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A Tire Manufacturers Guide:
Improve Quality Control during Tire Manufacturing

From raw materials to finished product, there are more than 100 manufacturing steps that go into making a tire and dozens of components. Controlling as many aspects of the complex tire manufacturing process as possible ensures a high quality finished product.

Quality control during the tire production process has traditionally been performed manually by machine operators. This process is time consuming and lacks the precision that modern state-of-the-art vision systems offer. Using 3D vision systems increases measurement precision, identifies errors earlier, ensures tire consistency, and helps reduce labor costs.

Advances in technology such as automating tire manufacturing processes can drive down costs. Quality counts in the tire business and making improvements to the quality process while producing tires more efficiently will positively affect both the top and bottom lines for tire manufacturers.

Traditional Inspection Solutions – Variable Results

Regardless of how it's performed, tire inspection is—and must be—inherent to the assembly process. Assuming the subcomponents are the correct shapes and sizes, typical manual quality checks involve ensuring that the layers of steel belts are properly aligned and that the splices have no gaps or overlaps. Other manual checks by tire builders include looking for contamination and guiding rubber pieces during the layering process.

Manual inspection places the onus on the operator to ensure the tire's subcomponents are assembled properly, in the correct sequence, and that they are properly aligned. If the tire is not assembled properly or not thoroughly inspected, the tire could have quality issues.

Also, operators have different skill and experience levels. Because no two operators assemble or inspect tires exactly the same way, inspection results will likely vary. Different operators work at different speeds. An individual operator may not work at the same speed each day or even throughout a single shift.

Using 2D vision to perform tire inspections that were traditionally done manually isn't necessarily an improvement because 2D camera operation is based on contrast. Backlighting an object creates a high-contrast shadow, which works for edge detection. While measuring the width of a piece of rubber using edge detection and identifying bar codes are good applications for 2D, in the absence of high-contrast features, 2D doesn't work very well.

Tire manufacturing requires technology capable of inspecting and measuring objects that are black-on-black. Because layers of black rubber are placed on black rubber, 2D systems can't see targets because the objects don't have the necessary contrast. To ensure reliability and consistency, 3D cameras detect objects and features of black-on-black targets and 2D cameras do not.

Tire Inspection Goes High-speed 3D

A typical 3D vision system uses laser triangulation to capture images by projecting a laser line across the surface of each target object while a high-speed camera captures an image of the laser line as an elevation profile. The system builds a 3D image of the target object based on the position of the laser line in relation to the object.

Generally, triangulation is based on the relationship between two constants: camera angle and laser position. The operating principle requires the presence of a known angle between the laser and the camera's receiving element. For a specific angle, the position of where the sensed laser light appears on the receiving element determines the measured height of the target object.

The 3D vision system uses software to search for light-to-dark transitions created by the laser line as it scans the object. A 3D image is created from combining the results of determining the width and height of the laser line as it scans the object.

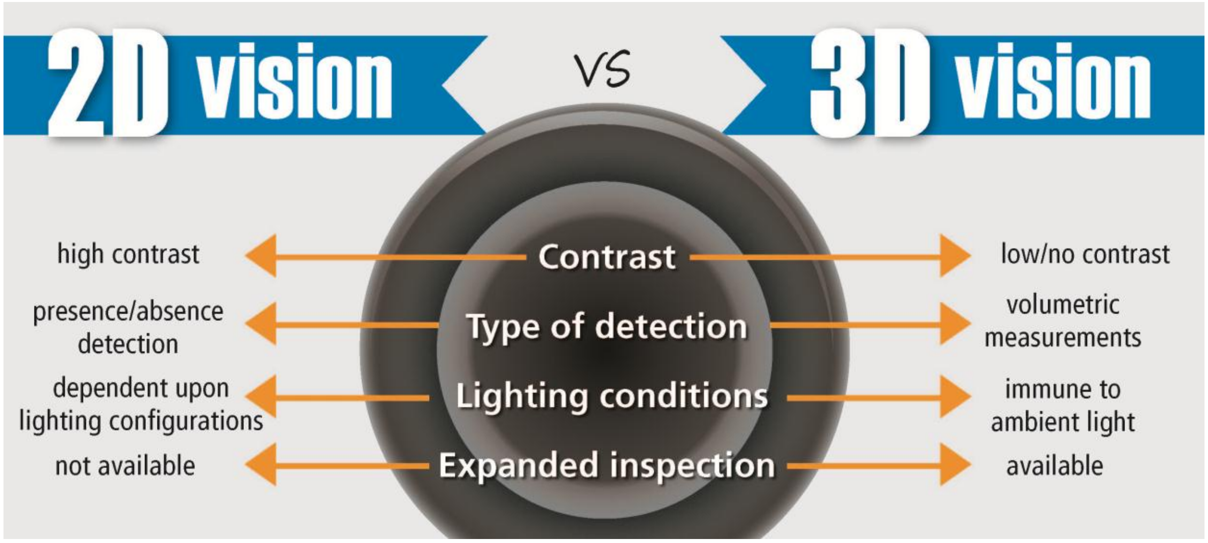
Using laser triangulation in 3D vision systems is not new. The technology has been available for years. However, 3D vision cameras that incorporate laser triangulation tools to measure height, width, shape, and volume on black targets—and obtaining these profiles at a high rate of speed—is a different story.

Creating full three-dimensional images at high speed requires specialized hardware and software that can process this complex vision information much faster than traditional cameras. The faster a system can create these complex 3D profiles, the better it suits quality inspections in tire manufacturing.

Drive Down Manufacturing Costs

Automating industrial processes such as tire manufacturing allows manufacturers to drive down the overall cost of a tire by being more efficient. In addition to efficiency, using smart 3D vision systems to inspect tires during the component preparation, tire assembly, and the finishing processes ensures the quality and consistency of the finished tire.

Typically, using high-speed 3D vision systems in tire manufacturing quality inspection applications can reduce labor time and costs as well as liability, resulting from defective tires. Overall productivity and product uniformity are improved as a result of increased measurement precision.



Compared to traditional 2D vision systems, high-speed 3D vision systems provide value to tire manufacturers in the following ways:

- Contrast: High-speed 3D vision systems allow users to inspect, measure, and analyze objects that cannot even be detected with 2D systems. Unlike 2D vision, 3D does not require good contrast. Consequently, 3D systems are ideal for inspecting black-on-black or very low contrast objects.

- Volumetric measurement: Using 3D systems allows users to measure and quantify key volumetric indicators that determine whether a tire process is good or bad such as shape- and position-related parameters. Volumetric shape measurements provide much more information than merely detecting the presence or absence of certain features.

- Unaffected by ambient light: Ambient light has virtually no effect on applications that use 3D technology. While 2D cameras require certain lighting configurations to work, 3D vision systems require laser-produced red light. Also, lighting conditions for 2D cameras must be very consistent. The programming for 2D systems is based on the assumption that lighting conditions will not change. For example, if plant lighting changes, some objects that previously passed vision inspections now fail because the lighting changed. Because 3D vision technology rejects light sources other than laser, lighting issues do not affect the results, making it more reliable than 2D technology.

- Expanded inspection capabilities: Using 3D vision technology, users are able to inspect objects they could not inspect previously. This expanded capability opens the door to inspection and measurement applications that were unavailable to them. In addition, these newly available measurements can be performed accurately and consistently.

Vision Applications

Many tire manufacturers use 3D vision systems throughout the production process for product inspection and verification. During component preparation, 3D cameras look for the presence, width, and position of materials such as layered flat rubber sheets. The 3D camera focuses on a raised line extruded into the rubber that serves as a reference point for guiding and positioning additional layers of rubber material. The extruded reference line is a very subtle edge that's very difficult to detect with 2D vision systems.

During tire assembly, 3D cameras are used to detect splicing and stitching issues such as gaps, overlaps, dog ears, and material that's folded over. They also can detect defects such as holes, blemishes, blisters, contamination, and wrinkles. These defects can affect tire quality.

High-speed 3D cameras are also useful during the final finish stage. Every tire manufactured in the U.S. is required by the U.S. Dept. of Transportation (DOT) to have a DOT code: a series of alphanumeric characters molded into the tire's sidewall that identify the plant where it was manufactured as well as the date it was made. The 3D camera acquires an image of the DOT code and supplies the data to a down-stream system for further processing.

Finished tires are also inspected for runout and uniformity. Using 3D technology to inspect tire shape and geometry allows measurement of tread depth and identifies dents, protrusions, and constrictions.

To accurately measure all the parameters required to manufacture tires, 3D cameras must go through a calibration and rectification process. Camera calibration ensures that measurements are in units of measure that make sense. Image rectification removes lens and perspective distortions. In 3D vision technology, calibration and rectification go hand-in-hand to provide accurate and reliable measurement values rather than merely pixel data. A calibrated 3D camera can provide accurate values such as width, changes in height, volume, and dimensional data of defects.

Conclusion

Maintaining consistency of the tire manufacturing process is imperative. Using 3D vision for tire quality inspection helps to ensure this consistency as well as a high quality finished product.

Although inspections can be done manually, having the accuracy, consistency, and efficiency of high-speed 3D vision ensures reliability. And that makes good technical and business sense.

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