Vision System for the Inspection of Piston Rings

Federal-Mogul Corporation, headquartered in Michigan, USA, designs, engineers, manufactures, and distributes technologies to improve fuel economy, reduce emissions, and enhance vehicle safety. In a joint venture with Goetze, Federal-Mogul is producing more than 500 different types of piston rings at a manufacturing facility in Bangalore, India, for application in a range of vehicles.

Federal-Mogul supplies original equipment manufacturers across India with piston rings in batches or “stacks” that contain the specific number of rings needed for installation in each vehicle. “It is critical that we deliver the piston rings exactly as required,” explains Mr. Srinivasan, senior manager, Quality at Federal-Mogul. “The number of rings used in assembly serves as a check to ensure that the specifications of each vehicle have been met. Having extra rings remaining at the end of assembly or too few rings available to complete the job means that the accuracy of the work must be verified manually to assure that no piston ring has been missed. None of our customers wants to make this additional, time-consuming step a part of their manufacturing process, and because Federal-Mogul is committed to ensuring quality control and accuracy for our customers, we wanted a solution to ensure that we delivered the exact number of piston rings required for each vehicle type.”

To ensure that each stack contained the correct number of rings, Federal-Mogul had relied on a process that combined the manual counting of rings in a stack—often 100 or more based on the vehicle—with a laser counting system that compared stack height to verify the count. Because rings can be as small as 250 microns, even seemingly minor variations could alter final counts, increasing the risk of error. Given the significant manual effort required to ensure accuracy, this process was labor intensive, time consuming, and costly. Federal-Mogul reached out to Qualitas Technologies, an industrial automation solutions expert in the region, to discuss alternative approaches that could deliver greater automation to minimize errors, increase inspection speeds, and boost productivity.

Through a series of meetings with the customer, Qualitas evaluated Federal-Mogul’s requirements and proposed implementing a machine vision solution.
At first, Federal-Mogul was uncertain of the viability of vision technology in their environment, but Qualitas offered thorough education about the solution, providing examples of how vision technology worked in other manufacturing environments and offering validation that it could work for their application. Federal-Mogul was impressed by the potential of the technology and agreed that Qualitas could complete R&D efforts and deliver a comprehensive proposal.

“Once Federal-Mogul understood the capabilities vision technology could offer in their manufacturing environment, they wanted to use the application in production quickly,” Qualitas Director Raghava Kashyapa notes. “They projected that vision would be a key innovation in their manufacturing facilities, reducing the likelihood of errors and saving costs overall. It was also particularly important to them to work collaboratively with a partner like Qualitas, which was headquartered locally to provide the level of service they required, and who had a proven track record of working with large organizations like Federal-Mogul.”

For the team at Qualitas, it was clear from the start that they would propose a vision solution from Teledyne Dalsa, but as Kashyapa explains, designing the ideal solution proved to be technically challenging. “In many ways, this is an example of classic machine vision: the camera, optics, lighting, and software are equally critical to the success of the application, and each element has to be exactly right,” he says. “There is no room for error, so our R&D efforts were intensive. If we chose the wrong lens or camera, we wouldn’t get the resolution we needed; if the lighting wasn’t perfectly designed, the software couldn’t do its job. We went through dozens of iterations, trying different cameras, lenses, and lighting, and the result was a solution that uses Teledyne Dalsa’s Boa Pro two megapixel camera, which incorporates embedded advanced Sherlock vision software, with a fixed focal length lens. The application also relies on a red linear light.”

Sherlock is ideally suited to challenging vision requirements. “The flexibility of embedded Sherlock was key to the success of the vision solution we proposed,”
Kashyapa says. “The software’s advanced design and inspection capabilities allowed us to experiment easily with different algorithms and various approaches once we captured a clear image.”

Today, an operator feeds each stack of rings onto a black rod or ring hanger, and then simultaneously triggers the light and the Teledyne Dalsa Boa Pro, which captures an image of the rings. The Boa Pro has a 1.600 x 1.200 pixel resolution to cover a field of view of 150mm. The embedded Sherlock software is designed to “count” the rings by tracking the edges, and if an edge appears to be missing, Sherlock generates a warning highlighting the problem so that the operator can verify the count. “The Sherlock software is so sensitive that it recognizes a problem instantly, even though the rings and the gaps between them can be less than 250 microns,” Kashyapa notes. “For example, a warning can be generated if the software recognizes a larger gap than expected, whether it is an actual space between rings, a shadow that impacts the lighting, or even a speck of oil on a ring altering its appearance. The operator can make adjustments to the stack to resolve problems, triggering the camera multiple times as needed to verify an accurate count.” The time required to complete each inspection is less than one second. The vision application seamlessly integrates with an industrial PC, and each inspection image—with related time stamp, data about ring type, and operator credentials—is logged in case it is needed in the future.

Federal-Mogul has deployed a single vision application to date, which is able to inspect approximately 150 types of piston rings. The rings may vary by composition or size, with an axial thickness of between 0.29 mm and 1.5 mm and an outer diameter that ranges from 44 mm to 120 mm. As the application is fine-tuned, Federal-Mogul expects to deploy cameras more broadly at facilities worldwide to inspect the more than 500 different types of piston rings it manufactures.

“With our vision solution from Teledyne Dalsa and Qualitas, we’ve been able to achieve 100% accuracy by minimizing human errors significantly and reducing overall error rates for improved quality control. This enables us to meet the agreements we have with our customers and cut costs overall,” comments Mr. Rohit, senior executive, Quality at Federal-Mogul. “Importantly, we’ve been able to reduce errors and control costs while increasing operator productivity through automation. We are consistently looking for ways to innovate and improve our manufacturing processes, and we anticipate broad application for the Teledyne Dalsa vision solution across our organization.”

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