Ergonomic design is everywhere: our homes, our cars, our workplaces. It seems that every appliance or accessory on the market these days boasts some type ergonomic design feature. But what exactly is ergonomic design, where did it come from, and why should electronics manufacturers care about it?

Ergonomics is the science of how the human body interacts with other systems, and it has a long, rich history. The first known application of ergonomic design principles was recorded in the 5th century BC, when Hippocrates described how a surgeon’s workplace and tools should be arranged. Many other applications have been documented over past 2400 years, but the modern, industrial usage as we know it began with mass production in America. In the early 1900’s, the study of human factors was applied to improve efficiency in manual tasks. People like Henry Ford, Frederick Winslow Taylor, and Frank and Lillian Gilbreth popularized time and motion studies to eliminate unnecessary, time-wasting movements on the world’s first assembly lines. Soon it was discovered that applying human factors not only improved productivity, but also improved product quality. By lowering fatigue and easing physical and psychological stress, better work setups substantially reduced human error in manual tasks, and therefore saved businesses the money and headaches associated with poor quality goods.

World War II brought the first mass production of printed wiring boards to manual assembly lines. Relatively small and complex ordnance parts required magnification as workers struggled to keep up with demand. But while The Greatest Generation of Americans feverishly hand assembled some 22 million artillery fuses using whatever magnifying lenses were available to them, the Swiss watch industry was looking at the bigger picture - the overall methods of magnified assembly and inspection. They quickly concluded that the visual acuity of watchmakers deteriorated rapidly within 15 minutes of beginning a shift, despite the aid of optical magnification. The root causes of improper assembly and missed defects were identified as eye and back strain – an ironic result of using the magnification systems that were meant to help the workers. Frequent breaks improved product quality, but it was clear that the equipment needed improvement. The concept of ergonomic work cell design was born.

Since its inception in the 1940’s, ergonomic design in the workplace has saved millions of dollars in lost productivity and quality problems. A modern case study in PCB assembly quantified the impact of ergonomic improvements on a visual inspection
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process. In a study of 20 inspectors using illuminated magnifiers known as Luxolamps, the operators described high rates of problems with eyestrain, headaches and fatigue in their upper extremities. Simple ergonomic intervention methods reduced eyestrain by 36 percent, headaches by 45 percent, and extremity fatigue by 28 percent. Within a few weeks the defective PCB escape rate was cut by more than half, saving the organization nearly $300,000 annually in customer returns.

The study demonstrated the immediate savings due to productivity increases, but did not document the longer term, often more expensive effects of poor workplace ergonomics – personal injuries. The costs of repetitive stress or strain injuries are physically and financially painful for employees and employers alike.

Most repetitive stress or strain injuries are classified as Musculoskeletal Disorders, or MSDs. MSDs are medical conditions that affect muscles, nerves, tendons, ligaments, joints, cartilage or discs. In the USA alone, nearly 2 million workers report MSDs each year. They account for 600,000 lost time injuries annually, and 1 of every 3 dollars paid out in workers compensation claims are for MSDs. Risk factors include force, repetition, awkward postures, static postures, vibration, contact stress and cold temperatures. They can act singularly or in combination with each other, and occupational MSD risk levels depend on workers’ exposure to the risk factors.

Microscope operators are at relatively high risk for MSDs. The US Occupational Health and Safety Administration cites the three largest factors in MSDs as awkward postures, repetition and force. While microscope operators are not required to experience large forces, they are forced to endure awkward, static postures and repetitive movements. 80 percent of microscopists across all occupational fields have experienced job-related musculoskeletal pain; 20 percent have missed work because of microscope-related problems. Figure 1 illustrates the locations where microscope users report feeling work-related pain.

The majority of the problems reported by microscope operators are for neck, back, shoulder and arm pain. The source of the pain is the compression of the brachial plexus, a bundle of nerves that runs from the spine, through the neck, and into the arms. The forward-leaning, bent-neck posture required by most microscopes puts pressure on this nerve bundle, and...
its effects can be felt anywhere along the neural network. Tingling, numbness or pain in a microscope user’s arm or hand may be the result of the position they are forced to assume to perform their job.

The effects of poor workplace ergonomics are not limited to short-term discomfort, however. They can extend to a lifetime. Occupational safety and health expert Luther Lockhard explains “when you adopt awkward or static postures regularly, you are literally folding yourself to death. The human body will accept the folded position as the new normal, range of motion will be lost, and proper posture will eventually become very difficult to regain. For example, consider chefs, machinists or other professions where people work at counter heights while standing. Many of them appear perptually hunched over from their years of poor occupational postures.” Remember when your mother told you to stand up straight or your slouch would become permanent? She was right!

Microscope manufacturers have not ignored the risks associated with their equipment. In fact, they have addressed them with a number of design changes, aftermarket accessories and guidelines for improved use. Equipment modifications incorporate eyepiece adaptors, armrests, height adaptors and video cameras. Extended eye tubes at 30-45 degree angles that swing and tilt to improve operator posture are widely available. Guidance for improving user comfort include:

- looking away from the microscope and focusing on a distant object at least once every 15 minutes, and
- using video displays to locate the inspection area and rough focus on it before using the eyepieces for final focus and observation.

Video displays are no longer just for object location and coarse focus, however, particularly in PCB inspection. High Definition video microscopes now outclass many of their optical counterparts in image quality, ergonomic design and even price. With available magnification factors of over 300X, HD cameras capture and process images at a rate of 60 frames per second. The levels of clarity and detail are better than most optical microscopes. Even 0201s are easy to inspect when they’re over an inch tall, as seen in figure 2.

The big-screen viewing eliminates eyestrain and makes inspection tasks faster and more accurate. The upright positioning of the display removes the awkward, static postures that cause temporary neck, shoulder and arm pain, as well as the more serious long-term disorders that result from repetitive stress or strain. Figure 3 compares the postures of traditional optical microscopes and modern, HD Video inspection systems.

This digital-age inspection tool facilitates three major objectives of production management: it speeds the inspection process, reduces escapes, and eliminates the opportunity for operator injury.

The benefits of HD video inspection don’t stop with efficiency and ergonomics, however. Most systems offer features like automatic focus, exposure, and lighting.
adjustments to effortlessly optimize image quality. Many also boast joysticks for image manipulation and measurement software to determine the dimensions of small features or offsets. Image capture capabilities are used for documentation and reports. Live HD video feeds are typically used for group training, multisite conferencing or team meetings, as shown in figure 4. But the best features of the modern HD inspection systems are their price tags: brand new, nicely appointed systems are available for less than $10K.

Although HD vision technology has been available since the 1990's, it has only recently become affordable for industrial inspection. The proliferation of digital cameras – both handheld units and those embedded in consumer electronics – has brought new economies of scale for lenses, image sensors, processor chips and applications software. The broad availability and competitive pricing of video components have enabled this new generation of cost-effective inspection equipment to help assembly operations improve their product quality, factory productivity and employee long-term health.

Hippocrates is considered the father of Western medicine; his oath is still taken by medical school graduates today. While the thought of surgery in 400 BC admittedly seems a bit barbaric, his description of arranging a surgical theater laid the groundwork for the modern ergonomic principles we now apply on a daily basis. Whenever we use hand tools with padded grips to prevent personal discomfort, computer keyboard shelves to avoid carpal tunnel syndrome, or HD vision systems to keep our inspectors alert and healthy (and keep our businesses profitable), we can trace our protective practices back two and a half millennia to the legendary Greek physician.

References: