HOW SAFETY & PRODUCTIVITY MEET

Case Example of a Work Manipulator

By Rick McCain and Dan MacLeod

Too often we read articles that provide excellent top-level guidance, but that do not show real-life examples of implementation. This article illustrates a case that provides direction on several levels to turn theory into tangible steps.

Safety and productivity can go hand-in-hand. The study of a work manipulator provides solid data and demonstrates the value of a safety improvement.

The principles of ergonomics referred to in this article apply to many tasks besides the case example. This article gives guidance for evaluations and job improvements in general, simple concepts that should be part of a safety professional's tool kit and used in daily work. The manipulator itself is unique to the market and can yield dramatic improvements where applicable.

This project was initiated when a safety professional on a general walkthrough noticed an employee working in an extremely awkward position on a traditional workbench. A brief discussion with the employee revealed that he and others experienced neck and back pain while performing the task. The safety professional was aware of a commercially available work manipulator and thought it fit the situation. After showing images of the manipulator to employees and leadership in the work area and getting consensus, the safety professional arranged to purchase it.

Note that no written checklists or task-scoring worksheets were used at this point. The problems were obvious and senior plant leadership had previously given support and directives to resolve problems based on professional judgement.

After the manipulator was installed and working properly, the following study was initiated as part of a continuous effort to show the value that a good safety process provides to the organization.

Before & After

A work manipulator allows users to adjust the work as needed to permit working in positions that provide better access to the product and put the arms neck, and back in a position for maximum strength and maximum dexterity. In this workplace, replacing a traditional assembly workbench with a work manipulator dramatically reduced strain on workers' joints and significantly improved productivity. The specific results were:

FIGURE 1
WORK BENCH VS. MANIPULATOR

Before: Traditional Workbench

Bending to access under side.

Strained arm position to flip product.

After: Work Manipulator

Easy to change product orientation.

Better working position.

FIGURE 2
LOWER BACK ANALYSIS

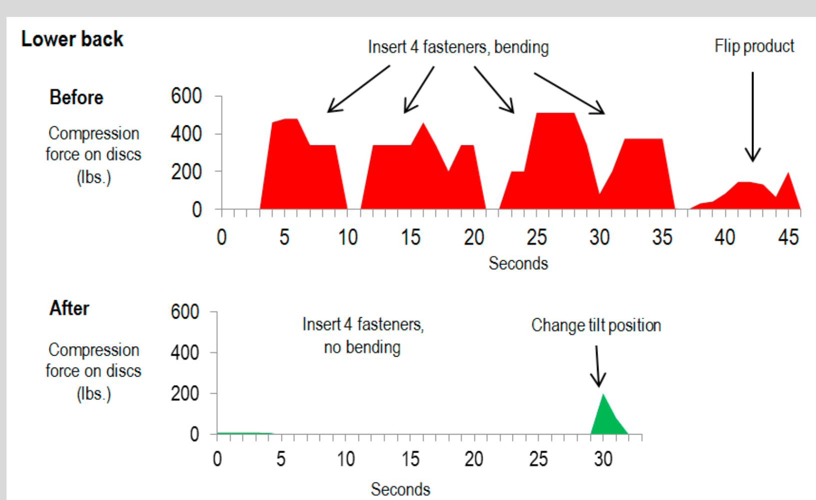
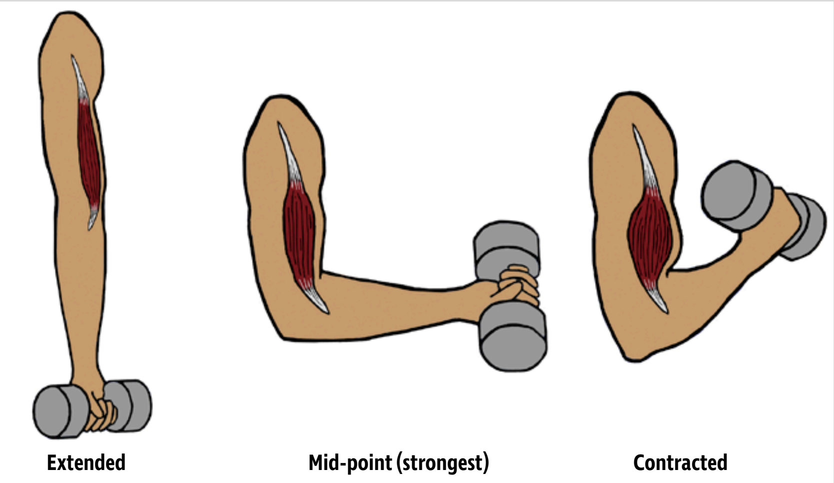


FIGURE 3
SHOULDER ANALYSIS

FIGURE 4
OPTIMAL POSITION

FIGURE 5
MUSCULE MOTION



1) Less strain on assemblers:
•lower back (97%);
•shoulder (61%);
•neck (91%).
2) Less assembly time (25%).

The job was to assemble aircraft parts, which essentially involves drilling holes and inserting fasteners to hold the components together. As shown in Figure 1 (p. 25), performing the work on a traditional bench requires considerable bending, reaching and flipping the product over.

In contrast, the work manipulator enables easy maneuvering of the product to create better access to the part and to work in better positions. Although there are still suboptimal working positions, the worst instances were eliminated and the remainder were relatively minor and were held for a shorter duration.

The assembly time data was taken from charge numbers for the year preceding the use of the work manipulator and the following year. The availability of 2 years of data provides good confidence in the comparison.

Interpreting the Figures

Figures 2 (p. 25) and 3 were generated by evaluating video clips of the job and calculating the load on the body for each step using standard biomechanic techniques. By knowing the weight of an object and the horizontal distance from the shoulder to the lower back, it is easy to estimate the load on those joints.

In Figures 2 (p. 25) and 3, the horizontal axis shows time and the vertical axis displays the load on the joint. The higher the peak, the worse the strain on the joint. The wider the figure for a given task or individual step, the more time is required. Thus, it is possible to create a visual display of the physical demands for the various job steps along with numerical results. Furthermore, it is then possible to compare the two work methods.

Figure 2 (p. 25) shows results for a representative segment of the entire job: inserting four fasteners, then flipping/tilting the part. A quick glance at the figures is enough to understand the difference, but the numerical summaries are as follows:

•These activities required 46 seconds on the traditional bench, but only 33 seconds on the work manipulator, a 28% reduction.

•The strain on the back from bending four times using the traditional bench is clearly visible. The peak compression force on the lumbar discs exceeded 500 lb on the worst bend. The load on the back when flipping the part lasted 9 seconds and peaked at 200 lb.

•In contrast, when using the work manipulator, there was essentially no load on the back associated with inserting the fasteners. Tilting the part required 3 seconds and peaked at 202 lb.

•By combining the loads with the respective time required for all the steps (i.e., the area under the curve), time-weighted loads can be calculated and compared. In this case, the strain on the lower back dropped 97%.

Figure 3 shows results for the shoulder. For the shoulder, the peak load at the bench was 19 ft-lb, when flipping the part. When using the manipulator, the peak was 8 ft-lb, when inserting a fastener. The overall area under the curve dropped 61%.

FIGURE 6
ELBOW HEIGHT WORK

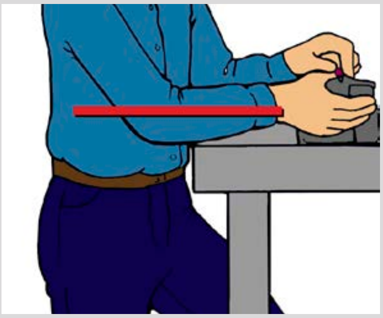


FIGURE 7
HEIGHT EXCEPTIONS

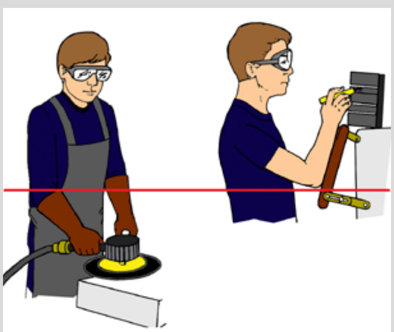


FIGURE 8
LINE OF SIGHT ACCESS DURING WORK

An equivalent biomechanical method for the neck does not exist, but the neck position was scored on a scale of 1 to 3. Although not illustrated here, the difference in strain on the neck dropped an estimated 61%.

Comments

Employees who performed this work readily experienced the dramatic reduction in strain on the body and they responded positively to using the manipulator. The change in working position was evident to even casual observers.

The quantified results are striking, but not surprising. The most noteworthy outcome is the time reduction. Improvements in working position tend to be easily recognized, but the time differences are not so self-evident. Usually the differences are noticed only by special study or documentation. When studies like this are undertaken, the ergonomic improvements generally result in both improved employee well-being as well as improved ability to perform a task efficiently, which is a double win.

It is not always necessary to conduct formal studies to document benefits. The underlying point is for safety professionals to be in the habit of gathering whatever evidence is available and using the results in reports and presentations.

Considerations for Orienting Work

Sometimes, it is intuitive for workers to adjust a work manipulator or any other workstation or piece of equipment. They simply feel better when they get it right. However, three considerations should be taken into account.

Optimal Working Position

A primary goal for all activities is to work in optimal postures (Figure 4): neck in its proper alignment, hands in the same plane as the forearm, elbows hanging naturally at the sides, and the back with its natural curve. In these positions, the person is stronger, has more dexterity, experiences less fatigue and is at lesser risk for long-term disorders. The work manipulator simply enables the workers to achieve these positions easily.

Muscles consist of long fibers that stretch out and contract as needed. A person is strongest when the muscles are at the midpoint (Figure 5). Moreover, the muscles generally work in sets of two. For example, the bicep lifts up the forearm and the tricep pushes it down. When the two sets of muscles are balanced, they are in the position for maximum strength and dexterity. This position tends to be at the midpoint of the range of motion for the affected joint. For this reason, it is often referred to as the neutral posture.

Best Working Height

A good general rule is that work should be done at about elbow height (Figure 6). Working at this height generally enables the optimal working posture for the whole body. Thus, when using an adjustable height workstation, working at about elbow height provides a helpful guideline.

However, there are some exceptions to the rule. Heavier work is often best done lower than elbow height to enable using body weight and larger muscles. Conversely, precision work and visually intense tasks are often best done higher than elbow height so the worker can see better (Figure 7).

Typically, it is impossible to look up the proper height for a workstation in a reference book. Proper height depends on the task being performed. Often the only way to find the best height is to try working at different levels.

Access & Line-of-Sight

OSH professionals must also take into account the worker's ability to access the item and see what s/he is working on. Changing the position of the item (e.g., slanting, turning, changing height) can improve the worker's access to the work piece, both physically and visually (Figure 8).

Comments

These three considerations may seem self-evident, but they are routinely overlooked. Furthermore, for some tasks, it may not be possible to combine all three factors simultaneously. For example, the best orientation for line of sight may not provide for the optimal working position. These cases may require compromise or finding a technique to overcome the barriers. The most common problem is that the best orientation for one step of a task may not be the best for another step. The work manipulator shows its value by providing the ability to switch rapidly between different orientations.

Finally, these three considerations can provide insights to problems and improvements in any task. There are certainly more factors that can come into play, but getting in the habit of evaluating tasks for just these three issues alone can lead to a surprising number of improvements. **PSJ**

Rick McCain, CSP, is a safety engineer at Lockheed-Martin in Ft. Worth, TX, and safety lead for the F35 production line. McCain is a professional member of ASSP's Fort Worth Chapter and a member of the Society's Management Practice Specialty. He holds an M.B.A. in Business from University of Texas at Arlington and a B.S. in Safety and Environmental Management from Slippery Rock University of Pennsylvania.

Dan MacLeod, CPE, is an independent ergonomics consultant contracted to Lockheed-Martin to help set up the F-35 production line. He is president of Dan MacLeod LLC, an ergonomics consulting company. MacLeod holds an M.A. in Industrial Relations, Organizational Development from University of Minnesota-Twin Cities and an M.P.H. in Occupational Health and Safety from University of Illinois at Chicago.