WELDING AND ERGONOMICS

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Abstract: Designing an ergonomic work place is a profitable investment from the economic point of view. Developing preventive ergonomic action leads to improvements such as higher productivity, less absenteeism and more self-satisfaction of the welders.
Ergonomic investigations require a thorough knowledge in various fields, especially physiology, psychology, sociology, technology and economics.

Ergonomic work, welding, standardization.

1. Introduction

The word "ergonomic", comme from the Greek words "ergos" meaning work, and "nomos" meaning know-ledge. So, it requires the application of specific know-ledge to the work place [11].

The welding industry is no exception in this regard. The trend towards mechanization and automation is, in part, based on ergonomic concerns. Nevertheless, and even though robotisation has taken over much of the traditional unqualified stereotype welding production, manual welding remains an essential activity in many companies. It still engages a large number of personnel in the industrialized world.

Manual welding of today is to a large extent a highly skilled job. A welder able to weld pressure tanks in alloyed materials has gone through years of training. His (or indeed sometimes her) skills represent a significant knowledge capital at the company where he works. Poor ergonomics means not only impaired quality of work, it also increases the risk to acquire health problems that may force the welder into sick leave and eventually premature retirement. In fact, welders who continue active work up to normal retirement age are extremely rare. It is well known that musculoskeletal disorders constitute a major reason behind the early retirement of welders. [4]

2. The design of a model welding workplace [8,9]

- A model for assessment and design of workplaces for manual welding
  - Basic variables
  - Additional demands
  - Remedies
- Design criteria for larger workplaces
  - Recommendation
  - The automated welding workplaces beyond 2000
- The workplace:
  - Good ergonomics is economical
  - Work organization
  - Sitting workstation
  - Standing workstation
  - Assembly line production

- Ergonomic research
- Environmental management of the industrial processes
  - Legal international framework
  - International standards
- Process gases and their influence on fume and gas emission.

3. Ergonomic survey

An ergonomic survey of a workplace comprises two parts:

- a survey of the station itself with a view of setting up the "medical record" for the said station
- gathering the data submitted to the works doctor during the various examinations (before engaging, periodic etc.).

These two stages lead to an assessment of the relative and absolute discomfort of the work station, which enables the persons in charge of the ergonomic investigation to possibly make suggestions regarding improvements in line with the firm's socio-economic possibilities [3].

Designing an ergonomic work place is a profitable investment from the economic point of view. Developing preventive ergonomic action leads to improvements such as higher productivity, less absenteeism and more self-satisfaction of the welders.

Ergonomic investigations require a thorough knowledge in various fields, especially physiology, psychology, sociology, technology and economics [3].

The actual arc welding process requires little physical effort or cardiac effort exceeding the permissible limits. In contrast, high rates of energy may be expended ancillary processes such as chipping and grinding, which may make up 10-40 % of the working time, and when the work requires the welder to maintain the same position for some time or adopt a strained posture as in over-reaching or when working in a cramped area.

Evidence in support of the effects welding has on the operator's muscles was obtained by electromyography studies. These measure the activity in muscles and thus give an indication of how hard they are having to work. Welders who had worked in the trade for less than a year were compared with those with over five years. The studies related to welding in tow different positions, vertical or horizontal-vertical.

The research work showed that:

- Are welding implies a static load on muscles, in the region of the shoulders in particular
- Static muscular contractions occur when the body or part thereof is kept fixed in a certain posture
- Inexperienced welders show a general fatigue of the muscles of the shoulders, whereas experienced welders show a fatigue of the supraspinatus muscles only [3,9]
- The welders of both groups suffered from inflammation of the tendons of the supraspinatus muscles witch shows that welding jobs contribute to the development of that condition
- The factors witch most involve the participation on the muscles of the shoulders are the lifting of the arm and the loading of the had (weight of the torch).

Preventive measures should be taken to allow and encourage the welder to maintain a posture which wild not result in undue wear and tear of his body. Van der Veen and Regensberg worked out an ergonomic welding table, the main purpose of which is to reduce the discomfort of welder's postures. The possibility of adjusting the height of the tables is considered by users to be its main advantage.

The load on the hand strongly affects the painfulness of welding postures. However, the static muscular effort amounts to 10 – 15 N during are welding and 24,5 N during gas welding [3]. However, when the arm is supported by a force of 10 -15 N the statistic load on the supraspinatus muscles is reduced, the intramuscular pressure is lowered by 22% and the electromyographic spectrum by 17% [3,4].

The necessary improvements should concern:

- the lighting of torches, electrode holders, blowpipes and grinders,
- the shortening of the distance between the little finger and the point of equilibrium, distance which determines the effort made by the hand in order to accommodate the moment due to the weight of the torch and bundle of hoses and cables.
- the installation of devices for hanging the equipment

The following methods can help to reduce bodily fatigue:

- alternation of working and resting periods
- changing the posture regularly
- automating or robotizing the more laborious jobs
- letting the welder organize his job
- extending the welder's sphere of competence, hence less division of labour and consequently, less repetitive and more tolerable cycles.

4. Static workload in welding

It is important here to recognize the particular ergonomic characteristics in welding work in the manufacturing industry in general. Welding is characterized by high precision demands with respect to positioning of the tip of welding electrode. Depending on the welding method, the welding torch plus cable may weigh between 1,0 and 4,0 kg or even more, depending on the welding method. In stick welding, which still constitutes a majority of manual welding work, melting of an electrode takes about 1.5 minutes, then some changing of welding rod, rinsing and inspection, all dynamic work at rather low muscular effort, takes place. In the case of semi-automatic welding (MIG/MAG), the electrode wire is fed continuously though the torch, which means that there is technical provision for continuing welding for as long as required in terms of production. This may mean several minutes of uninterrupted static hand and arm positioning. For o professional welder, arc time per day (the effective time of daily exposure to static work) may amount to approximately two hours per day [1, 3, 4, 6, 8, 9, 11].

Welding may take place in a variety of posture, ranging from welding downhand in optimal working zone, to welding overhead, kneeling or squatting. Irrespective of posture, however, the high precision demands require postural stabilization, particularly of the hand and arm, which means that the stabilizing muscles of the shoulder are active to a high degree for as long as the welding task continues.

Scientific studies on the effect of occupational exposure to static workload has revealed both acute and long term effects. Endurance is severely reduced by lack of muscular rest: at muscular efforts exceeding approximately 15 per cent of maximum, localized muscular fatigue develops rapidly. Fatigue is also accompanied by a gradual development of tremor, which clearly affects performance. The effect is based on the development of high intramuscular pressure, arresting blood flow and preventing wash-out of metabolites. In the long run, clinical and epidemiologic studies show that musculoskeletal problems specific to welding develop primarily in the shoulder-neck region. Typical diagnoses include rotator cuff tendonitis, tension neck syndrome and impingement syndrome. These conditions are painful, they develop gradually over time, and when manifest, they are difficult to treat. A welder with a history of recurrent rotator cuff pain outbreaks runs a high risk of becoming a chronic pain patient. [4].

5. Ergonomic standardization [1,4]

Every country has laws and regulation aiming health and safety at work. These instruments are based primarily on scientific evidence. In the field of musculoskeletal health, due to factors such as the complexity of exposures at work and individual vulnerability, scientific study is complex and results sometimes contradictory. This is why threshold limit values are scarce in ergonomic legislation. Recommendations tend to be general in character, for instance emphasizing that exposure to static workload should be restricted as far as possible.

It is interesting to note that there is at this time a high emphasis on development of standardization in the ergonomics field. This is the case in International Standards Organizations (ISO) as well as the European standardizations body (CEN). Standards are basically voluntary. They are developed through a consensus process, where scientific evidence is pooled with the experience and needs of practitioners. They address, in the area of ergonomics, the combined needs of preserving health and safety at the workplace, and securing conditions relevant to factors such as productivity and product quality. The development of standards is a complex process, results are sometimes less than adequate, and many times there is a need for continued revision. Nevertheless, standards do send strong messages to industry worldwide. They provide sometimes much more relevant information that can be found in national legislation [1,4].

There are several international ergonomics standards affecting welding production. The standard ”Design of work and work system” (ISO 6385), which can be considered the mother of all ergonomics standards, outlines the general ergonomics principles. There are standards on e.g. anthropometry, man-machine interfacing and control actuators that may be considered in e.g. welding equipment design. The most important standards to be taken account in the present context is ISO 11226: “Ergonomics – Evaluation of static working postures”.

In ISO 11226, static work is defined as “working posture maintained for longer than 4 seconds; this applies to slight or non-existent variations around a fixed force level delivered by muscles and other body structures”. This means that virtually all welding operations fall under this standard.

The standard outline acceptable and “non recommended” exposure to static work postures for different part of the body, including the trunk and the shoulders and arm [Table 1]. For the range between 20 and 60 degrees, the standard recommends a time limit of exposure ranging between 4 and 1 minutes (linear). It should be noted that the standard addresses postural aspects only. In the event of a welder handling heavy equipment, such as a MIG torch for high current operation, the effect of working in non-optimal posture is emphasized further.

Table 1

Examples of recommendation relevant to welding work – (ISO 11226) [1,4]		
Body part	Posture characteristic	Recommendation
The trunk	Asymmetric trunk posture Leaning forward without support	Not recommended >60 degrees: not recommended Between 20 and 60 degrees :conditionally acceptable
Shoulder and upper arm	Awkward posture Upper arm elevated	Not recommended >60 degrees from vertical: not recommended Between 20 and 60 degrees :conditionally acceptable

Poor ergonomic conditions elevate the risk of welders acquiring occupational disorders in the musculoskeletal system. This fact must be taken into account in the planning of work and the design of workplaces. The following checklist may be used as a point of departure in a discussion of how preserve workers' health as well as continued profitability in a welding company. It aims primarily at manual welding of objects in range of say, 5-500 kg. Smaller objects may be welded on welding tables. Larger objects on the other hand, tend not to be moved around in the welding workshop and there is no special workplace arranged [1,4].

- The workplace should be arranged so as to allow welding in optimal hand positions, that is, witch the hand between waist and shoulder level, not requiring twisted or forward bent postures. This requires in many cases ability to manipulate the object.
- Welding overhead or in a stooped posture should be avoided.
- Whenever welding in non-optimal welding positions is required, planning should ensure that a welder would not be required to spend a significant part of a working shift carrying out such work. Variation is a keyword in this respect.
- MIG welders should not have to weld long joints regularly in awkward positions without rest.
- In order to reduce the strain on the hand and arm, welding guns should have swiveling operation. They should be designed to allow operation by tow hands.
- Heavy cables need balancing. All handling of objects heaving than approximately 10 kg should be carried out using overhead hoist, balancing devices, lifting tables or similar aids.
- Welders should be given the opportunity of competence development, so as facilitate moving to other jobs when they become older. Their profound welding experience may make them apt to work as operators of robots, programmers, production planners, purchasers or instructors.
- Occupational health surveillance should be designed so as to make possible tracing of musculoskeletal health problems at an early stage, when ergonomic intervention at the workplace may still make a difference.
- Experience shows that ergonomic problem solving nearly always requires that technical and organizational aspects be addressed concurrently [1,2,3,4].

6. Conclusions

6.1. The trend towards mechanisation and automation is, in part, based on ergonomic concerns [1÷11].

6.2. The design of a model welding workplace are: basic variables, additional demands and remedies; the workplace in ergonomic research – good ergonomics is economical, work organization, sitting workstation, standing workstation, assembly line production.

6.3. An ergonomic survey of a workplace comprises two parts: a survey of the station itself a view of setting up the “medical record” for the said station and gathering the date submitted to the works doctor during the various examinations.

6.4. It is important here to recognize the particular ergonomic characteristics in welding work compared to work in the manufacturing industry in general.

6.5. There are several international ergonomics standards affecting welding production; the most important standard is ISO 11226 “Ergonomics – Evaluation of static working postures”.

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