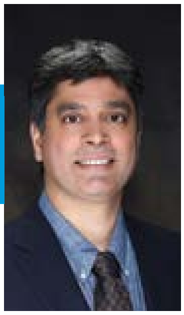

AN INSIDER'S PERSPECTIVE

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Artificial Intelligence in Our Industry

DISRUPTIVE TECHNOLOGY

Shot peening is the result of millions of media particles impacting and plastically deforming the impacted surface while altering its metallurgical characteristics. Therefore, disruption is hardly new to us shot peeners! However, when disruption could do more than just alter metallurgical state from austenite to martensite, it is time to take notice! A casual Google search will reveal the topmost disruptive technology currently to be Artificial Intelligence (AI).

I suggest that AI is a phenomenon that will continue to influence our lives in unprecedented ways and not just be acknowledged as a new technological experience. It is already showing its presence everywhere, starting with the above example of a Google search result, self-driving cars, and as a key element in a modern, automated factory. AI has gained enough prominence that the McKinsey Global Institute estimates the value of its financial impact to be about $13 trillion by 2030. Its rapid spread is also noticed outside of the IT sector.

To learn more, I expanded my research on AI through an online course at coursera.org/learn/ai-for-everyone. Though the information is fundamental, it provided sufficient reasons for me to present this topic to you and explore its impact on the blast cleaning and shot peening industries. I have often expressed my opinion in these columns about the pace of change in our industry and even likened it to watching paint dry! However, change is inevitable. We are about to be presented with a different landscape to operate in.

Currently, some Automotive or Aerospace customers specify residual compressive stress and surface roughness targets post-peening instead of, or in addition to, intensity and coverage. This is categorized as being uncommon, and a new and developing trend. Imagine the same customers demanding that they be alerted 40 hours in advance about a potential nozzle failure in the machine? Or in another instance, what if the same customers would like to know the probability of operator X causing part failure due to incorrect technique selection? Maintenance alerts and warnings about certain impending situations already exist in certain sophisticated machines. However, it can hardly be denied, especially by my programming friends, that we have barely scraped the surface of a machine controller's (PLC, CNC, etc.) capability. AI is challenging us to do exactly that. Terms such as "big data" and "Internet 4.0" are being brought up more frequently in discussions and machine readiness to address these requirements are being questioned. This takes us to the stage of discussing certain key terminology when referring to AI.

MACHINE LEARNING

One of the key tools driving AI is Machine Learning (ML). Some examples of ML in our everyday life are Siri/Alexa, Google translator, and the alarming accuracy with which Netflix knows what I want to watch next! ML works with data, and simultaneously also helps generate data for AI. We are aware that accuracy of results is enhanced by the volume of data and the power utilized for its analysis. ML does exactly that. It constantly gathers, compresses, and analyses data to determine the best required action.

Let us look at a simple example in our shot peening machine to see how this applies. The commonly used proximity sensor is a data gathering tool used in ML. This sensor, when located at one of the extremities of a nozzle carriage travel axis in an airblast peening machine, will instruct the nozzle to stop traveling upon reaching that location. This results in the part being peened within the required physical area. However, let us take a situation where the machine vibration has caused the proximity sensor to slide down to a lower elevation along the travel path of the carriage. Machine controls, oblivious of this change, will stop the carriage motion prematurely, resulting in the part being processed incorrectly.

Data, though important, should be correct data and not be tainted by other process-based inaccuracies. The next level of ML can be expected to use data from previous peening cycles and alert the operator of a potential issue with the carriage travel range. This will save large volumes of parts from being peened incorrectly.

ML is process intensive, but not hardware intensive. In fact, for shot peening and blast cleaning, the hardware necessary to process information, i.e. ML, is likely already there. There is more. AI introduces us to another concept called "Deep Learning." Predicting the weather or playing your favorite music through Alexa demands a simple algorithm, whereas analyzing medical records, creating music, and other art forms fall under "deep learning." This part of AI is still in its infancy and is not relevant to our discussions at this stage. Let us delve deeper into our current status with AI/ML and potential opportunities.

WHERE ARE WE WITH AI?

We are faced with a paradox within our industry. We have sophistication as well as blast cleaning and shot peening machines being operated with not as much regulation and control. The choice depends on many factors such as end-user requirements, industry criticality, etc. I often question our blast cleaning equipment users on their gage of performance parameters such as volume of parts cleaned, quantity of abrasive used, and replacement frequency of wear parts. Given the price of steel, users definitely intend to track such critical data, but the accuracy of such information and frequency of its collection is still not well-validated. In other words, we are faced with gaps at recording basic process information.

Though majority of machines built in the last 25 years have a PLC, the controller is designed to just control the programmable features of the blast machine. This includes sequencing of different components, establishing, and maintaining cycle timers, and safety circuits. The PLC's accomplishments are complimented by a TouchScreen HMI which does little more than replace pushbuttons and indictor lights that used to adorn older control panels like a Christmas tree! No active and useful data was drawn from such control systems. In the blast cleaning world, the above describes majority of the machines in use.

The advent of CNC shot peening machines with controls comprising of PID loops started giving us a brief taste of ML. Consider a recipe/technique created to peen a component at 40 PSI. If availability of air at this pressure is interrupted due to an unexpected need for compressed air upstream to the machine, this closed loop (PID) arrangement will attempt to correct the pressure. It will, within short duration, shut down the process if the situation continues. ML would have taken this to a deeper level and predicted this possibility by "learning" that the upstream perpetrator is likely to utilize the compressed air. This prediction would be made given a set of connected events also known as relevant data points. This is the potential future of ML in its simplest form in our shot peening machine.

Senior year and graduate students at Purdue University, through the CSEE (Center for Surface Enhancement and Engineering) and guided by Professor Paul Mort, have worked on imaging models to determine the sphericity of cast steel shot and conditioned cut wire. These students have utilized image analysis to determine the form factor—ratio of area of the block to that of the circumscribed circle, with one being the perfect sphere—of individual particles of peening media.

Weighted regression analyses of the data are used to calculate and visualize both size and shape distributions of the media. Note that regression is one of the foundations of machine learning. (Regression analysis is a statistical technique that allows us to determine which factors matter the most, factors that don't matter, and how these factors influence each other). The ultimate goal is to use these distributions in tolerance specification for media sphericity when sampling/analyzing new and in-use peening media. This is currently accomplished by visual examination with considerable subjectivity in the assessment, not to mention the time commitment to this exercise.

Further, this study will also help characterize the degree of conditioning (rounding) achieved with cut wire before being deemed fit to be used in a shot peening machine. If you can expand on this technique, visualize a protocol where results from shape analysis could predict the peening results and alert the user on the possibility of surface damage (nicks, etc.) on the component. As we know, this will ultimately have its effect on fatigue life. This prediction would signify advancement in our industry along the path of AI.

OTHER POSSIBILITIES WITH ML

ML offers tremendous opportunities for our industries, both in cleaning and shot peening, and every touchpoint of the media particle in the process demonstrates that. Here are some possibilities:

- The life of a coating is only as good as the surface preparation process. The effectiveness of mechanical surface preparation (blast cleaning) is dependent on the organic generation of a work-mix or operating mix in the machine. The abrasive being used for cleaning should be a suitable blend of large and small particles. Diligent operators test this operating mix at least once a week by obtaining a sample at the airwash separator and screening it to compare with recommended percentage distribution prescribed by abrasive manufacturers using field data.

Creation of this working mix is reliant on other factors such as selection of the correct hardness, size and potential blend of abrasives, replenishment practices and frequency of returning leaked abrasive to the machine, to list a few. When done right, an effective working mix will (a) optimize cycle time, (b) minimize re-blast, and (c) impact operating cost. In other words, it is a critical parameter to control.

- Now imagine a ML protocol which monitors each of these variables. For example, a sensor could be alerted when adding abrasive, a scanner could identify the type of abrasive being added (with the possibility of alerting the operator on current inventory levels in the warehouse as well as in the machine storage hopper), a prompt that informs the operator to obtain a media sample for routine testing and so on. The data collected could be used to develop a predictive model that addresses (a), (b) and (c) above. I acknowledge that this activity will involve significant discipline in the operator's role, but emphasis on his/her role in the profitability of the cleaning operation is bound to generate interest.

- The performance of blast cleaning or shot peening machines that form parts of a larger cell can be optimized through ML. High-output inline machines generally tend to operate continuously without any interruption to media flow to the blast wheels or nozzles in anticipation of a steady input of parts to be cleaned/peened. Unfortunately, this is not always the case, especially during disruptions to upstream processes. ML is already in use where a potential interruption to receipt of parts is identified in advance, leading to shutting down media flow in the blast machine. This timely stoppage of the blast machine that might be operating with eight blast wheels and discharging 5000 lb of abrasive per minute saves the cabinet's interior from unnecessary wear and the abrasive from unproductive breakdown.

- Inline measurement of residual stress and surface roughness offer opportunities in ML. SAE recommended practices and your own specifications might require you to run verification strips to check intensity at defined intervals. But the possibility of measuring residual compression at a rapid rate holds greater promise. Data from such readings directly correlate to machine operating parameters just as they assist you in quantifying the fatigue life of components being peened. This valuable data when recorded and compared constantly with the process helps generate yet another predictive model.

- A computerised curve solver software about to be released identifies points that don't reside on the best fit curve. In this situation, the software prompts the user to re-peen some of those ill-fitting values/strips and fine-tune the process. This is another example of ML.

- Inventory management, especially in machines that are fitted with complex components that are subject to wear, could be assisted with ML. A nozzle lance that is susceptible to wear within a specified number of hours could be regularly checked (automatically) for variation in air flow/pressure within a tolerance range. The operator/vendor could be alerted on the requirement well in advance without the need for manual intervention to check nozzle condition.

PRACTICALITY IN OUR INDUSTRY

Most advancements in our industry are driven by advanced manufacturing sectors such as Aerospace and Automotive, and these demanding customers are already deeply involved in ML to enhance their operating efficiencies in their production environments. Traceability is critical with aerospace components and many of us have adapted machine protocols to conform to AMS 2432 and Nadcap audit requirements. ML in many forms will continue to proliferate our shot peening and ultimately blast cleaning operations. It is best that we start thinking about different aspects of our machines and processes to implement this thinking into our routine activities.

In 1959, Arthur Samuel, an American scientist and pioneer in this field, provided a clear definition of ML as being a "field of study that gives computers the ability to learn without being explicitly programmed." Therefore, the application of AI and ML in our industry does not have to be restricted to a select few machine programmers. Anyone with working knowledge of the process and the desire to make it function better is capable of developing this emerging concept.

I often relate to the example of the operator who installed a webcam near the airwash separator curtain in order to monitor its completeness along the length of the lip. This was the operator's foray into developing a basic ML protocol leading to manual intervention when adjustment was needed! Complex AI/ML starts with application of such simple models and each of us can contribute to its adoption in our industry. I hope to report more on this to our readers as we progress along this path.

About Kumar Balan

Kumar Balan is a shot peening and blast cleaning technical specialist. He is currently assisting Ervin Industries achieve business growth in North American and overseas markets.

Mr. Balan has published several technical papers on blast cleaning and shot peening and is a regular contributor to *The Shot Peener* magazine. His expertise is in centrifugal wheel-type and air-type blast cleaning and shot peening equipment. He is a regular speaker at industry conferences and training seminars worldwide. He is also an EI Shot Peening Training Lead Instructor at their international seminars and workshops. Mr. Balan's contributions to the industry were recognized when he was named the 2006 Shot Peener of the Year.