Quantifying the Value of Increasing Turbomachinery Capacity

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Introduction

Capacity is often the single most influential element in the determination of Plant profits, yet, it is often not very well understood by those whom operate or are accountable for the plants production performance. Perhaps this is due to the overwhelming complexity of most plants, especially when considering the multitude of possible process/operating adjustments (Speeds, Pressures, Temperature, etc…), the continuous deterioration of component, and the dynamic evolution of plants (changes to input feeds that require design changes & equipment upgrades over time). With these influences considered, it is understandable why the only capacity loss component usually given any attention is equipment downtime, as it is easily recognized, quantified and relatively easy to manage.

The Oil/Gas Production Industry operates in remote regions and, as a result, has become dependent upon Gas Turbine drives to power the remote production recovery processes necessary to produce oil and gas. The capacity of these units can often have an enormous impact on oil/gas production rates, yet, the Industry has not placed a proportionate amount of effort to maximizing turbomachinery capacities.

The objective of this article is to assist operators in quantifying the value of increasing their Plant's Turbomachinery capacities using Turboperf's TMMS™ technology

Turbo Machinery Management System (TMMS™)

First and foremost in the journey of recapturing (and maintaining) lost turbomachinery performance is installing and utilizing a Turbo Machinery Management System (TMMS™) which can accurately quantify all of the capacity losses in your turbomachinery train. TMMS™ technology has been developed and used since 1993 on more than 40 Gas Turbine driven compressor, pumping, and electrical generator units for a combine total of approximately 4,000,000 hours of analysis.

While many Turbomachinery Engineers are skeptical about maintaining a program of this nature, with sufficient accuracy to yield meaningful results, the continuous streaming of correctly presented performance data provides a valuable picture to users. A picture, which tells a powerful story full of lessons which is NOT available with periodic "Snapshot" performance testing. Not only can instrumentation anomalies be detected immediately through logical deduction (which helps to maintain calculation accuracies), but many additional benefits not available thru conventional periodic snapshot performance testing emerge. One interesting example was experienced on a pair of Gas Export compressors in which TMMS™ detected rapid fouling rates. This discovery then launched an inspection of the compressors which revealed heavy hydrocarbon deposits within the compressor's flow passages. Further inspections revealed the process gas analysis had a normal composition down to C9, with a heavy tail showing up around C15 up to C20. In addition, the compressor's suction drum outlet vane pack was not a high

quality design. Following these discoveries high efficiency Peerless vane packs were purchased and installed in the suction drums along with compressor bundle replacements and the units enjoyed a 6-8 month period of perfect performance! Strangely after this, the compressor efficiencies entered into another period of rapid degradation. Prior to opening the compressors, it was speculated that vane packs had become clogged and collapsed but inspection revealed fouling was from corrosion debris. The TMMS™ Gas Compression trends had not only identified a loss of compressor efficiencies, but had also detected a failure of the corrosion inhibition program! Although the mechanism which attracted and caused the rust to bind to the compressor flow passages was never identified, our trends did reveal that the fouling was reduced following compressor shutdowns presumably due to loss of magnetic attractive forces between the rust and compressor rotor perhaps…? Whatever, this demonstrates the power of becoming intimate with continuous performance data. There is NO way that periodic snapshot performance testing would have revealed these lessons, especially so quickly. Without TMMS™ solving the above issues, it could have otherwise taken 10 years instead of the 1-1/2 years it took us!

The most revealing power however, when using continuous performance monitoring in combination with capacity analysis of turbomachinery, is the recognition of the lost capacities. Based on our many years of assessing turbomachinery performance and capacity losses throughout the world, we have found the following common traits related to TM capacity losses…

1. Capacity Losses (permanent and temporary) accrue immediately following the unit commissioning and startup.
2. Most units deteriorate at similar rates (see trend below in Figure 1)
3. Older TM Units (installed for >20 years) typically are operating at Capacity Availabilities of only 60-70%.
4. Many Aero-derivative TM units are experiencing massive Driver Output constraint losses (up to 40% capacity loss from this cause alone)
5. Downtime ,on average, only accounts for 4-6% of TM capacity Losses
6. TM Unit Control systems are often based on a strategy which causes significant capacity losses.
7. Gas Turbine Inlet Air Filter systems often have performance issues that are not recognized and lead to rapid Gas Turbine axial compressor fouling and engine Foreign Object Damage.

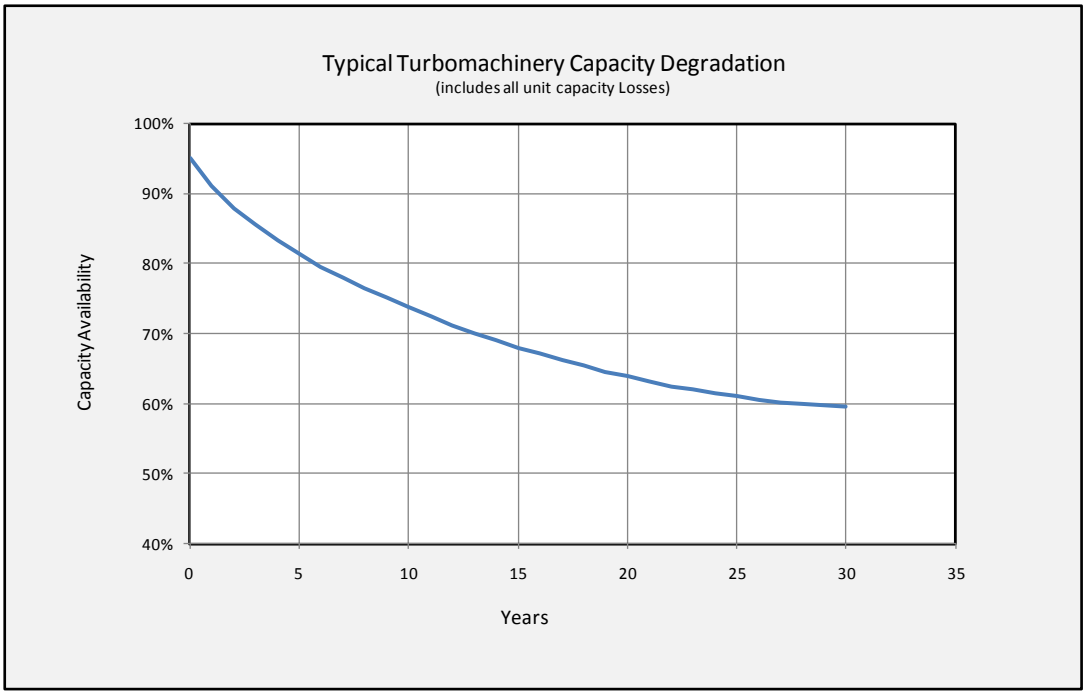

Figure 1

Figure 1 depicts average capacity degradation for a population of Gas Turbine Driven Compression units based on data acquired from TMMS™ assessments.

Using TMMS™ Technology to Restore Capacity Loss

Although using TMMS™ technologies provides unique insights into equipment performance behaviors and will establish unit capacity losses, it will not, on its own, eradicate the losses. The next step of the process involves recognition of the opportunities and execution of corrective action tasks to eliminate capacity related failures. This is where the "rubber meets the road"-- the human involvement -- in which one must effectively communicate to operations the opportunity detected, the corrective action task(s) required, and whether the work requires unit shutdown or can be effected online.

Considering the complexity of turbomachinery (see below Figure 2), it is no wonder operations are challenged to detect capacity loss mechanisms. Once the performance loss cause is identified, plans must be made to eliminate the failure. This is often also very challenging to accomplish as operations must become convinced that the opportunity is sufficiently rewarding enough to payback the production losses incurred from shutting the unit down and correcting the problem. Especially, considering that some of these corrective tasks (e.g. Compressor bundle replacement, GG Engine Swap, etc…) requiring the unit to be shutdown for extended periods, with acute related Production losses.

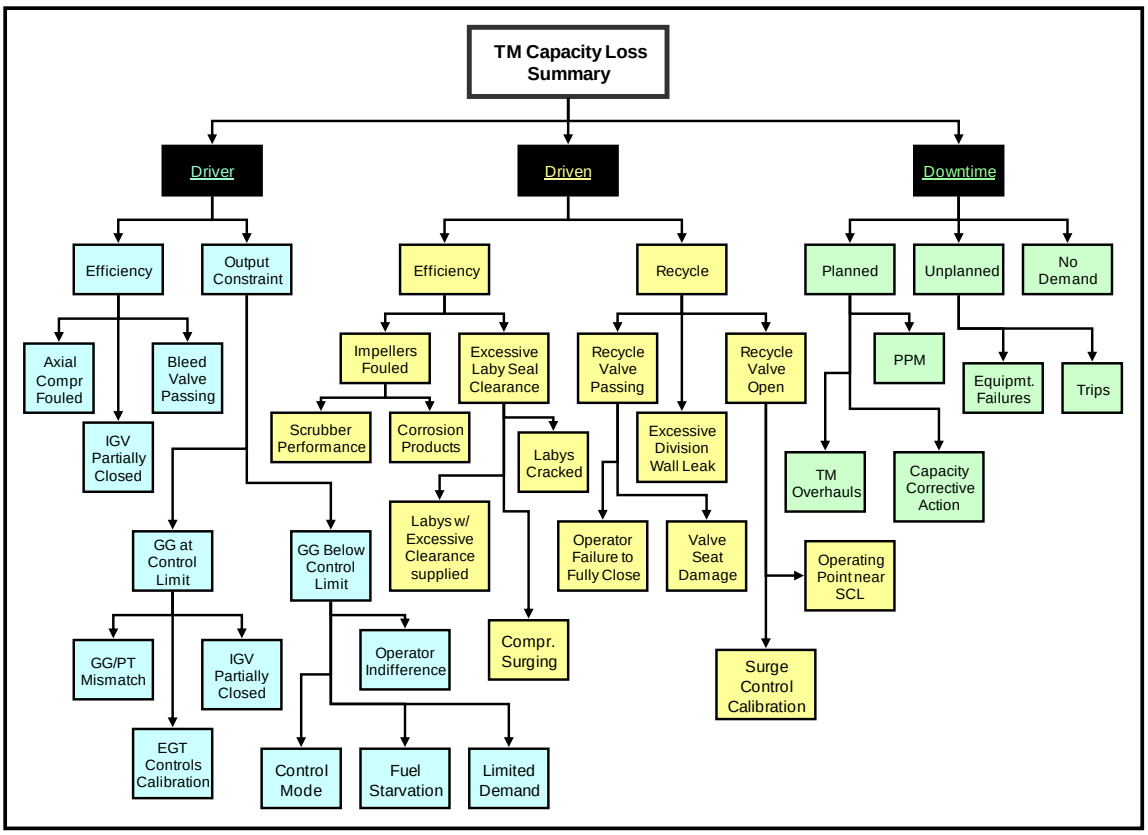

Figure 2

TMMS™ Development Trials (1993-2005)

Using TMMS™ technologies and related process we have documented the development of TMMS™ over a 9 year period (Figure 3) in which 25% capacity gains were achieved on 13 Gas Lift compression units. During this period, as the management was not supporting the technology and did not understand it, the work was accomplished purely thru influence (as opposed to authority) and with the eventual support of the maintenance and reliability organizations once the benefits became apparent. As a result, many of the recommendations to recover lost capacity (corrective action tasks) were not supported by the operations and required extensive training, discussions and persuasion.

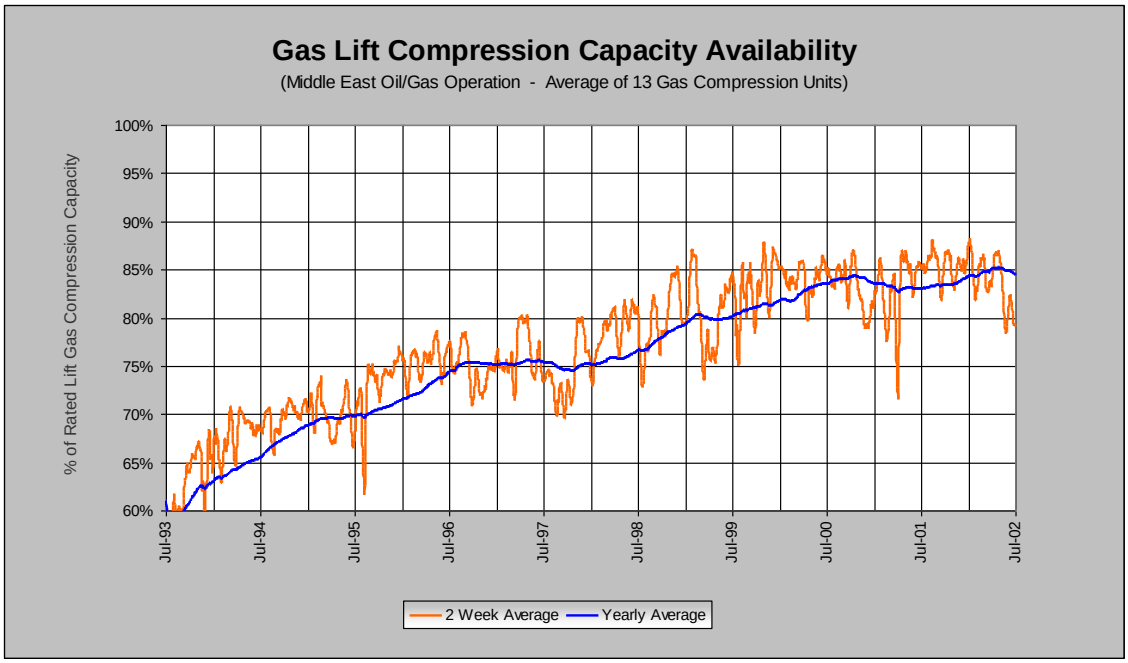

Figure 3

The next opportunity to trial TMMS™ technology availed itself with a single extremely critical Lift Gas Compression unit in a Far-East Oil/Gas Operation, installed and commissioned in 1993. The results of this trial (see Figure 4) not only validated the previous results in the Middle-East but far exceeded expectations in terms of both overall capacity gain (35%) and the rate of gain (< 3 yrs). This trial was also executed without management support and with communication (language/cultural) challenges, but again… the operations/maintenance staff eventually realized the benefits and bought into this technology approximately 1-1/2 years into the program.

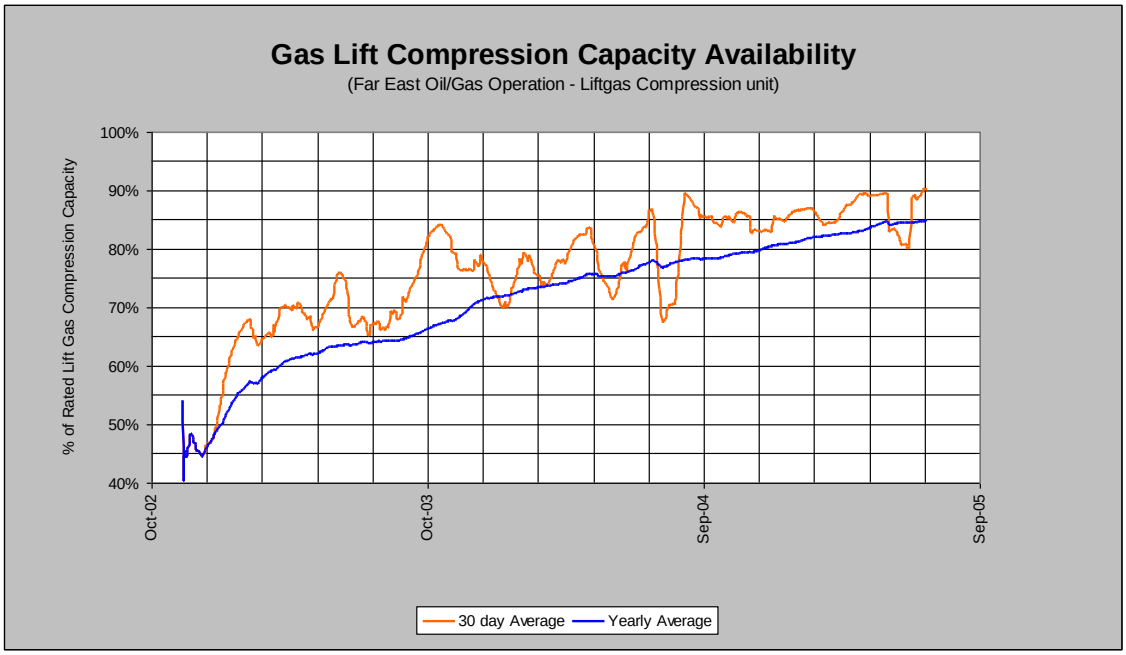

Figure 4

Calculating Capacity Gain Opportunities based on TMMS™ Historical Data

Based on Turboperf's TMMS™ development trials, which involved a significant population of 14 Gas Turbine driven Gas Lift compression units, the following key outcomes can be applied when analyzing the value of TMMS™ technology for Oil/Gas production operations:

1. In general, use Figure 1 data to establish the current predicted Capacity Availability of the operation's turbomachinery. This should provide a +/- 5% estimate.

2. When using TMMS™ technology, turbomachinery capacity gain rate should be assumed to fall somewhere between Figures 3 (3.6%/yr) and Figure 4 (13.5%/yr). Based on our experience a 10%/yr. capacity gain would be a reasonable assumption.

3. Finally, when predicting the maximum capacity availability that an operation can expect to reach, our historical data has revealed it is very difficult to average more than 85%. However, keep in mind that our results were achieved without management support. We believe, however with management support and strong focus a 90% Capacity Availability, level can be maintained.

The most challenging task of all is that of establishing the value of the turbomachinery capacity gains. While turbomachinery used in Gas Export Sales is straight forward (capacity gain x unit sales price of gas), other turbomachinery applications such as Gas Lift, Gas Injection & Water Flood have an indirect non-linear relationship to oil production, hence, are more challenging to quantify. As such, it is advisable to enlist the help of a knowledgeable Production or Reservoir Engineer with these assessments.

Power Generation units can also benefit from TMMS™ technologies. Most operators are not aware of this, but the majority of plant blackouts are the result of the severe capacity degradation of the power generation units. These units, typically, operate a substantial turn down rates (30-60%) and, as a result, do not receive much maintenance efforts to ensure that their capacities are maximized. Unfortunately, after severe performance degradation sets in, inevitably, one of the fleet is shutdown and the remaining units cannot carry the load which causes a cascading shutdown of each power genset and, ultimately, blackout failure. The value of TMMS™ for this application is realized in the number of blackouts prevented.

Operators should also be aware that even if additional turbomachinery capacity has no value on a steady state basis (with all units up and running), additional capacity is usually of value when one or more of the units are down for repairs or planned maintenance. The Middle-East oil/gas operation, in which TMMS™ technology was developed, had 13 liftgas units which were required to operate 100% of the time averaging a 4.5% downtime. If you do the math, one of the 13 units was shutdown 58% of the time, during which additional capacity took on an even greater value!

Summary

Hopefully, the above information has helped to educate the reader about the opportunities of increasing turbomachinery capacities. Readers that are interested in evaluating the opportunity at their specific Operation can use the link below for a free assessment.

http://turboperf.com/capacity.php