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A preliminary ergonomic evaluation of a grinding operation

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A PRELIMINARY ERGONOMIC EVALUATION OF A GRINDING OPERATION

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ABSTRACT

I conducted an analysis to determine the ergonomic stressors placed on an employee during a grinding operation. A review of a videotape filmed of the operation indicated that the employee's discomfort was probably related to the low work surface height, the abduction of the right shoulder, and the pronated grip used to hold the grinding tool. In order to improve the employee's posture, the following changes were suggested:

1. Raise the workbench to a height of 36 inches and enable the employee to tilt the work surface forward if desired.

2. Install a foot rail to reduce the static load on the legs

3. Instruct the employee to use a neutral power grip when holding the grinder to reduce the strain on the wrist and elbow tendons.

4. Eliminate the need to hold the right arm in an abducted position.

5. Insulate the grinding tool with insulating material to reduce vibration exposure.

6. Provide hearing protection for the employee to use.

PROBLEM STATEMENT

How should a grinding operation be improved for a cam assembly task so that employee fatigue and discomfort is minimized? In what way could work methods be modified to decrease employee discomfort?

BACKGROUND

In a cam grinding operation an employee uses a pneumatic grinder to remove the rough spots on a cam/shaft assembly. It is the employee's responsibility to ensure that the shaft rotates smoothly in the metal housing before he continues with the rest of the assembly operation. It typically takes 15 to 20 minutes to properly grind a cam. The shaft housing is six inches high and is placed on a metal workbench which is 25 inches high from the floor to the work surface that is parallel to the ground. The pneumatic grinding tool has a diameter of 1.5 inches and weighs five pounds. The employee stands throughout the operation although he is able to put a foot up on a shelf below the work surface to remove some of the static load on the legs. Throughout the operation, the employee grips the grinder with the right hand in a pronated position and the arm abducted (chicken-winged), see figures 1 and 2. An analysis of the environmental conditions of the work area indicates that the work area temperature is maintained between 68 to 74 degrees F. during the winter months and 74 to 78 degrees F. during the summer months. A test of the air circulation also indicates that air movement is at an acceptable level in the work area at this time. One area of concern that exists though is the level of noise the employee is exposed to. Although the noise level is not within the harmful range, it is in the distracting range and should be addressed. The employee has complained of pain in the right wrist, shoulder, upper arm, and lower back. The employee contributes this discomfort to the awkward position he works in.

Fig. 1

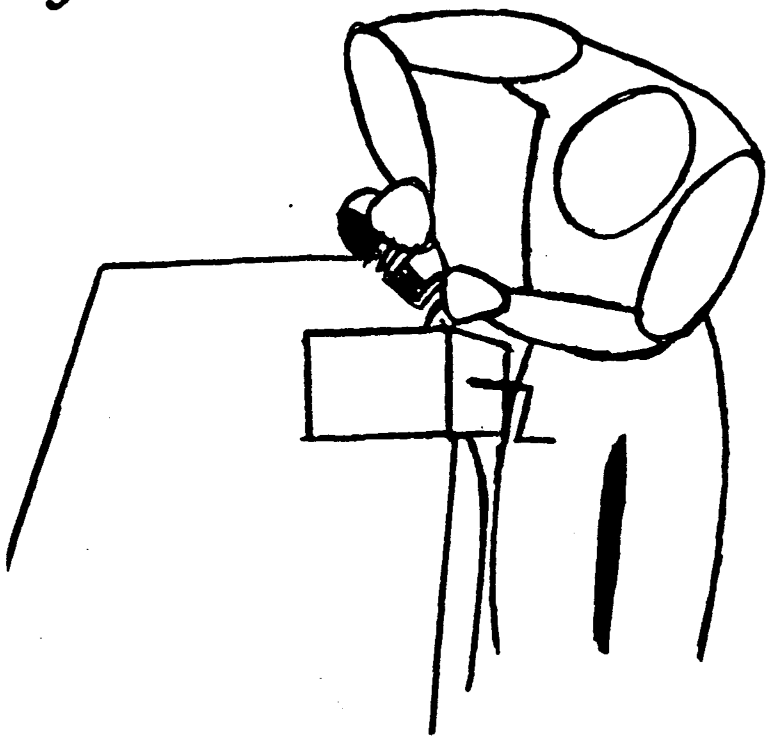
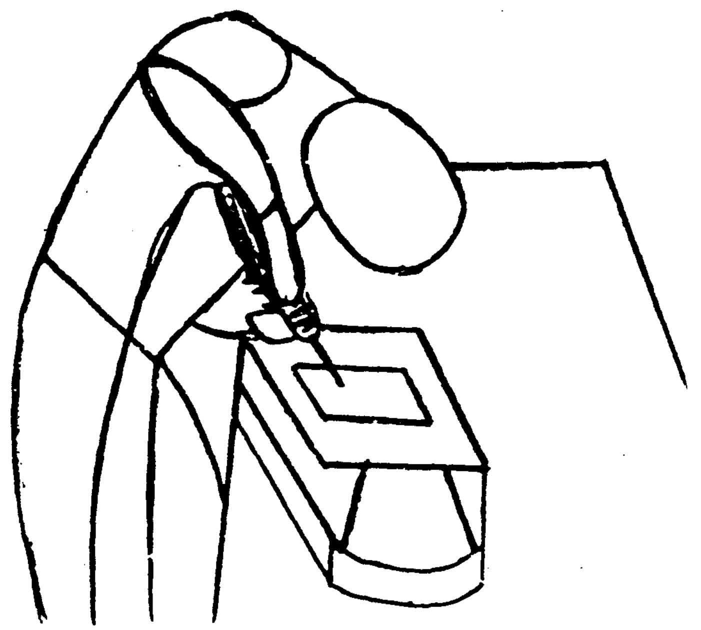


Fig. 2



HUMAN FACTORS PRINCIPLES AND INFORMATION USED TO SOLVE THE PROBLEM

The awkward position associated with this task is probably related to the low work surface height, the abduction of the right shoulder, and the pronated grip used to hold the grinding tool. The current height of the workbench is 25 inches. When the six-inch-high shaft housing is placed on the work surface, the work height of the hands is 31 inches. This work height is 11 inches below the recommended height of 42 inches for light duty work stations as indicated in the Eastman Kodak text p. 26. To improve the work station height, the work surface should be raised to a height of 36 inches. When used in conjunction with the six inch shaft housing, the work height will meet the suggested work level. Because the employee works in a standing position, a foot rail should be installed. This will help to eliminate the static load on the legs by giving the employee an opportunity to shift his weight. In addition to elevating the work surface and installing a foot rail, the employee should be given the option of tilting the work surface forward as depicted in figures 3 and 4. This will reduce the need to bend forward during close visual inspection of the cam/shaft assembly.

Fig. 3

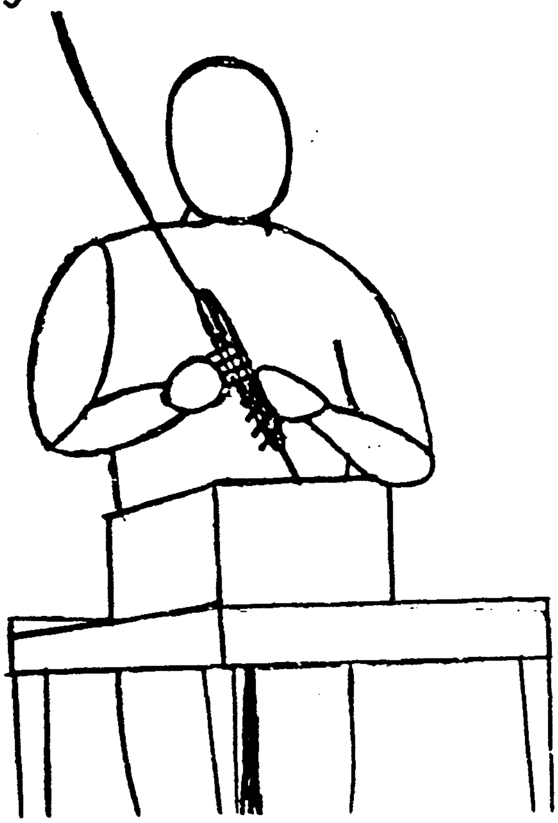
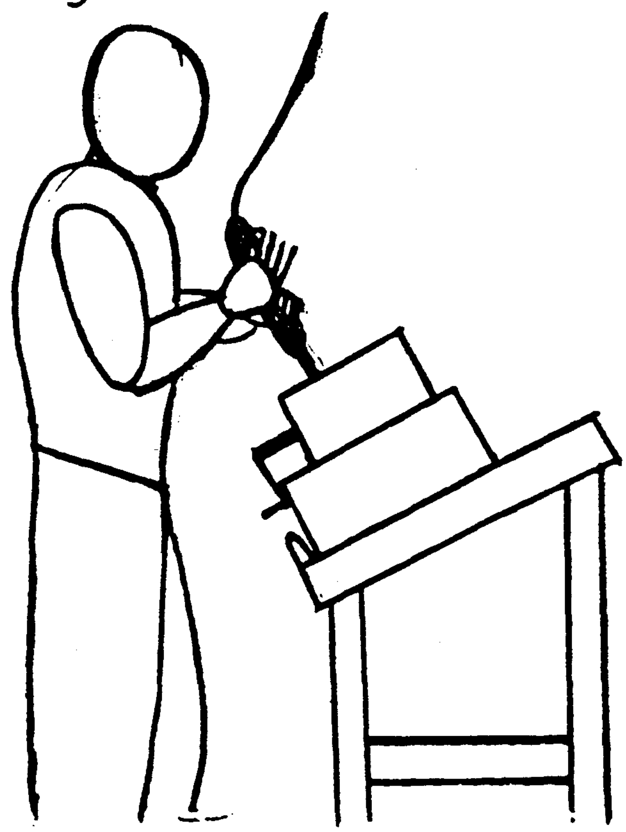
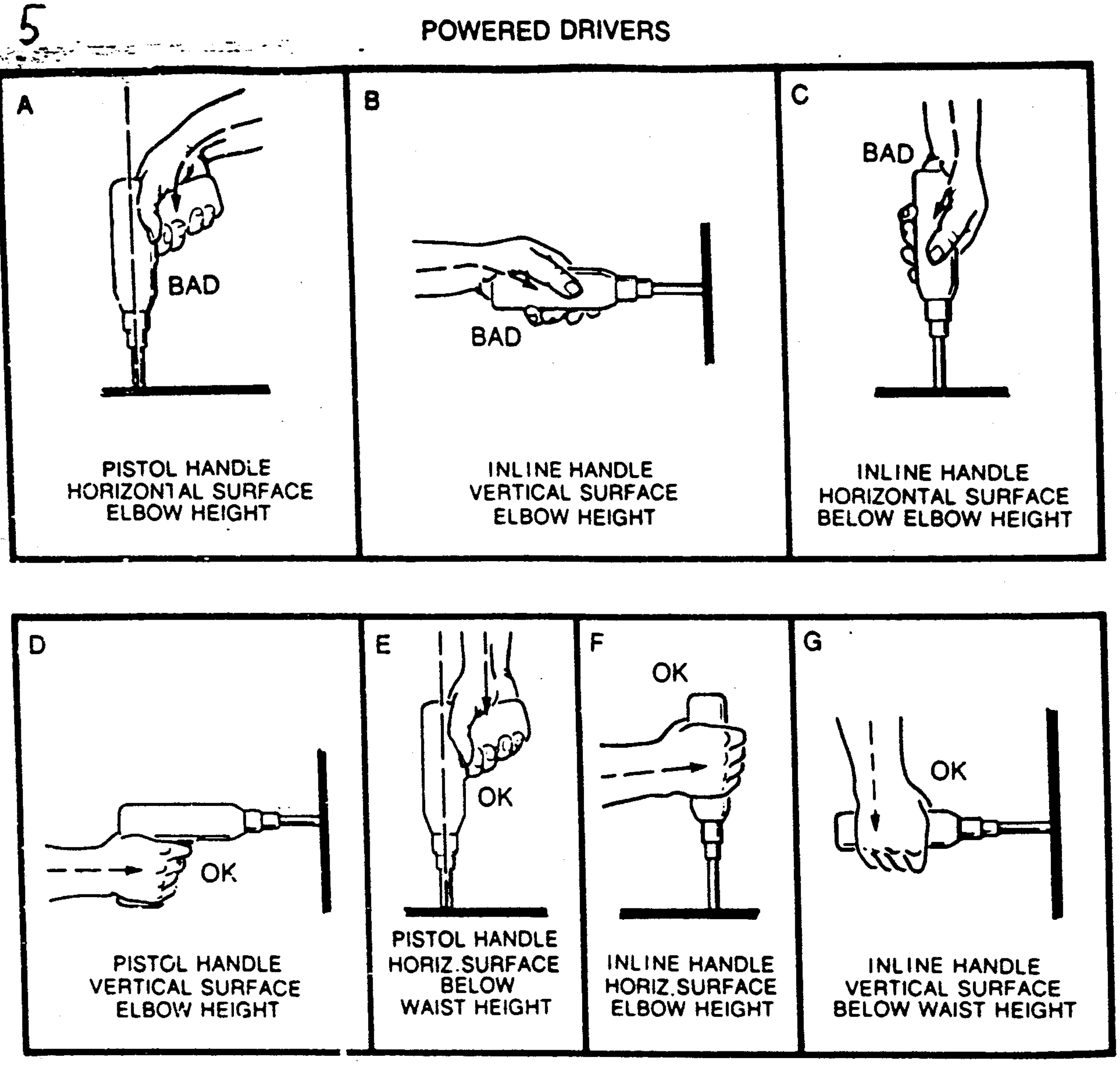


Fig. 4



The second factor that may contribute to the awkward posture is the pronated grip used to hold the pneumatic grinder. According to Anderson p.107, "Tool designs that require the wrist to be flexed and the arm pronated at the same time should be avoided, as this stretches the tendons and may contribute to lateral epicondylitis (tennis elbow), see figures 1, 2, and 5c. Fortunately, this problem can be remedied by instructing the employee to use a neutral power grip as depicted in figures 3, 4, and 5f.

Fig. 5



The repositioning of the hand both straightens out the wrist and places the hand in a neutral position which reduces the strain on the elbow. In addition, the neutral hand position addresses the problems caused by the abducted arm. Working with the arms in an abducted position for a prolonged period of time has been liked to cumulative trauma disorders. According to E. R. Tishauer:

> When tools are used in situations where the arms have to be elevated or the tools have to be held for extended periods, such as during grinding operations, muscles of the shoulder, arm and hand may be loaded statically. This loading can result in fatigue and reduced capacity to continue work, and it may produce soreness in the muscles within a day. The most severe manifestations of these complaints may be tendinitis, tenosynovitis, bursitis, epicondylitis, carpal tunnel syndrome, or deQuervain's syndrome.

Another common condition related to shoulder abduction is thoracic outlet syndrome. This condition exists when the nerves and the blood vessels between the neck and shoulder are compressed. Some of the symptoms related to this condition are numbness of the fingers, weakened pulse in the wrist, and the feeling that the arm is "going to sleep" (Anderson p.19). It is this researchers opinion that much of the employee's discomfort in the right shoulder, arm, and hand is directly related to the arm being abducted for long periods of time. By utilizing a neutral power grip, the elbow can be brought down close to the body, thus removing much of the employee discomfort.

In addition to the discomfort from the awkward posture, the employee has complained of numbness and loss of strength in the right hand. This condition may be related to the vibration exposure produced by the repeated contact with the metal grinding tool. As indicated in both the Anderson (p.68) and Eastman Kodak texts (p. 224), prolonged exposure to vibration may cause numbness, pain, and loss of strength in the hands, and blanching of the fingers. It is this researchers belief that the employee's claims are the result of the prolonged contact with the bare grinding tool. In order to address this problem, the tool should be covered with an isolating material so that the hand is not exposed to further vibration from the tool (Anderson p.224).

CONCLUSION

The following workplace and workmethod modifications can be made to decrease employee fatigue and discomfort:

1. Raise the workbench to a height of 36 inches and enable the employee to tilt the work surface forward if desired.
2. Install a foot rail to reduce the static load on the legs
3. Instruct the employee to use a neutral power grip when holding the grinder to reduce the strain on the wrist and elbow tendons.
4. Eliminate the need to hold the right arm in an abducted position.
5. Insulate the grinding tool with insulating material to reduce vibration exposure.
6. Provide hearing protection for the employee to use.

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A REVIEW OF TICHAUER'S ERGONOMIC PRINCIPLES

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Much of the human factor's information used in my preliminary analysis of a grinding operation came from Eastman Kodak's Ergonomic Design for People at Work, and Putz - Anderson's Manual for Musculoskeletal Diseases of the Upper limbs. While both of these texts are considered major works in the field of Ergonomics, much of their content came from the work of an early ergonomist named Erwin R. Tichauer. The goal of this report is to review some of the ergonomic principles developed by Tichauer and see how these principles have improved handtool and workstation design.

THE PROBLEM WITH TODAY'S TOOLS

According to Tichauer, tools should be designed to extend and reinforce the range, strength, and effectiveness of the limb or limbs engaged in the performance of a given task. While it is true that many tools help to increase the amount of force generated within the body onto the material or workpiece, many tools are not designed with the anatomical limitations of the user in mind. Thus, the tool is neither used to its fullest potential, nor is the user safeguarded from injury due to overuse. In severe cases, improper tool design can lead to the development of such afflictions as tennis elbow, tenosynovitis, and carpal tunnel syndrome.

Tichauer developed the following principles to aid in the development of ergonomically designed tools. Through their use, the interface between man and tool can be optimized:

1. Avoid stress concentrations - Finger grooved tools should not be used because they fit only one hand perfectly - the hand of the designer.

2. Avoid compression ischemia - Ischemia is the obstruction of the bloodflow due to compression of the blood vessels. Conventional tools, such as pliers, exert force on the ulnar nerve and artery, thus compressing these vessels and causing numbness and tingling sensations in the ring and little figure. It is important that tool designers be familiar with the major blood vessels and nerves of the hand so that they can design tool handles that exert pressure on the less sensitive areas of the palm.

3. Avoid muscular insufficiency - Muscular insufficiency exists when a weak muscle is chosen to perform a task instead of using a more powerful muscle. For example, a common electric drill uses the index figure to operate the trigger. Over a period of time the tendon on the back of the figure may become damaged due to the excessive strain.
   Electric tools should be triggered by a foot pedal or the thumb since the thumb is the strongest figure and has the greatest range of motion.

4. Keep the wrist straight - There are four motions of the wrist that may lead to fatigue, discomfort, and possible disease when performed to the extreme - ulnar deviation, bending the hand towards the little figure; radial deviation, bending the hand sideways towards the thumb; dorsiflexion, bending the hand back; and palmar flexion, bending the hand forward. Not only do these positions lead to possible disease, they also lead to a weaker grip which decreases productivity.

5. Avoid handtool vibration - Excessive exposure to vibration can lead to swelling and numbness of the figures and permanent nerve damage; thus, hand tools should be insulated with isolating materials such as foam rubber.

CONCLUSION

Improper design of hand tools can lead to several occupational diseases such as tennis elbow, tenosynovitis, and carpal tunnel syndrome. Erwin Tichauer was one of the first ergonomists to address this problem and today his work serves as the basis from which ergonomically designed tools are developed.