Evaluating physical work load and posture during testing of welding points – case study

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Abstract

When manufacturing a car, robots are used for welding. To check if the welding points comply with the quality requirements, ultrasonic measurements are carried out. In the current situation, there are 29 measurement plans divided over 10 workstations, spread over the welding department. During his entire shift, a worker carries out one measurement plan on a certain workstation and then proceeds to another workstation. It happens that during the same shift a worker returns to a workstation, he visited earlier, to test another measurement plan.

To reduce the travel time between workstation, the company decided to concentrate the different measurement plans on 6 workstations. In the future workers will spent more time testing welding points. In the present situation, more than 50% of the workers experienced shoulder and low back problems.

To evaluate if the future situation is ergonomically acceptable, Key Indicator Method (KIM) was used. Reduction of workstations lead to a reduction in risk score of body movement (KIM-BM) and awkward body postures (KIM-ABP), but the intensity of the physical load stayed the same. To reduce the intensity of the physical load and the time spent in awkward body postures adjustments of the selected workstations were needed.

Introduction

In a large car assembly factory in Belgium, robots are used for welding. To check if the welding points comply with the quality requirements, ultrasonic measurements are carried out. The welding points are tested according to a measurement plan. There are 29 measurement plans divided over ten workstations, spread over the welding plant. The number of measurement plans per workstation differ from one to eleven. During his entire shift, a worker carries out one measurement plan on a certain workstation and then proceeds to another workstation. It happens that during the same shift a worker returns to a workstation, he visited earlier, to test another measurement plan.

The number of welding points to be measured varies from 23 to 343 per plan and takes 4 to 68 minutes. For 69 % of the measurement plans the workers spent between 30 and 60 minutes.

To do the measurements each worker has a laptop connected to an ultrasonic measuring instrument. With two fingers the measurement unit is placed on the welding point. On the laptop the worker can see whether the welding point is good or not. To confirm the measurement results, the worker needs to press a few digits on a small numeric keypad.

Each worker has a step with a box to ride from one workstation to another. During the rides between workstations laptop and measurement instruments are in the box.

The different work stations are spread over the welding plant so that the welding points are tested close to the location where the robots weld them. When an error is found, it's easier to repair the default. On the other hand, a of lot of time is lost during a shift because of travelling between work stations.

The company decided to concentrate the testing of the welding points on six workstations, that were designed as ergonomic workstations, to reduce travel time.

Because already more than 50% of the workers experienced shoulder and low back problems, the question was raised if reducing the number of workstations would be ergonomically acceptable, and if not, what additional preventive measures should be taken.

Methodology

Both for the present and the future situation, physical workload was evaluated by observation and video recording. For the present situation a worker was observed and filmed during a normal working day. The future situation was divided in two day schedules, as would be performed in the future. Five different workstations were done in schedule 1 and four workstation in schedule 2. Each schedule was carried out by a worker, who was observed and filmed.

Based on the information we received during the observation and of the videos, different Key Indicators Methods (KIM) were used [2]. KIM is developed by BAuA, the German Federal Institute for Occupational Safety and Health and was renewed in 2019 and expanded to six tools: lifting, holding and carrying (KIM-LHC), pulling and pushing (KIM-PP), manual work processes (KIM-MHO), whole-body forces (KIM-BF), body movement (KIM-BM) and forced body postures (KIM-ABP). They are quick user-friendly tools that can be applied at the workplace itself.

The result of a KIM-tool is a risk score that can be used as an evaluation of the intensity of the load, the probability of the physical overload and the possible health consequences [2] (Table 1).

To evaluate the measuring of the welding point with ultrasonic testing, KIM-MHO was used. KIM-BM was filled in for the movement with the step between workstations. Per workstation KIM-ABP was used to evaluate the body posture during measuring. This means that per observed working day several KIM-ABP, one KIM-MHO and one KIM-BM were filled in.

Table 2. Relationship between KIM-risk score, intensity of the load and physical overload

Risk score	Intensity of load	Probability of physical overload
< 20	low	unlikely
20 - <50	slightly increased	possible for less resilient persons
50 - <100	substantially increased	Possible for normally resilient persons
>100	high	Physical overload likely

The results of all the KIM-methods per working day where imported in the Multi-KIM form (LMM-Multi-E). The LMM-Multi-E combines the assessment results of different sub-activities of a typical working day to determine the daily load [1]. Only the results of the different sub-activities of the same risk and evaluated by the same tool are combined [1].

In this case study LMM-Multi-E combined per working day (present, future schedule 1 and future schedule 2) the different KIM-APB to determine the daily work load. For KIM-BM and KIM-MHO only one tool was filled in which means that the risk score of the tool is the same as the risk score of the daily load.

During the observation workers were asked what they experienced as heavy and why.

Results

Comparing (Table 3) the scores of the LMM-Multi-E in the different situations future schedule 2 has the lowest scores for KIM-ABP and KIM-BM but has the highest score for KIM-MHO. Future schedule 1 has the lowest score for KIM-MHO but scores in the middle for KIM-BM and KIM-ABP between present and future -schedule 2. Although the scores for KIM-BM and KIM-ABP are in the future schedule 1 and 2 lower than the present, the risk score stays in the same category of load intensity: 20 - <50: slightly increased, 50 - <100: substantially increased and >100: high. With KIM-MHO the score of future -schedule 1 is in load intensity 3 while for the other situations the load intensity is 4.

By concentrating the testing of the welding points on six work stations, there is improvement score-wise for KIM-BM and KIM-ABP between the present and the future and for KIM-MHO between the present and future schedule 1 (Table 3).

Table 3. Results risk score LMM-Multi-E for current and future situation

Situation	KIM-MHO	KIM-BM	KIM-ABP
Present	101.8	48.1	145.2
Future schedule 1	96.6	38.9	137.9
Future schedule 2	109.8	33.1	101.9

The answer on the question what workers perceived as heavy was regular standing in awkward positions during measuring: back bent forward more than 20, twisting and/or lateral inclination of the trunk and reaching far with the arms.

Discussion

As the results show in table 3, the risk scores for measuring the welding points didn't vary a lot between the present and future situation, because the way of measuring remained the same. Only with future schedule 1 the risk score is a little lower then the rest because the total measuring time is less than the other situations. Therefore, to reduce the intensity of the load it is advisable to change the way welding points are measured and/or to reduce the measuring time. The latter is only possible when the time spent measuring is reduced by at least 50%. This means job rotation with another task where there is no risk for repetitive work. This is in contradiction with what the workers perceive. They didn't see the need of changing the measuring method and tools.

The risk scores for KIM-BM for the current and future situations were less than 50, indicating that the intensity of the load was slightly increased and physical overload is possible for less resilient persons. According to the workers, moving from one work station to another was a welcome change with regard to the awkward positions they had to work in when carrying out certain measurements.

Because already more than 50% of the workers experienced low back and shoulder problems improving the body postures during measuring was the most important measure to be taken. To reduce the combined risk score of KIM-ABP it is necessary to adapt the working stations.

Two of the six workstations had rotating fixtures so that the testing piece can be adjusted in such a way that the worker can perform the testing in acceptable postures for the different joints (low back, neck, shoulders, elbow, wrists) as mentioned in the European norm EN 1005-4 [4].

Discussion

At another work station the part to be measured could be turned around its axis but was still too high. For this workstation it was advised to provide an in height adjustable work platform for the workers.

Another work station was adjustable in height, but the degree of adjustability was too limited in relation to the plans to be measured. Here it was advised to expand the adjustability of the workstation or to provide an in height adjustable work platform.

The other workstations were not adjustable. To reduce the time that workers worked in awkward body postures [4] it was advised that these workstations can be turned around.

Conclusion

When comparing the results of LMM-Multi-E for the present and future situations with the perception of the workers, there is a difference. improving the working postures was the most important measure for the workers. While the LMM-Multi-E indicated that measuring instruments and work postures needed additional preventive measures to lower the intensity of the work load during measuring.

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