Parts Tracking

Tracking the Life of Critical Gas Turbine Parts

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Abstract

As the technology employed in gas turbines has steadily advanced, the “critical” gas turbine parts (i.e. combustion and hot gas path components) have seen a significant change in terms of their initial cost, repair cost, expected life limits and order lead times. In order to accommodate these changes, owner/operators have developed various business strategies that are designed to minimize the lifetime costs associated with owning and operating these gas turbines. Examples of these business strategies include the adoption of OEM service agreements to address parts availability & infant mortality risks, part sharing/pools to reduce lead times, maintenance programs (reliability based, condition based, etc.) that eliminate unnecessary removals and innovative repair processes to maximize parts life.

These strategies are all sound business practices, but none of them address the basic fact that to maximize the investment in these assets, by minimizing the associated cost of ownership, it is imperative to maintain a detailed history of all critical gas turbine serialized parts. Without the ability to monitor and measure the expected total cost of these critical parts in an almost real time manner, the owner/operator’s potential risk exposure is substantial. This risk can take the form of an expensive part that must be scrapped before achieving its expected life or in a potential safety issue where a part is unknowingly operated beyond its life limit. In either case, a large potential risk can be mitigated with a relatively straightforward process; tracking serialized parts by location and their accumulated age.

Although the requirement to properly track serialized parts may seem simplistic, most gas turbine owner/operators today do not do an adequate job of capturing this business critical information. Many depend on service agreement providers to track this information, primitively capture this information themselves in insular spreadsheet based formats, or depend on periodic written inspection reports to provide them with any required information. At best, maintaining and retrieving meaningful information from any of these sources can be a difficult, time consuming task. At worst, the parts information may be lost forever, along with the opportunity to actively manage these critical and expensive assets. Properly tracking critical gas turbine parts should be a concern for all owners because this information is crucial to the long term profitability of a gas turbine facility.

The objective of this paper will be to define the most critical elements of a parts life tracking strategy and then suggest specific practices that will result in better information based on an approach that had been successfully implemented at many companies of varying size and asset mixture.

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Background

Strategic Power Systems Inc.® (SPS) began tracking part serial numbers through the ORAP system as part of an OEM initiative to monitor the configuration of their units as they left the factory, went into service, were sent out for component repair and eventually retired. This process, which was integrated into the existing ORAP system architecture, was designed to track ~10,000 part numbers and ~500 serialized parts per unit. It allowed the OEM to determine the vintage of parts operating in their fleet (i.e. part numbers) and to specifically track the parts that were deemed critical from either a safety or life limits perspective (i.e. serialized parts). This system was successfully implemented in 1995 and has been continuously updated since that time, in both its state of the art system architecture and its inherent parts tracking capabilities.

In 2004, based on their knowledge of our OEM based parts tracking process, several existing ORAP participants contacted SPS regarding the need for a tool that allowed owner/operators to monitor the aging of critical gas turbine parts. Although inventory management software was available within the industry, it was not able to easily track the aging or the current location of all “critical’ parts within a given fleet of assets. In response to this request, SPS modified the user interface of the OEM parts tracking system to develop an easy to use and efficient critical parts tracking system for the owner/operator. During the development of the ORAP Parts Tracking™ application, many different design requirements and potential problems had to be addressed to ensure that the application met the needs of various owner/operators. It is this experience upon which the information in this paper is based.

The following sections highlight some of the considerations that must be reviewed when preparing to systematically track serialized parts and provide a glimpse of how they have been resolved in the ORAP Parts Tracking® application.

Critical Elements

In developing a parts tracking procedure, the major trade-off that will be immediately recognized is that the potential value of tracking parts within a fleet must be weighed against the time and money spent to maintain the information contained within the tracking process.

There is a strong economic case for tracking “critical” parts within a fleet. As an example, a first stage row of blades on an F technology gas turbine can cost as much as three million US dollars. The time & cost required to properly track these critical parts from a remaining life perspective, would pale in comparison to the possibility that they exceed their assigned time at temperature limits and are not repairable as a result. Another example would be a case where an owner/operator must take the most conservative approach in removing, destructive testing, or even scrapping high cost parts, because with no accurate parts life information their continued use could pose a safety concern. A simple parts tracking procedure, well thought-out and executed, could support a more informed, accurate business decision at a fraction of the potential incurred cost.

Finally, in the development of a business case in favor of implementing a serialized parts tracking system, the issue of its necessity in the presence of an existing OEM service agreement should be raised. In almost all cases, the service agreement has a contractual end point, at which time it may or may not be renewed. In the event that it is not renewed, the ownership of all of the serialized parts in the fleet remains with the owner/operator. If there is no serialized parts tracking system in place, with complete data transparency & clearly defined data ownership, the owner/operator is likely to inherit a lot of paperwork, but not a fully functional system that can be used to effectively manage their assets from that point forward.

Determination of Tracked Parts

Once the justification for the development of a parts tracking process has been accepted, the first decision to be made is which parts are going to be tracked. A rule of thumb in determining which parts to track is to include only serialized parts, typically ones which the OEM has identified as critical parts and which have a specified life limit. Unless a part contains a unique serial number by which it can be identified, there is little value in attempting to track its age or movement throughout a fleet. In fact, the only value in tracking non-serialized parts, outside of inventory management, is to know their current location in the event of a generic issue with the part that needs to be addressed. For the purposes of this paper, we will only review the tracking of serialized parts.

The second decision to be made is the specific serialized parts that will be tracked in the process. In general, all serialized parts that are considered critical to safe operation of the gas turbine, as well as those that have a significant impact on operations & maintenance cost should be tracked. In practice many of these serialized parts are both critical to safe operation and carry a sizeable initial & life cycle cost. Something to also consider are serialized parts that do not have any major safety risk associated with them, but are so costly both in terms of capital investment and repair cost, that knowing their condition and expected remaining life is crucial to managing gas turbine assets responsibly. Some owner/operators also included serialized parts that do not necessarily meet the criteria mentioned above, but whose failure could cause damage to other components, collectively making the repair cost a significant financial burden. The common theme in most companies is that all serialized parts that have a replacement cost above a specified financial value should be tracked. The exact amount of this financial threshold must be decided by the individual owner/operators. The most commonly tracked serialized parts in a gas turbine are the combustion & hot section components. In an F Technology gas turbine, arguably the unit's with the largest number of tracked parts, this would result in the tracking of ~350 individual serialized parts per unit.

Transactions

The next item that must be decided is how the serialized parts will be tracked. Typically all serialized parts are tracked on a transaction basis. Each time that a serialized part is either installed or removed from an operating unit, its status must be tracked. However, a decision must be made relative to the tracking of transactions related to the storage of a serialized part in a warehouse or those related to its induction

into a component repair facility. There is a strong case to be made that the transactions related to a component repair facility should be tracked as the serialized part may undergo modifications that will increment the number of repairs performed, typically a life limitation criteria. A less imperative, but not irrelevant, case can be made for tracking the transactions at both of these location types because it provides an uninterrupted chronology of the serialized parts history. Without tracking all serialized parts transactions, the validity of the process can be called into question because the serialized parts location is not known throughout their history and therefore may be considered suspect.

Serialized Parts Age Criteria

Probably the most important motivation for tracking serialized parts is the ability to measure age against pre-determined life limits as a means to understand remaining life, both from an operational as well as a financial perspective (e.g. depreciation). In order to track the age of a serialized part, a determination must be made as to the relevant age parameters. Age can be measured using many different criteria or values, typically some measure of operating hours (fired, equivalent, factored, etc.), starts (fired, factored, equivalent, etc), cycles (full, partial, etc.) and often trips. In most cases, the OEM provides guidelines on the age criteria that are relevant to the various serialized parts that they manufacture/sell. These guidelines vary in terms of the relevant age criteria based on the wear characteristics of the individual parts (e.g. low cycle fatigue, creep, corrosion, etc.). The specific age criteria that will be tracked must be defined by the owner/operator, based on the OEM limits, or their own operating experience.

Once the age parameters for the serialized parts have been defined, the process for tracking this information must be formulated. Since serialized parts have no built-in mechanism for determining their accumulation of age, this information has to be inferred. The simplest and most effective way of obtaining aging data on serialized parts is to determine the age of the unit in which it is contained at both the time of installation and the time of removal. In Figure 1 below, a simple example is provided to show how a serialized part accumulates service hours as a function of the operating unit(s) in which it has been installed. In order to effectively track the age of all serialized parts, it is critical that all units in the fleet consistently collect the same age information and that this data is commensurate with the various age parameters defined as critical to determining the useful life of all serialized tracked parts.

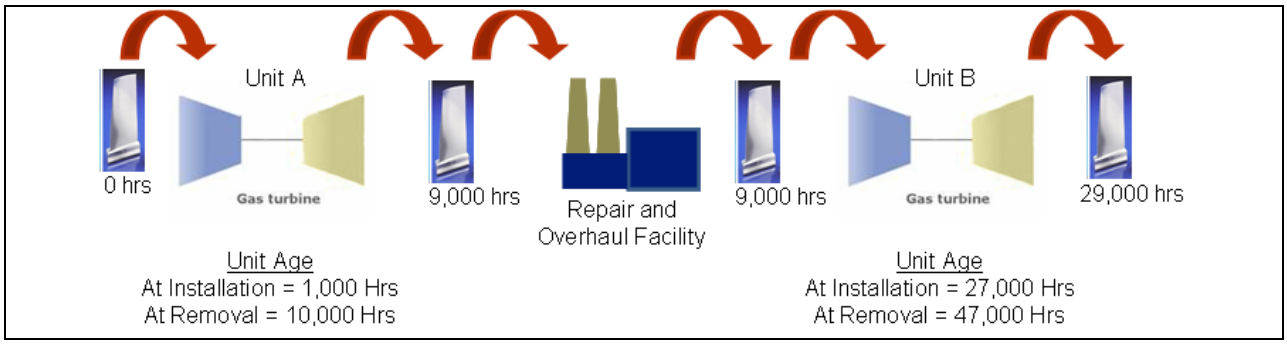

Figure 1: Tracking the Accumulation of Age on Serialized Parts

Initialization of Historical Information

The final critical element that must be determined prior to instituting a serialized parts tracking process is how to initialize information on serialized parts that have already been in operation for a period of time. The ultimate initialization process starts with the first installation of each serialized part and then identifies each subsequent transaction and all associated age accumulation. The reality is that this detailed level of information is not typically available when starting a formal tracking process. Therefore, the minimum requirement is to determine the current location of all serialized tracked parts and assign the defined age criteria to each of them as of the current point in time. This will limit any historical reporting, but will allow the process to move forward with the most accurate information possible for making future decisions. Additionally, if the system is well designed from the start, provisions can be made that allow historical information that is not initially available to be added to the system over time, increasing the accuracy and completeness of the entire process. Missing information could be related to serialized parts age or individual serial numbers. In either case allowances for historical information should be made, allowing for the input of placeholders until more accurate information can be obtained.

Best Practices

Once all of the basic elements of a parts tracking process have been defined, the mechanism that will tie all of these elements together must be put into practice. As with any process or system, the initial implementation will determine the success or failure of the project. There are many features that can be added to the basic elements that will make it more useful to individuals within a company, but for each additional feature there can be a commensurate increase in the time required to administer the process. A lot of good ideas that are all implemented at the start of a project can quickly turn the entire process into an unmanageable quagmire of tasks requiring extensive manual labor to provide even the most basic serialized parts tracking information. The following paragraphs detail some of the more common practices and describe their value in the overall serialized parts tracking process.

Data Repository

The most basic requirement of any data collection system is the means by which the data is stored for future reference and use. The data repository for corporate parts tracking processes range in technology from a file cabinet to a database system. The file cabinet is not in widespread use for the obvious reason that any time information is needed, a significant amount of elapsed & applied time will be required to collect the information. By far the most common implementation for tracking the movement and age of serialized parts is in an MS Excel spreadsheet. MS Excel is a powerful tool that is very easy to use, but when applied to more than a few units, quickly becomes unmanageable. Using a rough estimate of 350 serialized parts that need to be tracked for each unit, combined with the fact that most of these critical parts are fully spared at a ratio of 1 spare set per 3-4 units, a 3 unit fleet must manage the transactions and ages for ~1,400 serialized parts. Over time, as serialized parts are scrapped and replaced, this number can only grow. In a spreadsheet of this size, a single incorrect sort or mistyped value may not be discovered until the data is needed and obviously wrong.

Additionally, if more than a single person enters data into a spreadsheet then the probability of an error occurring becomes significantly higher. The only reliable data repository for a serialized parts tracking system is a fully functional, relational database with a graphical user interface designed to minimize errors and the time required to perform data entry. A properly designed database will also help to eliminate duplicate entries of the same serialized part in multiple locations at the same time, reduce duplicate entries and allow for the selection of data through drop down list boxes, eliminating the potential mistyping of part numbers and serial numbers, which often stretch to a dozen or more characters.

Standardization

In the implementation of data collection systems, it is always considered a best practice to harness the power of standardization. There is a level of quality and consistency to be gained from following a repeatable standard when recording and processing serialized parts information. It allows for the development of a written procedure that describes exactly how the data entry process should be performed, step by step. This is especially valuable in tracking serialized parts, where the transaction data is recorded infrequently and the recording responsibility is often transferred among various individuals.

User Interface

This interface is the primary mechanism by which the user interacts with & judges the parts tracking system. Having a common user interface that “guides” the user to follow the same data entry protocols every time information is recorded will avoid inconsistencies within the data, while easing the labor involved. From a reporting perspective, a common user interface ensures that all personnel utilize the same structure & terminology and information is provided through a common source. The user interface should be simple to use, require as little typed input as possible and contain as much error checking as possible. Ease of use is a subjective measure, but can generally be classified as; providing intuitive user selections & menus and providing functionality within a few “mouse clicks”. It is also important for the system, from both a security and usability perspective, to incorporate the flexibility to limit user access to only the functionality and information that they require in the performance of their job. A good user interface also makes extensive use of drop down menus that allow users to select existing values as opposed to typing them into the system. With very few exceptions, a good serialized parts tracking system should require very little typed input, outside of unit age information and transaction narratives, after the serialized parts have been initialized. Finally, relative to error checking, the user interface should trap errors and provide warnings to the user, but care should be taken not to put in error checking at such a level that it becomes prohibitive to the data entry process.

Reports

If the user interface represents the system to the users, the reports represent the business value of the entire process. The majority of the personnel making business decisions will do so based on the output provided by these reports. There are 3 distinct types of business users; Facility Management, Financial Personnel and Corporate

Management. Although there are many potential uses for parts tracking reports, the following are some of the major requirements that are common to most companies. In general, facility management utilizes parts tracking reports to understand the pedigree of the serialized parts that are currently on-site, which parts are driving their next outage and which parts are available for installation to minimize their downtime. Financial personnel are primarily interested in utilizing the reports to understand the expended and remaining life on the capital parts so that their depreciation can be accurately calculated. Corporate management are typically interested in having the reports provide a fleet wide view of where assets are in their useful life, what assets need to be purchased to maximize revenue opportunities and to maintain the appropriate level of inventory to support the business, while minimizing carrying costs.

Assignment of Responsibility

The issue of assigning responsibility for the entry of serialized parts information cannot be underestimated. The best designed system will be absolutely worthless if the required information is not input on a timely basis and in a quality manner. Depending on the size and staffing of the company, the data entry responsibility can be effectively performed at either each individual site or at a central location. The key is to ensure that an individual person or position is assigned the responsibility for overseeing that all serialized parts data have been input and that they have an established and accepted procedure in place to support their efforts. This position may have the responsibility and appropriate authority to perform the work, or to ensure that others are providing the required data. They should be aware of the corporate policies regarding the input of data at the operating sites, warehouses and component repair facilities.

Serial Number Definition

Another practice that is applied in many different ways is the definition of a part serial number. A part serial number is the unique identification of a specific part within the tracking system. Without a serial number, a part doesn't "exist" in the system and cannot accumulate age or be moved between gas turbines. The serial number utilized in the system can be the unique identifier assigned by the OEM, or one that is assigned by the owner/operator. However, if the serial number is not physically stamped on the part, the opportunity for confusion and errors at the sites and in the component repair facilities will be greatly increased. Additionally, as the unique identifier for a part, a serial number should never need to be modified to reflect modifications or repairs. This information should be attached to the serial number, augmenting its history as part of a transaction record. The modification of a part serial number is an inefficient practice and should be avoided.

Part Number & Serial Number Attributes

While the part serial number should never be modified, the associated part number or drawing number may be modified several times as upgrades or rework are performed on the part. The system should allow for these changes to take place, tracking the part or drawing number as an attribute of the serialized part. Other attributes that could be tracked would include; life limits, coatings, materials, OEM, alternative part numbers, other serial number references, etc. The only cautionary note,

as was discussed above, is that as more items have to be entered and maintained within a system, there is an increased time and expense requirement. Therefore, all optional attributes for serialized parts should be scrutinized to ensure that they have a defined value in the overall process.

Tracking Serialized Parts as a Set

It is also a common practice to track serialized parts in gas turbines as a set. This practice allows a large group of serialized parts to be tracked as a single serialized part, all accumulating age at the same rate and undergoing the same transactions. While this is a good way to limit the amount of work required to track individual parts for a whole fleet, it can introduce some challenges when the sets are re-configured during outages or repairs. A set is an artificial container that is used to represent a large number of serialized parts. The age of a set is always determined by its high time serialized part. As serialized parts are installed and removed from the set, the age of the set can change dramatically, because it is a conditional age based on an inheritance of the worst case value among its constituent serialized parts. As an example, figure 2 shows that a single serialized part in a set has reached 30,000 hours, making it the life limiting part in that set and the driver of the next repair interval. If that single 30,000 hour serialized part were to be removed and replaced with a new part, the age of the set would immediately drop to 25,000 hours.

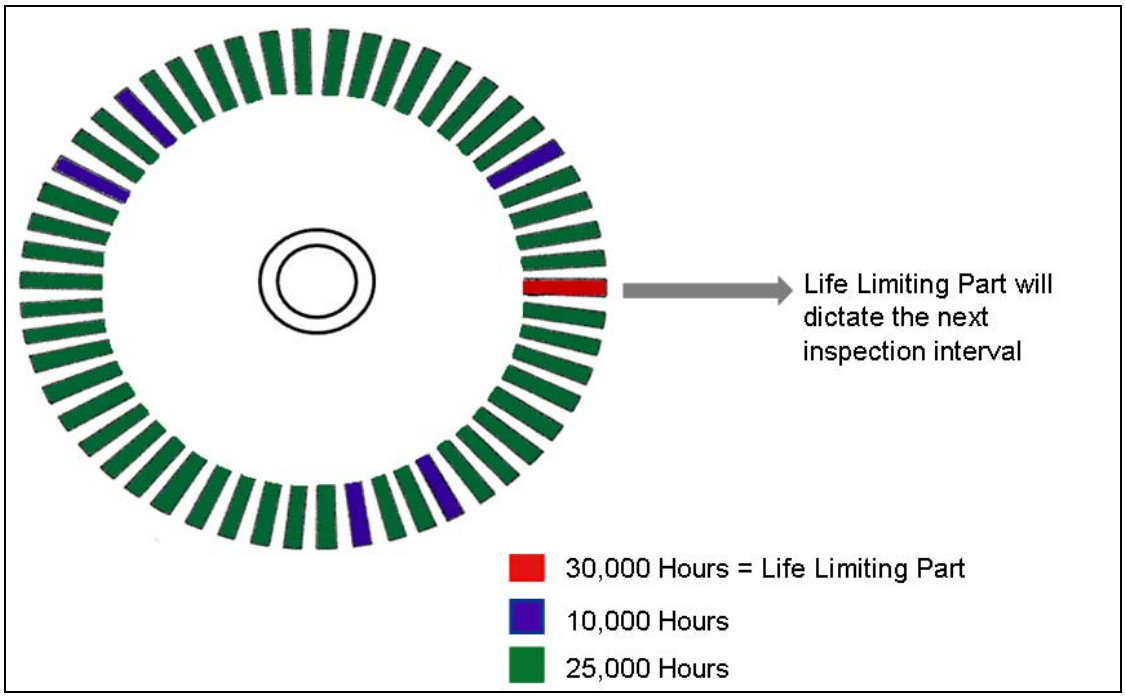

Figure 2: Tracking the Accumulation of Age on Sets

It should also be noted that there is often more than one age characteristic that needs to be monitored. The high time part for another age type, perhaps equivalent starts, might be a different serialized part, one that has a lower number of hours, but could still be the driver of the next outage.

Attachment of Pictures & Reports

Another optional feature of a serialized parts tracking system is the ability to electronically attach pictures and documents to specific serial numbers or transactions. By embedding this information electronically, the risk of losing a repair report or a picture that shows crack propagation on a specific component is negated. It also provides for a central repository of information that is readily accessible to all defined users via the user interface. This is a highly recommended, although not critical practice.

Information Sharing

In any case where information is manually entered into a system, the issue of information sharing with other corporate systems should be raised. The serialized parts tracking information discussed in this paper may have many varied uses within a company and should never have to be entered multiple times. Therefore, the ability to electronically share this information with other systems may become a priority. There are many ways in which this data sharing can be accomplished, from simple formatted text extracts to XML data file transfers. Each of these mechanisms carries with it an associated development cost and a maintenance cost. As a general rule, the more automated the process is, usually at a higher development cost, the more successful its implementation will be in the long term.

Build versus Buy

The final issue that needs to be addressed as a best practice is the question of whether a company should custom build its own serialized parts tracking system, or purchase an off the shelf product to perform the same function. There is no correct answer to this question. Both cases typically have an initial price and an ongoing maintenance fee that must be taken into account. Typically, the off the shelf product will be more robust and reliable because it has been tested and improved through its use with other companies. The internally built system will generally be tailored to the specific needs of the owner/operator, whereas the off the shelf product will be less customizable, depending on its design. The off the shelf product typically provides better customer support on an ongoing basis because the product represents its core competency and there is a vested interest in its success in the marketplace. The long term support of an internally built system is always in question because a system of this kind is not a fundamental part of the overall business objectives and therefore its longevity is susceptible to changes in both the market and corporate leadership. As with most software products, the best practice is typically to purchase an off the shelf product with a proven track record and features that match the defined critical requirements.

Summary & Conclusion

In summary, the overall financial risks relative to the lifecycle costs of critical parts to gas turbine owners has increased as gas turbine technology has advanced.

In order to actively manage these assets and minimize the financial risk associated with the critical parts, the following recommendations are made with respect to the development or adoption of a serialized parts tracking system:

- Devise a business case to underscore and communicate the importance of a serialized parts tracking system.
- Define the critical elements of your system. Keep it short & simple.
- Utilize a relational database to store serialized parts information.
- Develop a standardized user interface for the data entry & reporting aspects of the system.
- Write a formal procedure for performing the administrative tasks and assign a person or position the responsibility & authority to ensure that these are performed in a timely and quality manner.
- Implement output that is easily accessible and utilized by Management, Accounting and Operations & Maintenance staff.

A solid parts tracking system properly implemented will be invaluable as a tool for making business decisions relating to all of the critical parts within a fleet.