The Benefits of Integrating "Lean Thinking" Concepts into the Management of Infrared Predictive Maintenance Programs

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Lean Thinking is nothing new, nor many of its concepts, but the real value is in how these concepts are integrated into a total solution. Many companies today are either Lean Companies, or are utilizing Lean Thinking to maintain a competitive advantage in the market, for example (Dell, Southwest Air Lines, FedEx). With the ever-changing demands that are placed on company resources, rapid changes in personnel because of downsizing, and the demand to "do more with less" while increasing productivity and value, many companies have been applying Lean Thinking to the management of their maintenance programs. Companies like Ford, GM, Boeing, WE Energies, Entergy, Hawaiian / Maui Electric, Florida Power and Light and KEPRI, have all established Lean IR programs and are able to better manage and maintain the real value of their IR programs while drastically increasing their ROI.

Background

Batch & Queue vs. Progressive Production

Prior to the advent of the assembly line, activities were done in batches, or in batch & queue mode, where specific tasks are grouped together before going to another queue and waiting for the next phase of work to be completed. This type of batch and queue thinking is not uncommon, but it has some real disadvantages when it comes to speed of production and quality control. Because of these shortcomings, Henry Ford focused on the actual flow of the activities associated with the assembly of cars. He called this flow "Progressive Production", which led him to establishing what, is known today as the modern "Assembly Line".

By switching from a batch & queue mode to a progressive production mode, Henry Ford was able to reduce the time it would take to assemble a car by 50%. He actually had someone physically pulling the car's chassis through the assembly process. Next, by using a motorized conveyor system which provided for a continuous speed or flow, Henry had reduced what had taken 728 hours in a batch and queue mode to only 90 minutes, with an increase in production of 485%– thereby reducing the cost of goods sold, while increasing production and obtaining a higher quality product!

It has been said that, "The assembly line is the most significant technological development of the 21st century". Today, assembly lines make everything from the Apple iPod nano at 1.5 oz, to the Boeing 777. We can clearly see that progressive production has many benefits. By switching from a batch and queue mode to a progressive production approach, products and services can be performed faster, with less effort, and with higher quality. The key to your success though is in how you apply these methods.

The Birth of "Lean Thinking"

While large scale assembly line production was working well for the American automotive industry, Taiichi Ohno (1919 – 1990) a Toyota Motor company executive found that many of the principles would only work when you had large scale assembly lines and ample resources in material and labor. Toyota had a problem with trying to implement these practices on a much smaller scale, which was more in line with their manufacturing needs. Toyota needed to come up with a way to apply the benefits of the assembly line with their manufacturing restrictions if they were going to be competitive. They simply could not produce the same volume, at the same amount of waste. They had to find ways to do more with less.

Taiichi Ohno had to develop practices that would identify any waste in the process. But to define what waste is in any system, you must first establish what is of value, and look at the value stream to see what activities add value as opposed to those activities that do not contribute value or actually diminish that value. Anything that does not directly add value to the process is waste, and must be removed from the system.

Identifying and Removing Waste

For Taiichi Ohno, it was a matter of reappraising what was of value in the flow of their assembly line activities, eliminating any wasted steps or actions, and "right sizing" their assembly lines to match their changing production demands. They had to become Lean.

Lean Thinking is simply the discipline of: *doing more with less and less…* as in less wasted effort, wasted time and wasted materials! Taiichi Ohno identified seven types of wasted human effort, time and materials.

Seven Wastes (Manufacturing / Assembly Production)

1. Overproduction ahead of demand.
2. Waiting for the next processing step.
3. Unnecessary transport of materials.
4. Over processing of parts due to poor tool and product design.
5. Inventories more then the absolute minimum.
6. Unnecessary movement by employees during the course of their work (Looking for parts, tools, prints, help, etc.)
7. Production of defective parts.

Toyota was able to very effectively develop and apply the Lean concepts to their assembly line processes, as well as every other aspect within their company–from the way they handled paperwork, to the way they supported their car dealerships. They then took the success of their Lean Thinking concepts and worked together with their suppliers to apply the same principles within their business and build a Lean Enterprise that would work together to find waste in the entire system, and eliminate it. Today, Lean principles have been integrated into all types of business models, from Lean Manufacturing, Lean Services, Lean Software Development, even Lean Government Depts. and a Lean Navy! (Google Results: Lean Thinking= 495,000 Lean Enterprise = 426,000 Lean Business = 61,400 and Lean Maintenance = 16,000)

Lean Thinking and Lean Infrared

There are many similarities that can be made between the automotive assembly process and the Infrared Predictive Maintenance practices that are helpful in getting a better understanding of Lean Thinking principles.

When you look at the advantages of going from a Batch and Queue model to a Progressive Production model, and then apply Lean Thinking to help correctly establish best practices for your own specific situations and applying it to Infrared, you end up with a Lean Infrared program or Lean IR.

In the Automotive industry the focus is on the production activities of assembling car parts into a complete car. In an infrared predictive maintenance program, the focus must be on the activities of collecting/retrieving the data, which goes into the IR program. Whether it is car parts or data, if it is not of high quality and assembled in the right way, then what you get is "garbage in equal's garbage out", no matter how you build it. For a Lean IR program, the focus must be on quality data, delivered in the right sequence, while eliminating any wasted effort. Anything that can degrade or impede the quality of the data must be avoided.

Seven Areas of Waste in Conducting a traditional IR Inspection:

1. Not having a clear, defined route of what is to be tested.
2. Inefficient methods of inspection data collection and reconciliation in the field.
3. Redundant data entry once in the field and then back at the computer
4. Data entry errors, incorrectly identifying equipment that has a problem, etc.
5. Having to correct data entry errors. Having to go back into the field to get the correct information on a piece of equipment or a problem.
6. Not having a good method of establishing what IR and visual images go with which problem.
7. Being locked into a specific IR camera manufacturer's software because their proprietary IR image files will not work with other programs.

The Traditional Batch & Queue Model for Infrared Thermography

For example: A typical thermographer can expect for an eight-hour day of scanning, that 75% of their time is spent looking through the camera, trying to find problems (sort of like a search and rescue mode), while the other 25% of their time is spent writing up problems in the field when they find them. Of the first 75% of their time they are trying to stay on task, locate what equipment is to be inspected, keep some type of a list or inventory as to what had been vs. what had not been tested.

NOTE: If they are really doing their job the right way, they should also be reconciling all of the past problems (both open and closed) from all previous inspections! Making sure to close out any open problems that have been fixed correctly and checking to make sure that any past closed problems are not starting to reappear. This requires taking all of the past reports out into the field and examining each one to see if there was ever a problem on each and every piece of equipment. It should be noted that this is not easy or practical to do given the restrictions in the way data is handled in a typical IR program, because it would require lugging all of the past reports out into the field.

When the Thermographer does find a problem, they typically store the thermogram to a flash card in their IR camera, write their findings down with pencil and paper, and snap a visual image. (They may also save a voice annotation comment into the IR image or use a recorder).

At the completion of the inspection they now have stored in a queue, a batch of IR and visual images, as well as their notes (either on paper or voice memos) which will be used for compiling into a report. At some time later, the thermographer will have to sit down and take the stack of paper notes, thermograms and visual images, and enter them into their computer typically producing a MS Word document or other type of flat file.

It is not uncommon if you are going to produce a quality report, for an eight-hour inspection to easily require from two to four hours of report generation time after the inspection is done (if not more). In most cases the ability to actually sit down immediately after the completion of the inspection, or even the next day is not possible, and the report generation phase may actually take place a few days…to weeks after the actual inspection. (Note: it is also not uncommon for many IR consulting companies to take as much as two to six weeks to get the report back to their customers after the inspection).

We can see that the traditional batch and queue model that is used for report generation:

- Does not allow for any information in the field to be used, (no flow or pull).
- Allows for countless errors to be introduced into the data.
- Is very time consuming
- The batch and queue method does not add any value to the program.
- Because all of the actual data is in the form a report or flat file, there is no way for the data to flow or to be used in other ways or by other programs.

You're Lean Thinking Tool Kit.

We need to define specific terms as they apply to Lean Thinking and Lean IR.

Error Proofing

Error proofing your data is a very important tool that is used to eliminate the waste of having to redo a task. It involves looking closely at the tasks and anticipating all of the ways that errors can be introduced. Since having to correct data errors will stop the flow of the process, if not reverse it, and create a tremendous amount of wasted effort and time, it is very important to carefully consider any and all areas that errors can be made.

In the automotive industry it may involve using steel that is galvanized on all sides so that it can not be placed into the stamping press upside down. In conducting an infrared inspection, it may involve utilizing bar codes so that equipment and their associated problems are not incorrectly documented on an adjacent piece of equipment.

Typical errors that are made when writing up an inspection.

- Not correctly identifying the right piece of equipment that is to be tested.
- Not knowing if there was a past problem on the equipment that needs to be reconciled against the previous findings.
- Not correctly associating the correct IR or visual image with the problem.
- Data entry mistakes based on poor handwriting of field notes.
- Data entry errors / typos while entering data into the computer.
- Not recording all of the data and trying to commit it to memory, thinking that you can remember all of the correct information.
- Having someone, who was not actually present at the time of the inspection, type up the report/findings.
- Too much time has lapsed between collecting the data and generating the report so that the data is out of date.

Each of the above errors and many more are very common in the typical practice of conducting infrared inspections. If they are not adequately addressed, then they will create a tremendous amount of wasted effort, time, resources, and money.

Flow

In the automotive industry, "Flow" defines the flow of parts arriving "just in time" with the assembly process. In Lean Infrared, flow applies to the flow of information (like parts) to and from the thermographer, "just in time", in the field with the activities of the inspection.

The rhythm of the flow must ensure that the right amount of information, in the right sequence is delivered to the thermographer, for them to be able to do their job without any wasted effort. This rhythm must be flexible enough to allow the thermographer the ability to work in a variety of ways that best fits the circumstances in the field. The flow and rhythm of the information delivery system can be broken down into specific tasks that the thermographer performs while they are conducting their inspection.

Inspection Tasks:

- Locating the equipment that is to be inspected.
- Identifying if there have been any problems that need to be reconciled
- Scanning the equipment to be inspected
- Reconciling past problem conditions (closing out of past open problems)
- Documenting problems, either new or re-documenting any chronic conditions.

Flow Delivery System

When focus is placed on the value of having the correct data delivered to the thermographer in the field, just like a conveyor system delivering parts to the assembly line, then we must consider options for data storage and retrieval like a mobile database solution. We must also consider a mobile hardware solution that will provide a platform for data to automatically be collected in the field. The synergy of the two must and the rhythm of the data flow are key to what is called field force automation.

We see FedEx and UPS using portable data collection equipment that scans bar codes and track packages all the way up to where we actually sign our name on them. Police and Emergency Medical Technicians, utility company meter readers, even stores like Home Depot use portable data collectors to track inventory.

Pull

In relation to the automotive industry, pull happens through an event (for example: the man that was pulling Henry Ford's car chassis through the assemble line). His activities pulled the required materials that are needed to fulfill the order through the system.

In thermography, the pull event happens when the thermographer is requesting information from the mobile database that will allow the inspection to be performed. For example, by scanning a bar code on a piece of equipment, a mobile database can pull up the equipment's entire history and provide it to the thermographer so it can be reconciled to see if there are any past problems on it. By studying the specific activities that are required by the thermographer in the field, and setting in place a mobile delivery system for the flow of the specific information that is in rhythm with what data is required, you can easily put in place a system that automatically delivers the information when the thermographer needs it (just like a perfect dance partner). The key is in matching the rhythm of the flow, to the rhythm of the pull. When this is done, you make the thermographers job much easer because they have all of the information at hand when and where they need it.

The Thermographer will need to "pull up" information in regards to:

- Being able to locate what equipment is to be tested based on a geographical hierarchical route list so that equipment can be tested in a sequence that affords the most economical utilization of effort.
- Knowing what the test status is on the equipment that is to be tested, or has been tested.
- Knowing what the problem status is on the equipment that is to be tested.
- Reconciling past open problems to see if corrective repair actions have been made correctly.
- Reconciling past closed problems to double check that the repair actions have been made correctly and that the problems are not coming back.

Flat Files vs. a Mobile Database Solution

Relational databases offer an extremely useful method of data collection and retrieval as compared to having the data reside in a report. By using a relational database, data entry can be dramatically reduced because you do not have any redundant data. Once it is entered into the database, the data can be used over and over again without having to retype it. Reports can be run against the database to provide a hard copy printout in the same way that your bank sends you a bank statement at the end of each month.

By using a mobile database solution that can deliver the right information, just in time, that is in rhythm with the thermographers activities; you can significantly increase the quality of the data, and eliminate redundant data entry, as compared to the typical batch & queue method of report generation. One byproduct of using a mobile database solution is the benefit a "progressive report production system", that allows immediate information distribution and report generation without having to come back to your desk and type up your report, because the report is being done literally in the field while you are collecting data.

The user interface of the mobile database program can be customized using many visual controls to present information graphically, for example an Explorer Route view of equipment and locations similar to the File Explorer in Windows. The software can automatically provide "progressive filtering" of the information so that what you are looking for is readably available.

Visual Controls

Visual controls are visual tools that allow for immediate access to information (like pressure gages on a control panel) that provide ways to easily identify what the conditions are at the moment. When visual controls are integrated within the user interface of the database software, you can easily convey a lot of data quickly, without having to go through extra effort to look up the information. They play a very important part in the flow and pull of information to the thermographer. Simple visual signals like using stoplights to display the problem status of equipment, such as red to indicate a problem exists, yellow for a past problem, and green for not having a problem, dramatically show how a symbol used as a visual control can quickly and easily convey a lot of data to the thermographer.

The user interface can take advantages of many methods of allowing the thermographer to easily pull up the information. Visual controls can by used to convey information to the thermographer such as routes, test status, problem status, repair status, as well as providing all of the past IR and visual images from all of the past inspections. And by using bar codes you can error proof the data entry and automate the retrieval of equipment history, thereby providing the thermographer with the ability to reconcile information effortlessly.

Field Force Automation
In this case right sizing the data delivery system for both the hardware and software are very important if you are going to take advantage of field force automation and data collection.

Matching not only the needs in the field, but of the overall IR program is very important. Anticipating the ever-changing demand that will be placed on how the data will be used in the future is critical. You don't paint yourself into a corner. There is a large number of mobile hardware options that can accommodate the growth of your IR program. The Pocket PC today, for example, is very powerful and comes in just about every conceivable configuration from combat hardened devices to systems with built in phones, cameras, GPS and bar code scanners.

Right Sizing
Since we can draw on the comparison of batch and queue model vs. a progressive production mode, and the analogy of part vs. data, we need to look for the right size/method of data retrieval and data input. That is, a method that takes advantage of error proofing, and allows for a seamless flow of data as the thermographers activities pulls it.

The key to success is in making sure that the specific solution is the right size for the thermographer to be able to use. This means that the hardware and software solution will actually meet their needs in the field. One of the biggest mistakes is in trying to fit a round peg into a square hole, (or a better analogy is 10 lbs of chocolate into a 5 lb. box.) The case in point is that trying to make a CMMS program like MAXIMO or SAP into what the thermographer needs to be using in the field for data collection will be a complete failure in the field for the thermographer because it is completely out of touch with what the tasks are for the delivery of information while they are doing their inspection. It's like delivering the wrong parts, at the wrong time and in the wrong quantity in the assembly line process. The way to work through this is to utilize a database that will allow for the exchange of data in a variety of ways that allows for migration of information from one database to another.

Lean Infrared and Progressive Report Production
One of the best benefits of establishing a Lean Infrared program is that you now have in place a method of "Progressive Report Production" for the process of data collection and retrieval. That will allow for the progressive flow of information to and from the field as the inspections are being performed. This lets the thermographer actually pull up the information when and where they need it without any wasted effort. This Progressive Report Production system also includes methods of error proofing to ensure that the quality of data is also being collected.

Progressive Report Production by using a mobile database solution also eliminates the necessity of having to sit down at a computer and type up a report since all of the data is entered into the database during the actual inspection. By synchronizing the mobile database with a desktop computer or server, all of the data that is gathered in the field is automatically uploaded to the computer for immediate access as well as printing out reports. So what may have taken days to enter and then distribute is now done instantly.

The advantages of combining Lean Thinking concepts, Progressive Report Production, Mobile database solutions into a Lean IR program for the automation of data collection, and the ability to share the results in real time would even make Henry Ford proud.

The benefits of a Lean IR program

- Focus is on methods to improve the quality of data.
- Utilization of error proofing to ensure quality data.
- Automation of the flow of data to the thermographer that is in rhythm with when and where they need it.
- Reduce effort by the thermographer to have to find information.
- Better informed thermographers about equipment history.
- No report generation time is required because of a Progressive Reporting Process.
- Faster response time because information is immediately available when problems are found.
- All problems are able to be trended over time and adequately followed up.