Pressure Mapping Solutions for Advanced Manufacturing Processes

Covering the Diverse Roles Pressure Mapping Technology Can Fill to Capture Critical Data that Drives ROI

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INTRODUCTION

Actionable Tools to Cultivate Trust in Your Advanced Manufacturing Concept

For many of us, stepping outside our comfort zone is not something that comes easy – especially when it comes to employing new methods to advance a manufacturing operation. **The mantra "that's the way we've always done it" can be difficult to break, unless there is a clear way that the new manufacturing concept you're producing can quickly demonstrate ROI.**

ROI comes in many forms; a technological innovation that elevates throughput efficiency, a safety measure that promotes a less dangerous working environment, or a smart tool that ensures the accurate delivery of a product. Given the explosion of recent technological advancements in all of these segments, developing applications that stand out to your target user can be challenging.

Change always brings skepticism, but as a design engineer of manufacturing machines and assembly equipment, smart utilization of proven technology may be your gateway to the next landmark manufacturing innovation.

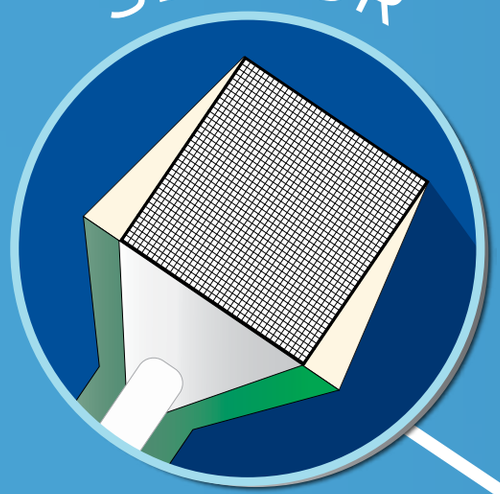
Exchanges in pressure are present in just about every manufacturing operation – whether made manually by an employee on the manufacturing floor, or mechanically by a machine. There's a wealth of information about a process that may be going unnoticed without a reliable method to measure these pressure exchanges.

Whether used in R&D design, on-site commissioning, or as a maintenance instrument, pressure mapping technology offers endless ways to capture critical data that quantifiably drives ROI. Having the ability to measure interface pressure distribution in paper-thin spaces can acquire invaluable data that truly demonstrates success.

This eBook will explain the basics behind pressure mapping technology and its role in delivering tangible information on the entire manufacturing process, from production through delivery. These concepts will be supported with real-world applications for this technology used in the field today.

COMPONENTS OF A PRESSURE MAPPING SYSTEM

SENSOR

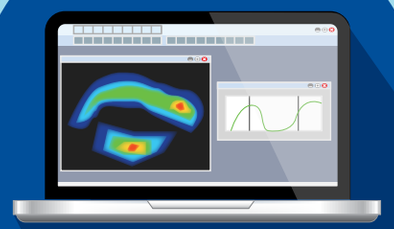


- **Minimal invasiveness**
- **High resolution**
- **Thin and flexible**

ELECTRONICS

- **Scan thousands of sensing points within each sensor**
- **Instant data relay to PC via USB or WiFi**

SOFTWARE



- **Display pressure distribution data in multiple formats for superior analysis**
- **Display pressure data graphs in 2D and 3D**
- **Capture peak pressures and center of force in real-time**
- **Allow for video playback of pressure data**

WHAT IS PRESSURE MAPPING?

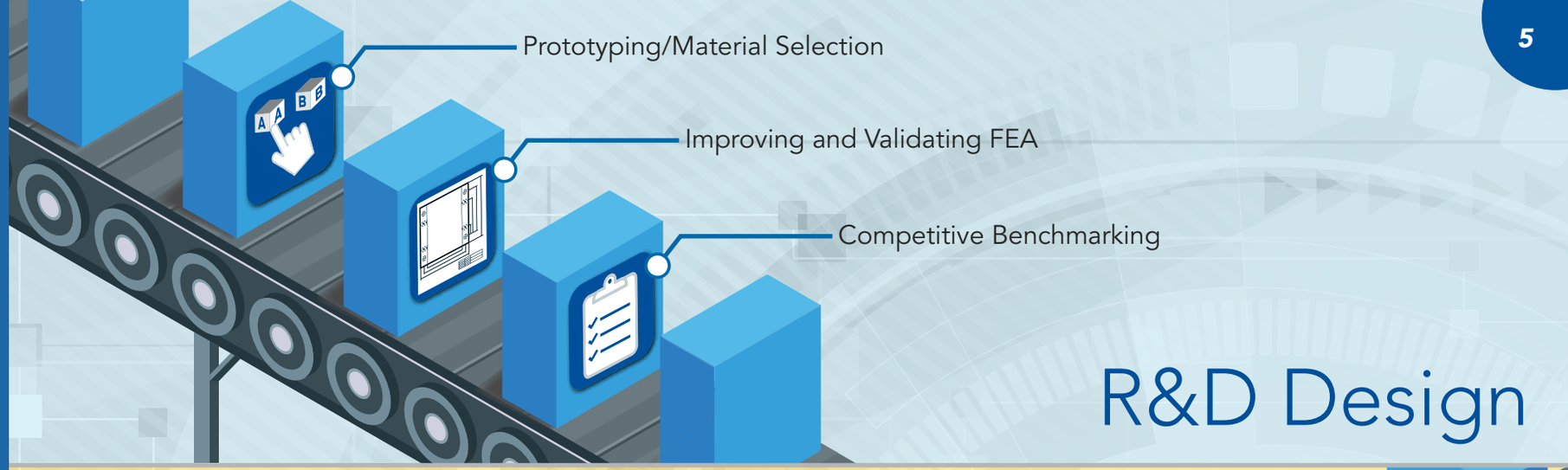
Even between relatively flat surfaces, one finds the interface pressure distribution is often not uniform within localized areas of peak pressure. Pressure mapping technology helps design engineers obtain insight into areas that may impact design and quality.

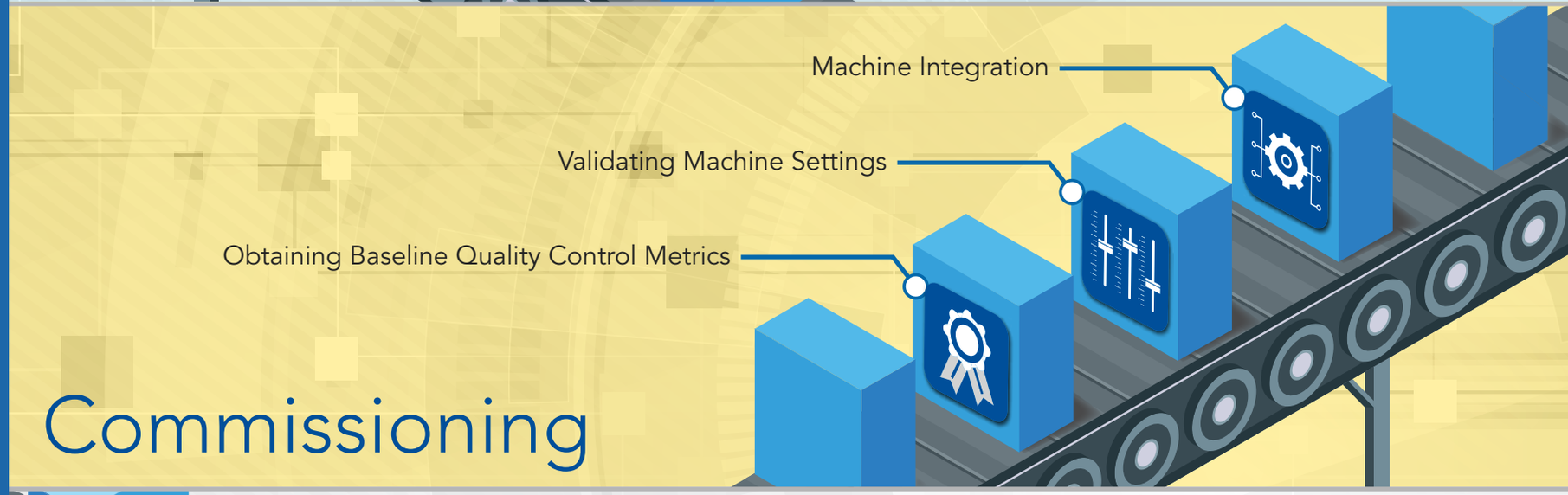
Pressure mapping systems require 3 components – **sensors, scanning electronics, and software** – to deliver real-time, actionable data, in ways other methods cannot.

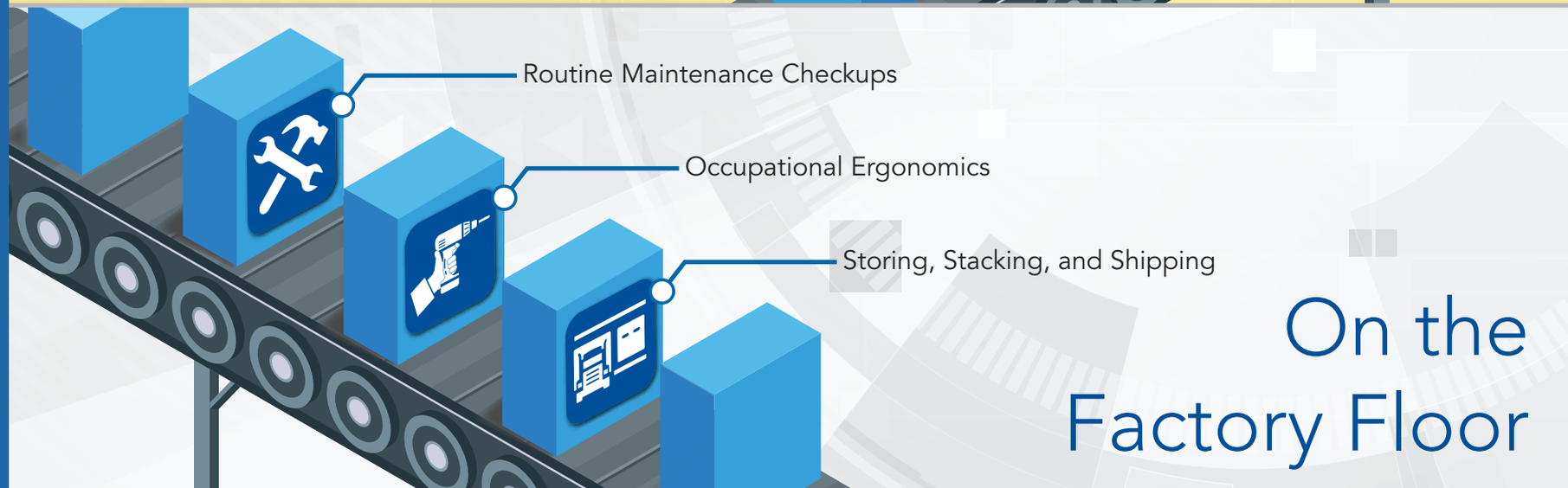
- The **sensor** transforms compressive pressure loads to a change in resistance.
- The **scanning electronics** collect analog data from the sensor and convert the data into a digital signal.
- The **software** displays real-time activity of the sensor area, allowing the user to see force, pressure, contact area, and timing data.

PRESSURE MAPPING AND MANUFACTURING: A MATCH PROVEN OVER THE DECADES

Pressure mapping is a prime example of an intuitive, far-reaching analysis technology that does not fall into any single use category. The images on the right display just a few of the many applications for pressure mapping technology for nearly every manufacturing segment.







R&D DESIGN APPLICATIONS

The following pages share applications specifically covering the design aspect of advanced manufacturing machines, systems, and processes.

#1 Evaluate Repeatability of an Automated System

Pressure mapping has a long track record of helping design engineers understand the inner workings of their machine designs in ways no other technology can achieve.

Automated or robotic manufacturing machines are trusted to perform repeat actions with a high-level of consistency. The slightest misalignment over time can throw off an entire production run. Addressing potential challenges in a design with pressure mapping technology helps ensure your machine will deliver top quality product and require less routine maintenance.

CASE EXAMPLE: Commanding Robotic Assembly Actions In-Real-Time

Robotic systems have become quite common in manufacturing environments ranging from high-precision electronic component assembly, through automotive manufacturing. They require frequent checks for changes in alignment that can occur with routine use.

One robotic system developer employed pressure mapping technology while in the design phase of a new generation system, to evaluate the consistency of the robot's actions. As shown in **Figure 1,** the design engineers placed sensors on the contact points of the robot, and were able to see high- and low-pressure points in the pick & place process. They used this data to make adjustments to the machine alignment, as needed.

While using the technology in R&D, they had a breakthrough idea of embedding that same technology within the machine's UI, so the operator could perform alignment spot checks on-the-fly.

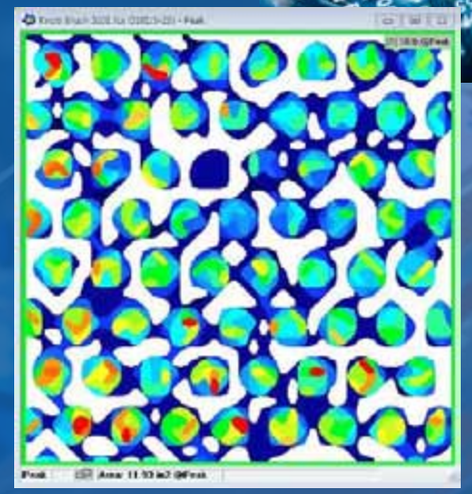


Figure 1
Display of pressure distribution as a robotic system applies components to a circuit board.

Other Similar Applications

- **Robotic Grip Control**
- **Welding System Evaluation**
- **Mediating Impacts in Automated Assembly Lines**

#2 Address Component/Facility Wear And Tear

Pressure mapping can uncover potential problem areas in a design to prove or disprove the finite element model.

In some cases, an innovative system that streamlines certain elements of a manufacturing process may be doing harm to other areas of the operation. Utilizing pressure mapping technology can help expose these potential hazards.

CASE EXAMPLE: Proving a Smooth Ride Under a Heavy Load

Warehouse robots are immensely useful for improving productivity of high-volume manufacturing facilities or storage warehouses. Not only can they carry the load of entire shelving units with ease, but their precise movements make the transportation process quantifiably more efficient.

However, given the extreme weight these systems can carry, their movements can cause damage to the warehouse floor, which can be dangerous to employees, and the company considerably in repairs.

One warehouse robot manufacturer used pressure mapping technology to understand pressure points produced by the robots while carrying heavy loads. The data shown in **Figure 2** displays potential hot spots for wear and tear on the floor. With this information, the manufacturer could tweak their designs to distribute pressure more evenly and reduce stress on other parts of the operation. The robot could be programmed to adjust their movements, depending on the total weight of the structure they were transporting.

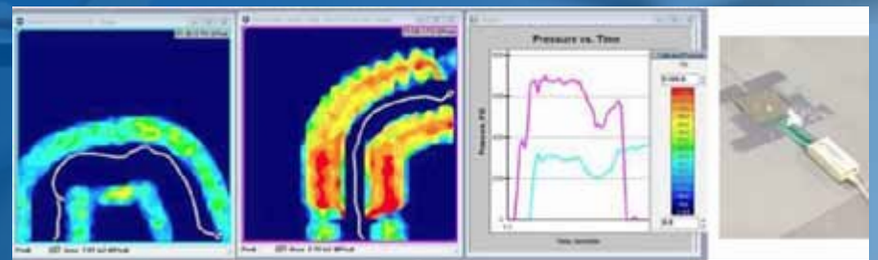


Figure 2
Pressure data captured as a warehouse robot carries pallets across the floor, including cornering.

Other Similar Applications

- **Tire Footprint Analysis**
- **Storage Facility Mapping**
- **Drone Delivery Systems**

#3 Mediate Occupational Ergonomic Risks

Pressure mapping helps identify ways to improve tools and machines to address long-term on-the-job health risks.

Sometimes, the right tool for the job isn't always the best tool for the user's well-being. With a better understanding of the dynamic forces an operator applies to their tools, machines, and other devices, design engineers can identify ways to make a less painful working experience.

CASE EXAMPLE: Make Drilling Less of a Struggle

For certain manufacturing processes, nothing can take the place of the human touch. Of course, repeat movements or gripping actions can wear on an individual, and can cause long-term health issues like carpal tunnel syndrome.

One drill manufacturer set out to develop a more ergonomically-sound design. As shown in **Figure 3**, thin and flexible pressure mapping sensors were positioned around the drill design, to show areas of peak pressure while a human subject operated the device.

In this particular test, the R&D team wished to see if there were different effects of an individual gripping the drill with either their left or right hand. Similar tests could be done to assess peak pressures while holding the drill in different positions.

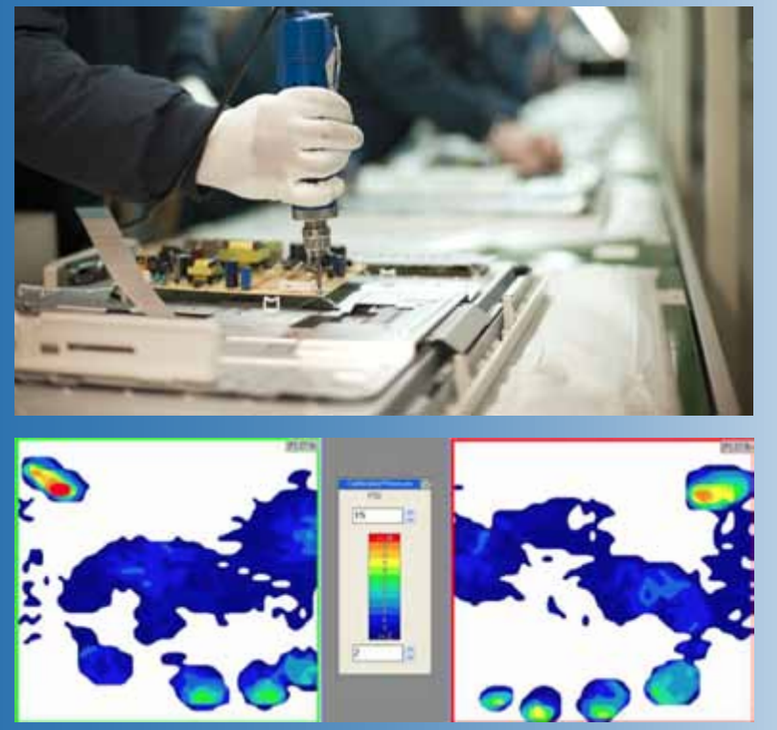


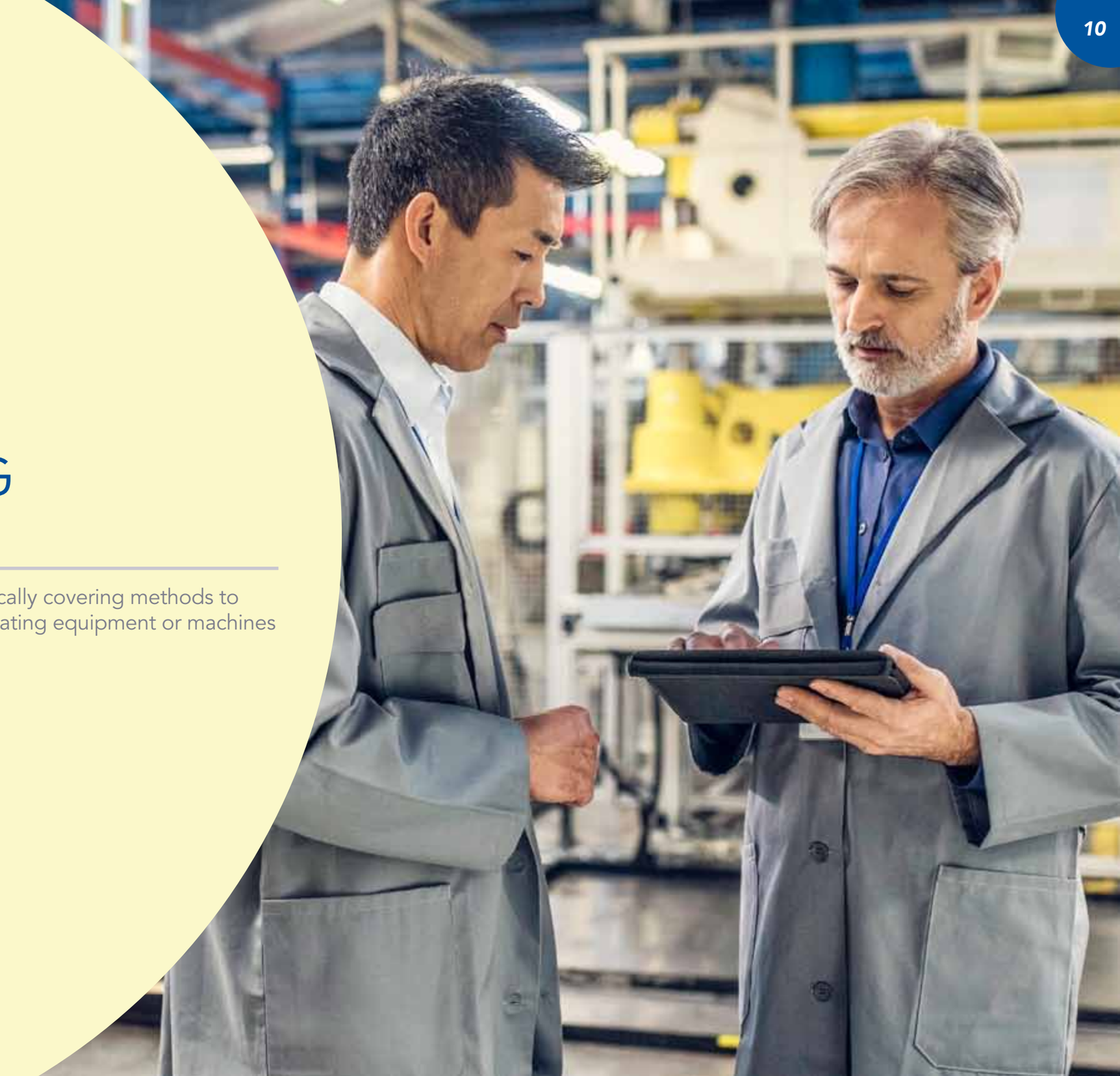
Figure 3
Display of pressures felt by the operator using the drill with their left or right hand.

Other Similar Applications

- **Various Manufacturing Equipment Design**
- **Safety Equipment Design**

INDUSTRIAL COMMISSIONING APPLICATIONS

The following pages share applications specifically covering methods to use pressure mapping technology while integrating equipment or machines into a new or existing operation.



#1 Ensure Successful Machine Integration

Pressure mapping technology verifies that all facets of an operation are performing to spec when installing new production systems or equipment.

Industrial commissioning engineers have an actionable tool in pressure mapping to affirm that a new machine assimilates accordingly with other machines in the process.

CASE EXAMPLE: Confirming Conveyor Connections

As manufacturing companies expand to meet growing demand, their sorting and distribution systems can quickly be pushed to their limits. For conveyor systems, such as the image pictured in **Figure 4**, re-routing sections are incredibly important to ensure the right units are being delivered to the correct areas of the plant.

Any misalignment in the conveyor system can spell disaster, especially when transporting sensitive components that can damage easily. While installing new conveyor lines or dividers, industrial engineers can obtain a better understanding of system performance with pressure mapping technology.

Whether it's establishing alignment between one conveyor line to the next, monitoring a safe distribution of weight across the line, or ensuring product is reaching its next stage of the manufacturing process at an efficient pace, pressure mapping can be a valuable quality-benchmarking tool.

Figure 4
Installing new connecting points within a conveyor system requires a clear understanding of pressure distribution.

Other Similar Applications

- **Monitoring Position Shifting of Machine During Testing**
- **Machine Re-alignment After Delivery**
- **Monitoring Tension in Web-Converting Operations**

#2 Establish Ideal Operation Settings

Pressure mapping technology can be used to institute a baseline quality standard that fits the needs of a specific operation.

When manufacturing operations managers invest in a new system or piece of equipment, it's vitally important to prove the new addition will deliver expected results for their unique operating conditions. Pressure mapping technology can help set up facilities for success by displaying clear performance data.

CASE EXAMPLE: Instituting Proper Nip Roll Uniformity From Day 1

From printing, packaging, laminating, and converting, nip rolls are a vital part of many different operations. Nip roll alignment can be difficult, tedious, and potentially dangerous for the operator, but it is a vital pre-production necessity. However, using pressure mapping technology can help establish an optimal standard uniformity to make this alignment process quick and easy.

The Nip Pressure Alignment Tool (NPAT™) is a useful maintenance tool for industrial commissioning engineers to capture nip footprints and relative pressure distribution between nip rolls. Depending on the material being manufactured, some rolls may require a heavy or light crown to produce a top quality product.

As shown in the screenshot in **Figure 5**, the NPAT system contains several sensing columns that independently scan across the nip roll to show areas of high and low pressure. With this tool, the engineer can map out the ideal nip uniformity settings, to ensure success after installation of a new machine.

Figure 5
The NPAT pressure mapping system (positioned between the rollers above) helps technicians establish a "gold standard" roll alignment setting.

Other Similar Applications

- **Sealing Bar Setup**
- **Ultrasonic Welding**
- **Automated Adhesive Application**

#3 Assess Impacts to the Outside Environment

Pressure mapping technology can be used to capture the full landscape of pressure effects across an entire manufacturing operation.

Heavy machinery can be loud and disruptive, both within the production facility, and to the neighboring community. With pressure mapping technology, operators can understand the impact their system will have, and use the data to make accommodations.

CASE EXAMPLE: Addressing Vibration Concerns of New Machinery

Excessive noise and vibration is often the cost of doing business for many manufacturing operations. In particular, hydraulic metal stamping systems, as shown in **Figure 6**, can cause plenty of ruckus that can affect operations in other areas of the manufacturing plant.

In an effort to understand seismic effects of using a metal stamping machine, an industrial engineer used pressure mapping technology to map out the approximate vibrations felt from different spots of the manufacturing plant. One area in particular – which was a high-precision automated assembly section of the plant – was tested to determine tremors while operating the stamping machine, and whether they could impact the quality of product that other area of the plant would output.

With this information, the engineer could take appropriate actions to try and mediate the amount of vibration expelled by the stamping machine. These measures were also well-received by residents living in close proximity to the manufacturing facility.

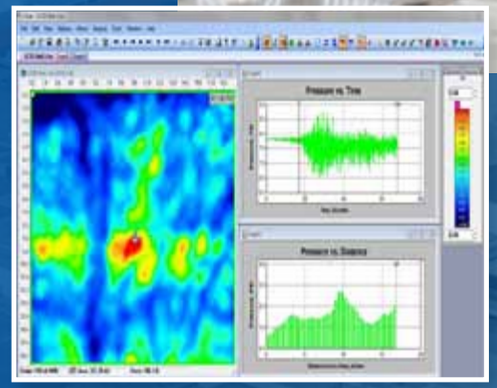


Figure 6
Pressure mapping was used to help interpret seismic activity of a plant running a hydraulic metal stamping machine.

Other Similar Applications

- **Soil Compaction Testing (During Construction)**
- **Durability and Drop Testing**
- **Other Geotech Manufacturing Processes**

ON-THE-FLOOR APPLICATIONS

The following pages share applications specifically covering methods to use pressure mapping technology as part of a routine maintenance program, or commanding the supply and shipment of a product.

#1 Spot-Checking System Accuracy

Pressure mapping technology can be used as a benchmarking tool to confirm proper contact of different components of the system.

As this eBook has shared to this point, no progressive manufacturing system is 100% perfect. Using pressure mapping as an innovative maintenance tool can be a useful method to ensure operations are running as smooth as possible.

Case Example: A 'Uniform' Seal of Approval for Emblem Application

For many of us, the vehicle we drive is a reflection of ourselves. When you consider both the mental and financial investment that goes into a vehicle purchase, there may be few things more frustrating than finding a part of the vehicle's identity has fallen off due to poor manufacturing processes.

Vehicle badges, like the image in **Figure 7** displays, are often applied through a wet-out (or "quick wet") method. In this process, adhesive is applied to the badge, which is then pressed onto a vehicle part using a pneumatic tool handled by an operator, or administered by a robotic system, as it passes through an assembly line. Uneven application on the vehicle can create gaps in the seal, which can cause the emblem to fall of the vehicle over time.

One automobile manufacturer set out to improve their wet-out application consistency by testing pressure uniformity applied by their pneumatic emblem application tool. A pressure mapping sensor was positioned onto a vehicle door to record pressure distribution across an entire emblem design. The operator could adjust the position of the pneumatic tool, and also reposition themselves to apply the emblem at the better angle for an even seal.

Figure 7
This pressure display image shows higher contact toward the middle of the vehicle badge, but lower pressure on the edges.

Other Similar Applications

- **Machine Alignment Applications**
- **Windshield Application**
- **Printing/Label Contact**

#2 Maintain a Safe Storage Environment

Pressure mapping technology can be an actionable method to acquire information on proper product storage.

In a high-volume production operation, it may be easy to overlook certain details, especially when stacking product in a storage facility. Taking appropriate measures to ensure safe stacking can protect against damaged product, and promote a safer work space.

CASE EXAMPLE: Assessing the Risks of Stacking Box Designs

Misalignment of corrugated boxes stacked on top of each other, such as when stacked on a pallet, considerably reduces the strength of the boxes. Most inventory managers can only assume that the stacked packages are safe and secure, but data analysis may say otherwise.

A group of researchers used pressure mapping technology to evaluate what happens when boxes unevenly stacked would distribute pressure after compression was applied. As the data in **Figure 8** shows, there was a significant discrepancy of pressure distribution between boxes stacked uniformly versus non-uniformly. This data helped identify ways to improve the box design, and also develop some best practices for warehouses to employ when stacking packages.

Similar methods could also apply to other quality control storage aspects, and apply just about any mass of material, including pallets on shelving, weight distribution on a shipping vehicle (discussed in further detail on the next page).

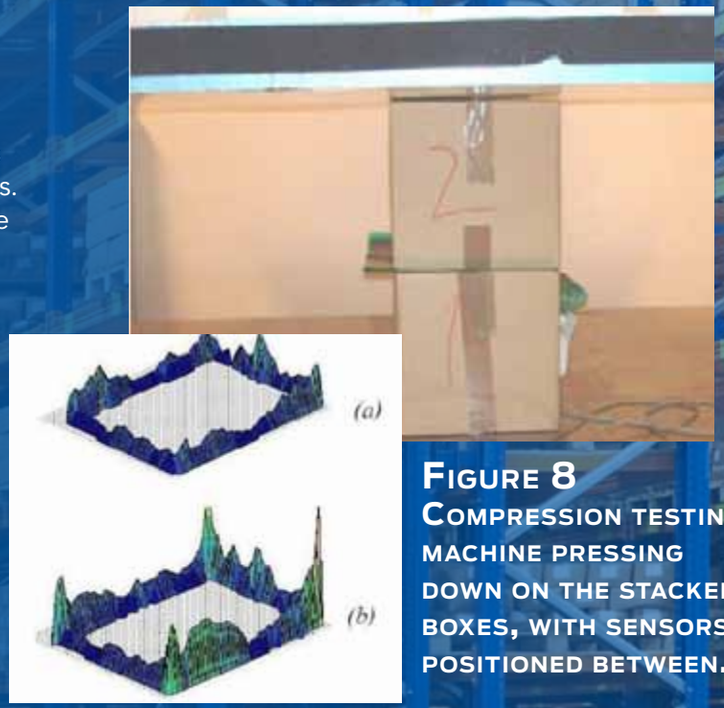


Figure 8
Compression testing machine pressing down on the stacked boxes, with sensors positioned between.

Subfigure (a) represents a uniform load distribution before buckling the sidewalls. Subfigure (b) shows non-uniform distribution.

Other Similar Applications

- **Inventory Management**
- **Identifying Safe Movement of Pallets**
- **Identifying Appropriate Packaging Material**

Source: Meng, Guanqun, et. al. "Stacking Misalignment of Corrugated Boxes - a Preliminary Study" (2007) Presentation at the IAPRI Symposium on Packaging.

#3 Provide a Smooth Road to Delivery

Pressure mapping technology can become a method to keep customers assured that their purchase has a quality delivery process so it arrives in the best possible state.

Even after employing strict quality control measures in the manufacturing process, there are always unknown variables in play once the manufactured product is shipped to its final destination. Pressure mapping technology enables smart shipping capabilities to provide an overview of the product's route to delivery.

CASE EXAMPLE: Taking the Bumpy Journey to Market

Food transportation can be especially difficult in underdeveloped nations, or regions with poor transportation infrastructure. Given their soft form factor, tomatoes are especially sensitive to excessive bumps on the road, which can lead to significant losses on the way to their destination.

A group of researchers in South Africa utilized pressure mapping technology in their studies to develop deterioration models that would predict the quality losses under different supply chain conditions. Sensors paired with accelerometers were placed within the tomato bins or cartons, as show in **Figure 9**, to assess the impacts experienced while traveling on some of South Africa's more challenging roads.

Their results showed in-transit pressures did affect a tomato's shelf life, and that packaging choice was also a critically important factor. Tomatoes transported in bins ripened faster and had structural damage as opposed to those transported in cartons (shown on the right).

The minimally-invasive nature of pressure mapping technology allows manufacturers the ability to understand the shipping process, and make adjustments to their containment structures accordingly.

Figure 9
Sensors placed within the boxes of tomatoes monitored impacts while traveling on the delivery truck

Other Similar Applications

- **Smart Packaging Design**
- **Package Tracking/Managing Theft**

Source: University of Kwa-Zulu Natal (Department of Agricultural Engineering) in collaboration with the University of Pretoria (Department of Civil Engineering)

CONCLUSION

Seize the Opportunity to Drive ROI with Pressure Mapping Technology

The examples and successes shared in this paper are the result of an R&D team partnering with a trusted pressure mapping resource that could provide a solution to meet their specific goals. While every process is different, there are important qualities an R&D team should consider when selecting a collaborative partner:

1. **Experience & Longevity**: Does the company have a respected position in their market and a proven track record of success?

2. **Mastery of the Technology:** Is the company continuously delivering new innovations and improvements to their technology?

3. **Proven & Diverse Application Portfolio:** Has the company demonstrated several examples where they were presented with unique challenges and developed value-added solutions?

Let's discuss your next pressure-specific manufacturing application.

We at Tekscan understand the challenges R&D teams face, and the risks they take when investing in test & measurement technology. Whether it's a standard pressure mapping system, or a custom solution, Tekscan has a proven track record for helping R&D teams achieve a better understanding of their products and procedures by providing trustworthy, actionable data. Your return on investment comes in the form of confidence in your product design, a shortened development process time, and an improved end-user experience.

Visit www.tekscan.com or call 1.617.464.4282 for more information.

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