An Evaluation of Postural and Environmental Stress at Workplaces in Smitheries (a case study)

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The Austrian Worker's Compensation Board has as one of their liabilities to care for prophylaxis in the field of accidents and occupational diseases.

The application of safety specifications in complex work-systems cannot be carried out only with technical measurements. Guidelines for ergonomic design at man-machine-interfaces have to be considered. The following study tries to pay attention to the way mentioned before.

An analysis of the accidents in some smitheries showed concentrations in low mechanised manufactures like smitheries for hand tools such as scythes, shovels and sickles.

Visits in these plants and interviews with the employees there showed up following potentials of danger as possible reasons for accidents and diseases:

1. Old machines not adapted to human factors cause muscular skeletal problems. The machines originate from a time when technology was applied according to the contemporary development of engineering meeting the demands of technology but not adapted to the needs of man.

2. Manipulations with glowing material together with high bodily stress result in a high risk of injuries. The main operation of the stoker is to remove the glowing material, for example the glowing half-finished scythe from the oven, to make a simple control of shape, to knock off the hammer-slag and to handle it over to the black-smith at the hammer.

Compared with other plants with hot metal working at least a risk of accidents that is twice as high could be recognized.

The main sources of danger are close contact with glowing material and an improper posture of the body caused by the narrowness of the room. Interviews with stokers showed that at least small burns cannot be avoided at any time during the procedure of work.

3. In smitheries the whole stress of work results from the demands of sensomotorical abilities and handicraft skill. In addition to these facts there are series of stressing environmental parameters like intensity of heat above the niveau of thermal comfort, noise over 85 decibel, harmful vibrations, insufficient illumination and disturbing dusts or fumes.

Caused by these stress-characteristics and the fact, that the smitheries inquired are plants of low commercial and technological structure, where complex concepts of reorganization with conceptional ergonomics measurements had to be excluded from the beginning, we had to decide for simple proposals of corrective ergonomics.

A first step were some techniques of measurement for evaluating stress and strain at some important work-places, at forge-hammers and annealing furnaces.

Amongst measurements of climate and heat the work-load was judged by the pulse-frequency as a physiological parameter.

For objectivation of the heat-stress according to Austria's legal requirements the corrected effective temperature by Yaglou was calculated. This method was assisted by the aid of the analytical method for judgement of thermal stress explained in
ISO-DIS 7933 and some other methods for evaluating heat-stress, such as wet bulb globe temperature, heat-stress index, allowed exposal time and predicted four hour sweat rate index.

Dry temperature, wet temperature, air velocity and the heat radiation were measured. The thermal resistance of clothing was established with 0.7 clo corresponding with light working clothing. The factor for the intensity of work was fixed with 165 Watt as an average value for operation of a furnace or work at a forge hammer.

As a result the physiologically tolerated extreme values of stressing heat according to the corrected effective temperature by Yaglou were permanently exceeded at the stokers and were exceeded dependent on the actual step of work at the forgerammers.

The supporting valuation after ISO-DIS 7933 affirmed this result. At the annealing furnaces in all cases a limit of exposal time was indicated even with heat acclimatized stokers.

Therefore, the hypothesis could be made, that the main stress of the stokers is caused by heat radiation, whereas that of the blacksmiths is caused by the position during their work and their task.

To judge the dynamic work load stress and strain of work at the forges were rated by measuring the frequency of pulse, whereby the recording was made continuously during one shift by using an electronic storage unit for the data of the electrocardiogram.

The analysing computer made the interpretation of pulse frequency automatically. To support the timely coordination the relative moving activity of the test persons as well as the surface temperature of the clothings were taken into consideration.

The frequency of working pulse was evaluated in a way that the limit of steady-state amounted to 35 pulses/min. over the frequency of resting-pulse.

The analysis of the courses of pulse-frequency showed at more than 50% of the testpersons at the forge hammers a rise over 35 working pulses and no steady-state. Such tests support the necessity of heat protective measures at the furnaces and plan ergonomics measures for the forges and other machines.

Protection from heat had to be reduced to steps for reducing heat radiation, as it was impossible to consider an expensive air conditioning.

Though longer periods of manipulation at the annealing furnace are requested, standing just in front of the furnace is not possible because of a very high rate of heat-radiation. The manipulation has to be done from aside and stepping out of the area with the highest radiation is often necessary. A normal door in front of the annealing furnace is not possible because of frequent manipulation and loading of the furnace with material. Because of that the solution had to be found by a radiation-absorbing curtain of flexible chains.

In consideration of the position during work the working places at the swages of the forgerammers are most problematic. The basements of the swages prevent the blacksmith, who is working at the forge-hammer, from a proper working position.

The working height is on average too low, hardly higher than the level of the knees of the sitting or cowering employees.

The result is a bent forward position which has to be seen as steady strain for the muscular functions of the body.

A optimal solution of these problems could only be achieved by a complete changing of the forge-fundaments and anvils. One will have to alter the shape of the fundaments to achieve room for the legs of the workers and will have to change the level of the fundaments to get a proper working height and so a straight position while sitting with enough space for the legs.

Because a specified mass of the swadge is requested and a shape differing from a round swadge, that could supply sufficient space for the legs in combination with a relative low sitting-position, was technologically too largescaled and too expensive, we
Fig. 1  The swadge with the cowering sitting position

The higher swadge with a smaller diameter and a standing position

An alternative shape of a swadge with a normal upright sitting position

Picture 1  A special seat construction with inclined guidepins for movement from one machine to another with different working-level above floor.

recommended to have a higher swadge with a smaller diameter.

In this way the worker at the forge hammer can have an upright sitting position that might be supported be a "standing-aid". Caused by a more practicable distance from the hands to the hammer an intensive flexion of the trunk is no longer requested at any state of the work.

A further detailed solution had to be found at a work-place, where two machines had to be handled. The problem was, that some movement with considerable difference between the level above floor at two machines was necessary. We recommended a seat with inclined guide pins and a compensation mass to keep the balance of the seat and the worker on it. The picture shows the final solution by using a marketable integral-moulded seat.

For all areas of the plants investigated it was basically recommended to pay special attention to the seats and standing aids. According to the character of the machines used in most cases the seats
could be marketable articles, whereby very often costs had also been taken into consideration.

At some places car seats were used as a low cost solution. They could be adapted to the low working-positiones of the old machines because of their possibility for adjustment.

The presented study in smitheries should explain, that by the application of simple but very specialized ergonomics methods also in plants, where caused by tradition and structure very old technology and structure very old technology is used, improvements in the sense of corrective ergonomics to minimize work-load and postural-stress are available. As a result the complaints of the employees decreased. Effects of accidents and occupational diseases in the smitheries inquired remain to be seen.

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