operating system dictates the operator in a fixed position

5.3 Future design

On the basis of the investigation results, TNO experts and manufacturers held a brainstorm session. The purpose was to address the main issues to be improved in a new to design compact sweeping machine.
It appeared that the ideas that were discussed could be clustered into two themes 'sight and view' and 'space, sitting position and layout operating system':

- to improve the view capabilities particular sensory aids are mentioned, for example lane keeping system, camera systems and pop-up displays, acoustic signal system, robotics and sonar aid;
- to improve sitting positions some options were mentioned and must be investigated to increase the space in the cabin and to modify the operating elements in relation to the seat.

5.4 Conclusions

The main challenges for cabin innovation in sweeping machines are to improve the basic body posture of operators (of varying stature) by changing the cabin size, optimising the body fixation points and using the aid of detection systems, to reduce the risk of injury by both robotizing regular sweeping functions and improving the positions of the controls and their way of handling, and finally, to improve the physical environment and to prevent fogging windows by optimising the climate control system.

By improving the ergonomic layout of the cabin we expect to promote comfort, to improve performance and to reduce the health problems as neck and back pain.
Based on expert view (and following the ergonomic standard for lorry cabins), the cabin of the compact sweeping machine can be considerably improved by applying modern technology such as sensory aids, lane keeping system, robotics, camera monitor systems and further automation of the manual task.
The left brush is sometimes used to clean the left gutter of the road. This task requires improvement in order to eliminate the unfavourable working posture (rotation of trunk and neck) as well as losing all view on the environment.

5.5 References

Massaccesi M, Pagnotta A, Soccetti A, Masali M, Masiero C, Greco F. Investigation of work-related disorders in truck drivers using RULA method. Applied Ergonomics 2003;34:303-307.