Improving quality management in manufacturing

How artificial intelligence is becoming the eyes and ears of quality management

Watson IoT

IBM

Contents

Introduction

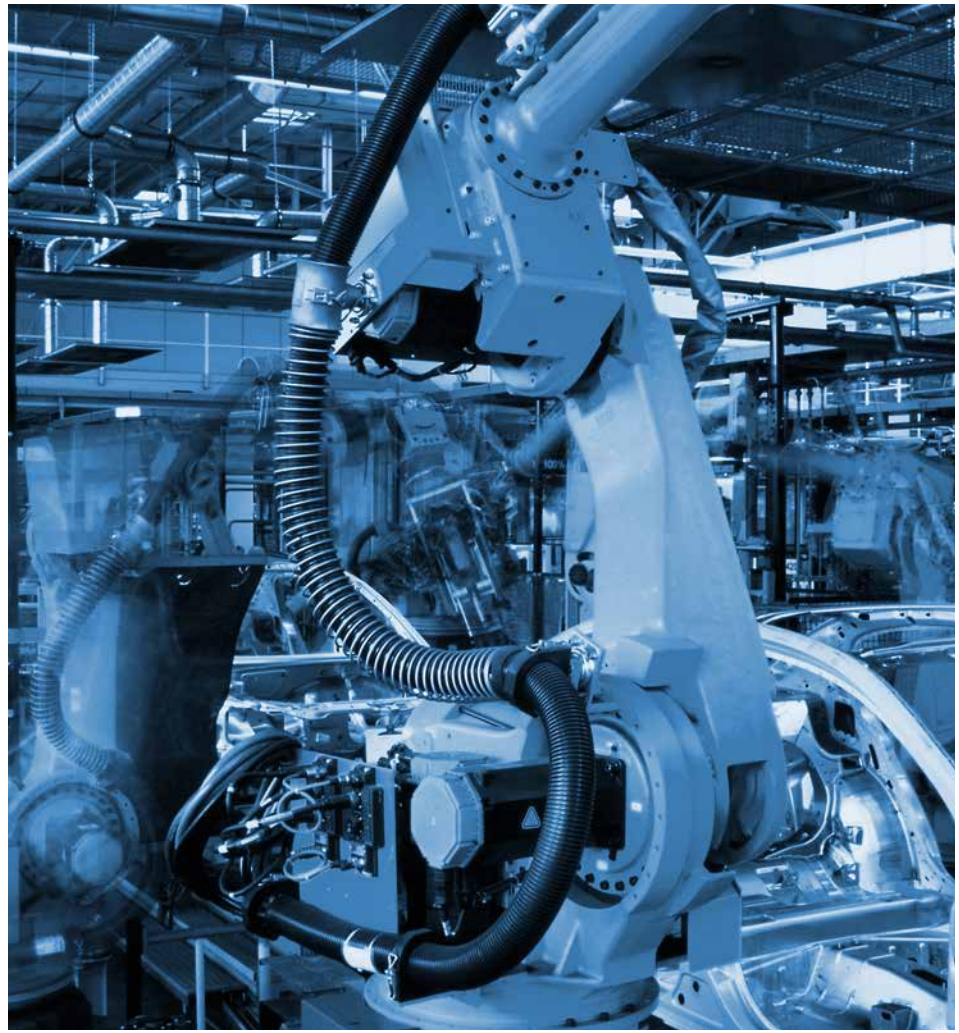
Can you envision a manufacturing environment where you can detect quality issues earlier and more definitively? Where product defects too small for the human eye or too subtle for the human ear to notice can be detected in seconds?

This is the present and the very real future with Industry 4.0

Industry 4.0 applications enabled by the Internet of Things (IoT) are expected to create a new surge of factory productivity, creating value up to USD 3.7 trillion per year in 2025.[1]

Manufacturers are embracing the IoT for several reasons, that largest of which are the increased focus on efficiency and cost of production. In general, they seek to improve their value chains—from the sourcing of raw materials to the final product and, in some cases, the maintenance and service of already-delivered items.

In this ebook, we explore the current challenges that manufacturers face around quality practices, and how the intersection of IoT, cognitive computing and quality management can drive new levels of business value.



The challenges of quality in manufacturing

The growth of the installed base of manufacturing IoT devices will expand to 923 million in 2020—that's an increase of three times from 237 million in 2015.[2] This means manufacturers will be adding more sensors and connecting equipment across their manufacturing operations. This rise in devices will fuel a growth in data at every stage of the manufacturing operation, making the quality versus quantity conundrum a richer topic of conversation.

Manufacturing operations strive to deliver the highest quality during every stage of the production or assembly process. Scrap and rework can cost manufacturers 5-10 percent of sales revenues, and warranty costs can shave another two percentage points off the bottom line.[4] Adopting a shift-left methodology and moving quality monitoring to earlier in the production lifecycle helps enormously reduce the cost of product and process quality deviations and reduces scrap, recall and associated costs.

"Many organizations will have true quality-related costs as high as 15 to 20 percent of sales revenue, some going as high as 40 percent of total operations. A general rule of thumb is that costs of poor quality in a thriving company will be about 10 to 15 percent of operations."[3]

The ASQ Quality Improvement Pocket Guide: Basic History, Concepts, Tools and Relationships, Grace L Duffy, ASQ Quality Press, 2013

Why quality analytics?

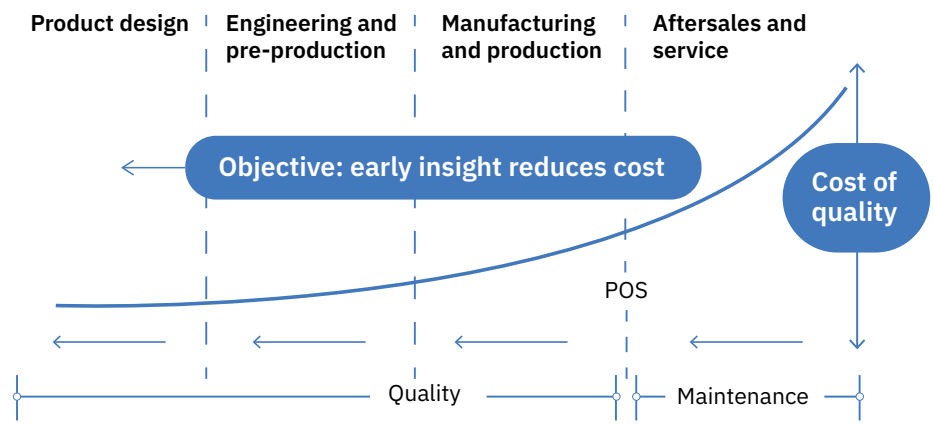


Figure 1: How gaining earlier insight reduces cost.

"Manufacturing defects are a huge issue for the industry. In some cases, 50 percent of production can end up as scrap because of defects, while in some complex manufacturing lines the rate of scrap can be as high as 90 percent."

– Odd Myklebust, the IFACOM coordinator at the Norwegian University of Science and Technology in Trondheim.[4]

Improving yields is challenging when relying on manual inspections. Inspection processes, which are often fully manual and reliant on staff availability and expertise, can cause bottlenecks. More than half of these quality checks also involve visual confirmation.

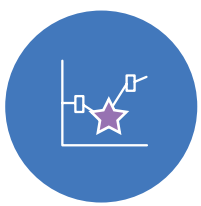
In addition to visual inspection, manufacturers also use sounds—or acoustics—in determining quality. The misaligned jets of a dishwasher make a distinctive sound, as does the sound of a faulty engine. Often manufacturers rely on highly skilled manual inspections to do this non-destructive testing. Experienced inspectors identify the sound of defects and determine the resolution.

Manual inspections within a manufacturing environment can be time-consuming and occasionally dangerous. Furthermore, manual efforts do not scale, often require long and costly training programs and can be subjective. Automating these types of visual and acoustic quality checks is very difficult because of the volume of inspections, product variety, subtlety of variance, and the possibility that defects may occur anywhere on the product and could be of any size and severity.

The case for cognitive operations and processes in manufacturing

Overcoming common obstacles with machine learning

Pioneering firms are applying AI and cognitive technologies to their products and their daily operations. Some are living the future, others have just begun the journey. Tapping the power of cognitive computing helps enable organizations around the world to move from IoT vision and proof of concept to strategic deployments aimed at driving real transformation.



92% of outperforming manufacturing executives
say AI and cognitive computing will enhance performance in production planning.[5]

Cognitive solutions infuse intelligence into machines, operations and processes—from the supply chain to the factory floor to finished product. The result is a new industrial era defined by factories, machines and parts capable of self-assessing, triggering actions and exchanging information with each other, and with the people who manufacture and maintain them.

Stages of cognitive capability adoption

Collect the data

Collect and curate the right data—data on processes and operations you would like to improve, data across your systems, both structured and unstructured. Connect systems and sensors to bring in near real-time data for more accurate insights.

Visualize the patterns

Visualize your data on a platform. Quickly build up dashboards and use simple analytics to determine patterns. Supplement with external sources of data and analyze variables that impact the process and operations you would like to improve.

Analyze with purpose

Apply purpose-driven analytics to gain new insights from your data. Develop advanced models, process a combination of variables and utilize the prediction engine to generate the best recommendations that drive the most business results.

Deliver with cognitive

Whether it's dealing with vast amounts of IoT data or dark and unstructured data, cognitive computing capabilities bring light and clarity. Take advantage of the processing power of cognitive to enable you to learn, apply, act, resolve and deliver better results.

The adoption of cognitive capabilities within the manufacturing industry has led to improved quality, greater process efficiency and better asset reliability. For example, applying cognitive capabilities to manufacturing process and operations can help to drive higher yield, improve productivity of w rather than reactive, expedited service calls that result in reduced repairs and warranty costs.

Executives say they expect to double their use of cognitive computing for operational optimization in the next three years.[6]

The impact of cognitive on quality management for manufacturing

Cognitive capabilities can help reduce inspection time and improve consistency in detecting defects, which helps reserve human expertise for when it is truly needed. By aiming for zero defects in total quality management through continuous improvement approach, companies can improve their productivity and performance.

Let's look at four different use cases.

Use case 1: Inspection processes

Objective:
Improve accuracy of inspections, while helping reduce costs associated with visual and acoustic inspection

Visual and acoustic inspection evaluates key defect types during inline processes and communicates with systems that process and classify them with go and no-go flags for monitoring and verification. It removes defective parts and products before they get into the marketplace.

Using IBM® Visual Insights and IBM Acoustic Insights, organizations employ AI technology to review and analyze parts, components and finished products, and identify defects by matching patterns to images or sounds fof defects that were previously analyzed and classified. Deployment through edge computing on the factory floor helps enables rapid image capture, analysis and consistent and reliable identification of manufacturing defects.

What is edge computing?

While many early IoT applications were mostly about collecting data from *Things* and sending them elsewhere for analysis, the growing abundant computing capacity of *Things* now allows increasingly complex computation to run on-site, without ever leaving the physical world. Edge computing is a way to emphasize that part of the work that happens right at the edge of the network where IoT connects the physical world to the Cloud. A fundamental part of it is the strong and seamless integration between IoT and Cloud; between the physical world and the world of computation.[7]

With quality analytics from IBM® Watson™ IoT, manufacturers can analyze hundreds of process variables, historic and real time, to identify issues contributing to quality issues and resolve them before they occur. The process is fast, doesn't get fatigued or tired and is accurate. This helps drastically improve production and yield while reducing operation and material costs. For example, using cognitive capabilities for visual inspection, a European automobile manufacturer increased overall productivity by 25 percent.[8]

In addition to rapidly spotting defects, IBM Visual Insights also uses 3D techniques to classify the severity of the defect such as the depth of the scratch or blemish. Over time, the accuracy of the system improves—effectively learning—as it becomes exposed to more defect types.

Benefits

Quality inspections cost reductions

AI-powered visual and acoustic inspection capabilities help to automate the inspection process by accurately identifying defects with confidence and speed, augmenting and/or significantly reducing the need for manual inspections. This enables non-destructive testing of products.

Inspection process reliability improvement

Unlike humans, a system doesn't get tired, it doesn't take a break, and it doesn't have a bad day. The system can spot defects that the human eye or ear can't —it classifies defects, including confidence thresholds to help improve consistency and accuracy compared to manual approaches.

Inspection time reduction (including training)

Cognitive capabilities can increase speed and accuracy of defect identification to help reduce inspection time, improve manufacturing yield, and increase process throughput and decrease inspection time. The system also helps reduces training time. It can be trained to identify defects in new models in hours/days compared to traditional training programs where human inspectors need weeks to build proficiency.

Root-cause analysis and problem resolution

Combining visual and acoustic inspection data with other IBM analytic tools enables root-cause analysis. Defect data is automatically classified including location/type of defect and severity. This data can be input into other tools like IBM Prescriptive Quality on Cloud and IBM Equipment Advisor, which when combined that data with other data around the condition of the equipment.

Watch the demonstration video to see the solution in action.

If you have manufacturing inspection needs that could benefit from IBM cognitive capabilities please, take a few moments to watch the video about IBM Visual Insights.

Use case 2: Knowledge transfer and training

Objective:
Eliminate knowledge silos and shorten inspection training to improve agility

Human-based manual inspection requires costly and time-consuming training of inspectors. At great expense to both productivity and cost, inspectors are trained to identify and classify defects while conducting technical root-cause analysis. This process can take weeks, or longer, and is required to be repeated for each new inspector and for each new model of product. Too often, knowledge about defects, their cause and potential technical resolution reside with select employees who have decades of experience. This bespoke experience can be difficult to access and replicate, particularly across geographically dispersed networks of manufacturing facilities.

IBM Visual Insights and Acoustic Insights can help address challenges across knowledge transfer and training. The system can learn quickly—starting with just a few hundred defect images or sound files, while improving over time. Once implemented, retraining the system to spot defects in new models can take just hours, while new inspector onboarding costs are eliminated. Perhaps most importantly, the system can scale seamlessly across a geographically dispersed network of shop floors, which frees quality knowledge from employee silos and enables fast communication about defect types and resolution.

Benefits

Unlock silos of expertise

Inspection experts previously trained the systems. This expertise is seamlessly deployed across the manufacturing process and across geographically dispersed plants.

Reduce inspector training time

Support new product models and eliminate the need for lengthy training programs for manual inspectors. For example, as new models and features are rolled out, inspector training time can be significantly reduced.

Reduce inspector churn impact

Knowledge about defect classification and root-cause are captured centrally, which helps reduces the impact of churn among inspectors.

Use case 3: Product and process quality

Objective:
Identify quality problems earlier and more definitively

The application of statistical process control (SPC) methods over recent decades has greatly improved quality processes globally. SPC methods are well established standard tools for quality control. However, there are limitations with the SPC approach—false positives, slow detection of small and moderate changes and trends not readily visible.

IBM Research has developed a set of algorithms—Quality Early Warning System (QEWS)—that detect and prioritize problems and parametric shifts earlier and more definitively than can be done using traditional techniques of statistical process control. IBM uses these algorithms throughout its own supply chain and manufacturing processes to meet established quality standards. The result: earlier identification of nascent quality problems, increased production yield and reduction of problems that lead to service and warranty costs.

Benefits

Low false alarm rate	Advanced statistical algorithms detect developing quality problems (at a low rate of false alarms) and can alert to quality issues at any stage of manufacturing for production process.
Detect quality issues earlier	Detect process and product quality issues earlier and more definitively in comparison to statistical process control methods.
Monitor product quality	Address quality of materials or components to prevent introduction of substandard materials. Determine if components or products manufactured during a critical step conform to specifications.
Monitor process quality	Monitor production steps to determine if equipment is properly calibrated. Determine if process input and output variables remain within target ranges. Alert in event of unfavorable changes.

Use case 4: Quality root-cause analysis

Objective:
Identify and resolve drivers of poor quality

Visual and acoustic assessment is executed in one step in a quality management system approach to help identify defects and take corrective action. Today, many manufacturers struggle with a fragmentation of quality data and tools. Manufacturers that optimize quality can help unify the quality approach. This includes clear communication of relevant information as well as clean and augmented data classifying defects, severity and time and location data within the manufacturing process.

The IBM Visual Insights and Acoustic Insights solutions are designed to integrate seamlessly with other cognitive analytics tools and asset management systems to help manufacturers take a holistic view of quality including resolution. For example, defect data generated from image analysis helps automatically track the location, type and severity of the defect along with when that defect occurred. This data can be integrated into tools such as IBM's Prescriptive Quality and Equipment Advisor, which combines the data with other data around the condition of the equipment, including data such as temperature and humidity. Integrated as a solution, these tools can begin identifying the root-cause for the defect, whether it is a malfunctioning machine or other external anomaly.

As data expands, the cognitive nature of the tools mean that they can become predictive and alert to conditions before defects occur. Products or machinery can self-heal or suggest when there is a potential quality issue.

The analytics output from Visual Insights can be fed into Prescriptive Quality to get insight into the quality of manufacturing operations and alert early of impending quality issues that can be costly to ignore.

Benefits

Identify root-cause analysis

Combining visual inspection data with other IBM analytic tools such as IBM Prescriptive Quality and Equipment Advisor, IBM can help identify root-cause analysis.

Spot quality issues before they occur

The predictive nature of IBM Analytics may even mean you can spot quality issues before they occur. Products or machinery can self-heal or suggest when there is a potential quality issue.

Get a holistic view of quality including resolution

Integrate seamlessly with other cognitive analytics tools and asset management systems to help manufacturers get a holistic view of quality including resolution.

Advantages of cognitive visual inspection

What are the advantages of cognitive visual inspection?

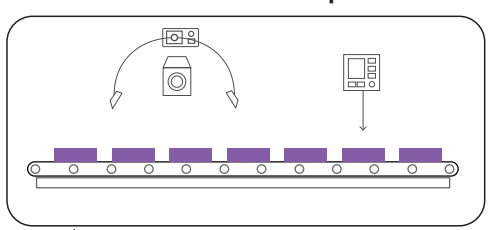
Human workers can miss minute details or make mistakes. Did they get enough sleep? Have they been staring at the same product all day? Are they distracted? With cognitive visual inspections, these issues disappear.

For manufacturing organizations, using a cognitive assistant on the factory floor minimizes costly defects and increase product quality, while reducing inspection. Based on early testing by several global corporations producing electronics, automotive, and industrial products, the solution helped reduce inspection time and cut incidents of manufacturing defects by 7-10 percent.

IBM Visual Insights delivers reliable results with low escape rates to reduce the dependency on specialized labor and to improve throughput of quality processes across multiple industries. Several global corporations that produce electronics, automotive and industrial products are successfully putting the solution into practice. The system can support analysis of up to 6,000 images per minute, to help significantly reduce the need for manual inspections.

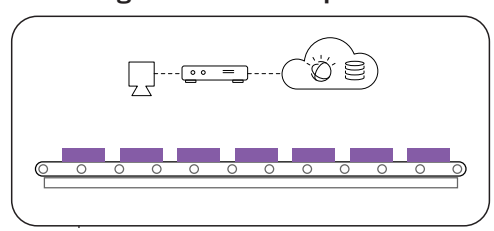
Cognitive visual inspection vs traditional visual inspection

Traditional visual inspection



- OCR/measurement rule based analytic methods often result in high escape rates
- Weeks to re-program analytics to adapt to new products and scenarios
- Difficult to scale due to proprietary all-in-one approach
- Require maintenance windows to update firmware and software impacting production throughput
- Closed system extensible by vendor only
- Local reporting only specific to single function

Cognitive visual inspection



- Machine learning based analytic methods result in low escape rates
- Days to retrain analytics to adapt to new products and scenarios
- Easy to scale—agnostic to any image capture
- Use of cloud helps eliminates need for maintenance windows
- Use of general purpose hardware reduces operational cost
- Big Data Analytics platform to drive multiple optimization scenarios across multiple work-cells

Transparency and trust in a cognitive era

The purpose of AI and cognitive systems is to augment human intelligence, not replace it. Each will increasingly be embedded into the processes, systems, products and services by which business and society function—all of which will and should remain within human control.

For cognitive systems to fulfil their world-changing potential, it is vital that people have confidence in their recommendations, judgments and uses.

We believe that clients should own their own business models and intellectual property and that they can use AI and cognitive systems to enhance the advantages they have built, often through years of experience. What this means for manufacturers that use IBM Visual Insights and IBM Acoustic Insights is that your images or sound files will not be used to train other models—or shared with other organizations. Your data belongs to you and is not aggregated with other data from other organizations.[9]

Learn more about IBM Watson's data policy, visit ibm.com/watson/data-privacy

Integrating edge devices and analyzing data in the cloud

Cloud implementation means that the inspection process can be centrally managed through a dashboard, complete with wide-ranging reporting metrics. Reports can be generated in near real time, or at given intervals as needed, and summarize overarching activities as well as drilling down into individual processes.

In an Industry 4.0 setting, directly integrating edge devices—such as machines and robots—in the cloud using Watson IoT helps enable manufacturers to develop personalized products and services, improve operations, reduce costs and avoid the risk of downtime.

Summary

The $152 billion-dollar opportunity

According to the market research report "Industry 4.0 Market by Technology (Industrial Robotics, Cyber Security, Internet of Things, 3D Printing, Advanced Human-Machine Interface, Big Data, Augmented Reality & Virtual Reality, Artificial Intelligence), Vertical, Region—Global Forecast to 2022", the market—previously valued at USD 66.67 billion—is expected to reach USD 152.31 billion by 2022.[10]

Key take-aways for quality management

This ebook introduced five areas where cognitive technology can help you overcome the detrimental effects of poor quality management:

- Moving quality monitoring to earlier in the production cycle helps reduce the cost of product and process quality deviations and can help reduce scrap, recall and associated costs.
- Manual inspections within a manufacturing environment can be time-consuming and occasionally dangerous. Introducing visual or acoustic inspection technology can help reduce inspection time and improve consistency in detecting defects.
- Computers never get tired. Human workers can miss minute details or make mistakes. Cognitive technology enables a safer, more efficient environment.
- Knowledge transfer and training issues can be mitigated. Cognitive visual and acoustic inspection learns and gets better over time, making on-boarding of new models faster and more efficient.
- Many manufacturers struggle with a fragmentation of quality data. The ability to integrate with asset management systems and analytics tools makes Visual Insights and Acoustic Insights a winning solution to provide a holistic view of the issue, root cause and resolution.

Learn more

Cognitive capabilities can help manufacturing organizations accelerate inspection processes, achieve greater consistency in defect recognition, and reduce inspection costs. To learn more about IBM Visual Insights, read the full report.

Discover how IBM is revolutionizing the manufacturing process by visiting ibm.com/internet-of-things/iot-solutions/iot-manufacturing/cognitive-process.

"The quality manager must be clear, right from the start, that *zero defects* is not a motivation program. Its purpose is to communicate to all employees the literal meaning of the words 'zero defects' and the thought that everyone should do things right the first time."

Quality Is Free by Philip B. Crosby (McGraw-Hill Books, 1979)

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IBM Corporation
Route 100
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Produced in the United States
of America, November 2017

WWM12360USEN-01

Watson IoT™