

Ergonomics in machinery

Problems and potential solutions

The European Machinery Directive 2006/42/EC requires manufacturers of machinery to reduce to a minimum any inconvenience, fatigue or physical and mental stress on the part of the operating personnel. At the same time, the Ordinance on Industrial Safety and Health obligates employers to ensure that the work equipment they provide to their employees fulfils ergonomics principles and to take serviceability and ergonomic design into account right from the risk assessment stage.

So how come the ergonomics of machinery is still not a priority for customers and designers (and hence also for the bodies responsible for drafting the standards)?

Ergonomic principles are difficult to quantify

It is no problem to establish unambiguously whether a machine works or not. The same applies to its degree of productivity. Therefore, buyers and designers invest their resources in the factor *functionality*, not only because they feel a responsibility, but also because otherwise they will almost certainly suffer economic repercussions (and in the case of the manufacturer likely even contractual consequences).

This may not apply to the factor *safety* to quite the same extent, but it is usually equally clearly established: under reasonably foreseeable conditions a dangerous moving part is either accessible or not accessible. Safety equipment shuts down a machine via its control system at the right moment or not. Therefore, buyers and designers invest their resources in the factor *safety*, not only because they have a benevolent attitude towards the health of the future operator, but also because otherwise they could run the risk of administrative, civil or criminal proceedings (and could thereby be put at an economic disadvantage).

However, it is not always possible to operate or service a machine in compliance with ergonomic criteria. Further, it is not as a rule immediately obvious just which physical, mental or psychological stresses are involved in its operation, and to what extent these occur. This is because many aspects of ergonomics cannot easily be assessed, let alone measured. For these reasons, market surveillance authorities have great difficulty in pushing demands for ergonomic principles. Therefore, customers and designers may possibly invest resources in the factor *ergonomics* if they have discovered a market niche or if they are particularly innovative, but they are much less likely to do this because they can see additional benefits for themselves.

Placing greater emphasis on ergonomic criteria

It would be ideal if the concept of "inherent ergonomics" could be established in design engineering. After all, any principle that applies to safety must equally apply to ergonomics: the earlier ergonomic criteria are integrated in the planning process, the more economically and effectively they will be translated into user-friendliness, hence rendering the products more attractive to customers. Incorporating ergonomic properties at a later stage is a very tricky task - probably far more difficult than retrofitting product safety features.

However, up to now this realisation has not gained any widespread acceptance. Apparently, the existing business and regulatory framework has more or less brought about the present status quo. Since new *top-down* incentives to counteract these framework conditions are hardly likely, the only resort is to focus on *bottom-up* incentives gleaned from practical experience.

So how could design engineers be encouraged to apply ergonomic principles in the design of machines, and what contribution can standardization organizations make

towards this endeavour? What could persuade purchasers to order a machine which is better adapted to the needs of the operator? What actually defines an ergonomic machine, and which aspects need to be taken into account in the design of such machines?

KAN web portal presents examples of good practice

For answers to these questions, KAN relies on examples of good practice, and it has commissioned a study to define some of these. Initially, in-plant transportation and machine tools were selected as broad topics of investigation. The web portal developed as part of the study by the TU Darmstadt contains design examples of machinery, or components thereof, which are particularly effective in fulfilling ergonomic criteria. They demonstrate innovative ways of reducing hazards arising from non-implementation of ergonomic criteria.

Since the beginning of 2017, the individual examples have been accompanied not only by photos, but also by characteristic illustrations. These focus the attention of the viewer on the specific solution and facilitate abstraction of the solution to other machines and situations.

At present the portal offers two main menus: the first section is subdivided according to types of stress (physical, mental, environmental) and presents some proven, detailed solutions for specific machines. In the second section "Machinery", there are two main categories "Machine tools" and "In-plant transportation machinery" with corresponding sub-categories. Here, both machinery developers and procurement officers can search directly for a particular kind of machine. Under "More information" for each solution there is a link to the standards search tool ErgoNoRA¹ and a list of search terms to aid in finding the respective relevant standards.

Further good-practice examples requested

KAN is always on the lookout for new examples of good practice for ergonomically designed machinery or machine components. This applies not only to the fields of in-plant transportation and machine tools, but to **all types of machinery**. An online form² is available on the web portal for new suggestions.

If a new example is suggested (either for an entire machine or a component), it is checked by a KAN working group to establish its suitability for inclusion in the portal. The basic condition for inclusion is conformity with the Machinery Directive (CE marking). No deficiencies regarding ergonomics or work safety must be detectable. The applicant or the manufacturer must submit to KAN on request any necessary information for the assessment of the machinery. The online form on the website only serves as a rough guideline. The verification procedure may take some time due to the necessary coordination processes involved. NB: Applicants/manufacturers please note that there is no automatic guarantee that a proposal will be included in the portal.

Further solution approaches in the Internet

The ErgoMach³ website presents some viable solutions for machinery ergonomics from so-called *Feedback* projects, in which the experiences of machinery operators have been systematically recorded over many years. The "Guide to application of the Directive 2006/42/EC" published by the European Commission⁴ explains the requirements of the

¹ <https://nora.kan-praxis.de/ergonora/en>

² <https://maschinenergonomie.kan-praxis.de/neues-beispiel-vorschlagen>

³ <https://ergomach.wordpress.com/>

⁴ https://ec.europa.eu/growth/sectors/mechanical-engineering/machinery_en

Machinery Directive, including those in Section 1.1.6 "Ergonomics" of Appendix I. These explanations are supplemented by fact sheets on the five ergonomic factors: operator variability, space for movement, work rate, concentration and man-machine interface. The fact sheets created by the former ErgoMach group and linked to the Guide by the European Commission also include a number of typical applications.

The examples of good practice from the KAN web portal could be included in a future update of the Guide in order to render it more understandable by specifying potential design principles.

Examples of good practice from <https://maschinenergonomie.kan-praxis.de/en/>

Example for "Transport trucks"

The control system touch2move by the company Espresso can be used for moving materials within the plant using two handles with integrated power sensors which can be fitted to various types of drives and trucks. [Note: Patent on sensor handle (touch2move), industrial property right word mark touch2move]

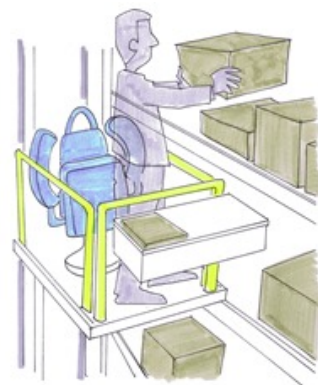
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Example for "Forklift trucks"

On Crown high-rack order pickers, the driver's control station can be adjusted to the needs of the individual operator and to the task in hand. The driver's seat with its control elements can be swivelled through 110°, thus enabling both sides of the machine to be viewed easily during pallet handling. For reversing, the seat can be rotated up to 90° in relation to the direction of travel, and for manual order picking the driver's seat can be folded down and the armrests with the controls raised.

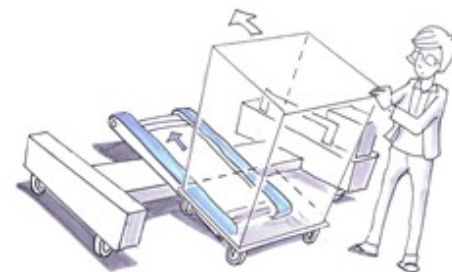
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Example for "Tractors and tigger trains"

For transport of large material containers to the workplace, tigger trains such as the MultiLiner by LKE are fitted with ergonomically designed trailers which enable the operator to avoid having to exert great force when loading the trolleys onto these trailers.

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Assisting standardization based on examples of good practice

An important declared target of the DIN Standards Committee "Ergonomics" is to reformulate standards pertaining to ergonomics in a more user-friendly fashion. Clearly understandable practical examples of standard-compliant design of work equipment are intended to promote and improve the effective use of ergonomics standards.

The standard EN 13861:2011⁵ embodies an already existing guideline supporting the use of ergonomics standards in the design of machinery. In the appendix thereto, 20 different hazards are linked to the applicable Type B standards. In order to improve the implementation of EN 13861 and to facilitate comprehension of the referenced Type B standards, it would also be beneficial to link the information contained therein to examples of good practice.

The plethora of existing Type B standards primarily includes fundamental and structural requirements. These are duly noted, but are not generally implemented from the very beginning in the design process. One of the reasons for this is that, due to the composition of the responsible standards committees, they are mostly drafted in scientific language rather than with a view to practical application. The practical examples on our new web portal could hence be used to assist the experts in the standardization bodies to add specific ergonomic requirements for particular machinery in Type C standards.

In addition, in June 2017 the technical report DIN ISO/TR 22100-3⁶ appeared. It demonstrates how ergonomic principles can be taken into account to minimize risk in accordance with ISO 12100, and how relevant ergonomic standards for machinery can be implemented. Furthermore, it aids engineers involved in the design of machinery to take decisions pertaining to ergonomic aspects and it can also be applied in cases where no relevant Type C standards are available.

Are the machinery users aware of their market power?

Many of them apparently not. However, without doubt the greatest leverage for increased implementation of ergonomic solutions lies with the user companies. If they demand the fulfillment of ergonomic criteria, the manufacturers will deliver just that. And for designers the best, most workable and most economical ergonomic solutions can only be gleaned from the operators of their machines. Here we have a promising interface with customer satisfaction!

We need to convince operating companies that ergonomically designed machinery, even if the costs are marginally higher (which must not necessarily be the case), will pay off in the long run. It is crucial that those responsible in the company are made aware not only of their obligations concerning ergonomics as laid down in the Ordinance on Industrial Safety and Health. But it is equally important that the machine operators persuade the company purchasers, either directly or indirectly via the safety officers/representatives, to order products designed according to ergonomic principles. In this respect, the web portal, and in general more information on examples of good ergonomic practice, can be helpful.

Corrado Mattiuzzo, Secretariat of the KAN Commission for Occupational Health and Safety and Standardization

⁵ EN 13861:2011 "Safety of machinery - Guidance for the application of ergonomics standards in the design of machinery"

⁶ DIN ISO/TR 22100-3 "Safety of machinery - Relationship with ISO 12100 - Part 3: Implementation of ergonomic principles in safety standards (ISO/TR 22100-3:2016)"