Development and validation of ergonomic screening-tools for assembly lines

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Abstract

Disorders of the musculoskeletal system are of a common occurrence throughout Europe. Manually applied effort is often required by operators working for their intended purpose. Risks exist if the design of the work situation is not in accordance with ergonomic design principles. Ergonomically designed work systems however enhance safety, effectiveness and efficiency, improve human working and living conditions, and counteract adverse effects on human health and performance. Good ergonomic design therefore exerts a favourable influence on the work system, and on the reliability of the human being within it. In automotive industry assembly work is characterised for example by unfavourable working posture, action force and material handling. The screening tool "Automotive Assembly Work Sheet" (AAWS) based on EU machinery directive allows the recognition of deficits in existing workplace layouts. The ergonomic quality of design is proven by an ergonomic checklist. The checklist was designed to identify human physical performance concerning potentially ergonomic risk factors on assembly lines.

Keywords: ergonomic checklist, assembly work, musculoskeletal disorders,

1. Introduction

The new worker protection law of 1996 requires an ergonomic and organisational optimal system. The reality in the workplace frequently gives a different picture. The ignoring of ergonomic principles in the planning and design stages leads to elementary errors in the design of the workplace. These errors lead to complaints and sickness amongst the workforce. It can be proven that in the automotive industry a human-oriented ergonomic workplace design can improve worker satisfaction and support the economic goals. Despite of new technologies and technical aids, physical workload still plays an important role in industry. In automotive industries high efforts have been made in order to decrease the operators’ physical workload. For this reason high action forces and high loads, that have to be manipulated manually, do hardly appear in assembly lines. Never the less and despite of adjustable workstations, unfavorable postures are still common in automotive assembly tasks due to the physical characteristics of the vehicles being assembled.

The screening tool AAWS represents a recently developed ergonomic design tool based on the “new production worksheet” (NPW, developed by IAD in cooperation with the ADAM OPEL AG), that focuses onto the evaluation of industrial work tasks with special respect to assembly tasks [1]. This study aimed at investigating reliability and validity of the checklist for the assessment of physical workload directly at the workstation, for work planning and in design process. The primary goal of the NPW (and the recent development of AAWS) was to ensure ergonomic
favourable conditions by means of standardized ergonomic problem tracking systems, linking plant and ITDC (International Technical Development Center) activities. Besides these, the screening-tool should comply with national and international legal requirements for health & safety with special respect to European legislation (e.g. EU-Machinery Directive [2], EU-Framework Directive).

2. Methods

Assembly-line work is mostly fitting, adjusting, controlling using the hands. Weak points of an assembly line are muscular (cardiovascular), biomechanical stress of the back and dynamical stress screening method was tested in the automotive industry in the hand-arm-system.

At shop floor level an AAWS scoring is primarily operator oriented (cycle, (sequences of) minute(s) or shift), i.e. it shall be analysed, whether the operator works under “green” “yellow” or “red” conditions. This evaluation is typically based on cycles. For short cycle times (ca. 2-3 min.) an evaluation on basis of seconds is recommended. For longer cycle times it is more convenient to evaluate working tasks on basis of percentile values (%). For assembly tasks that include a lot of options, it is recommended to evaluate a period of several minutes (% basis) in order to gain an average load situation. Non-cyclic tasks are scored for a whole shift on percentile basis.

To evaluate the screening tool AAWS several methods were used to compare more than 250 assembly stations. The screening-tool was tested and validated at the stations of the assembly line at Opel AG/Rüsselsheim, Germany by the method inventory that created the scientific basis. Therefore the criteria of evaluation based on four classification: „body posture“, „action force“, „upper extremities“ and „manual handling“ (i.e. Fig. 1, Fig. 2, Fig. 3).

The scientific evaluation of the screening-tool are related to international and national methods like f.e. TOYOTA [3][4], OWAS [5], RULA [6], NIOSH [7], LMM [8], REFA [9], ISO 11226 [10], ISO 11228 [11], EN 1005 [12] and EN 614 [13].

Especially for relaxation times to lessen physiological stress for overhead work the method of Bier [14] was used.

Fig. 1: Evaluation of working posture (extract)

To evaluate manual materials handling (MMH_points) the part of the AAWS corresponds to the Key Element Method (LMM) [8] of the German Federal Institute of Occupational Safety and Medicine (Fig. 3).
Select mass according to gender, assign postures and frequencies, distances or holding times!

Fig. 3: Evaluation of manual materials handling (extract)

3. Results

All stations were again scored by the newly developed screening-tool and later on by a combined occupational medicine / ergonomics expert rating (correlation r=0.8**).

The located bottlenecks of the assembly work are given by muscular (- cardiovascular), biomechanical workload of the spine and upper extremities. During the validation phase of the screening method, ergonomic improvements were introduced which brought a noticeable reduction in stress for some workstations. By using the method the potential for design change was recognised.

The screening-tool AAWS enables a prospective evaluation of individual workstations with respect to their ergonomic design quality and to health related hazards. This checklist could be used as an objective and practicable method to estimate physical workload and gives hints for bottlenecks of the assembly work.

During the validation phase of the screening method, ergonomic improvements were introduced which brought a noticeable reduction in stress for some workstations. By using the method the potential for design change was recognised [15]. The communication between the planning phase and the development and construction phase was improved. An educational concept for AAWS has been developed which improves the communication between the various phases. The ergonomic potential for design was identified and improved on assembly lines.

References