THE BETA BULLETIN

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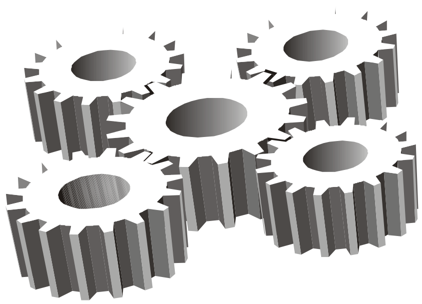
MACHINERY ANALYSIS



INSIDE VOLUME 9 #2

Dresser-Rand and Beta Machinery Analysis Announce Strategic Alliance

Dresser-Rand Company and Beta Machinery Analysis, have formally signed a strategic alliance agreement to provide complementary technical services and joint marketing efforts between the two companies. The main objective of the alliance is to provide increased value in after market services for operators of reciprocating compressors, engines and other industrial machinery.

Dresser-Rand brings its extensive customer base, its large base of installed equipment and its network of service centers. Beta Machinery Analysis adds world class expertise in analysis of condition and performance of industrial reciprocating and rotating machinery. The combined offerings will enable customers to reduce costs of operating and maintaining their equipment, while potentially increasing revenues.

Dresser-Rand is an international company that designs, manufactures, sells and services highly engineered machinery packages including centrifugal and reciprocating compressors, steam and gas turbines, electric motors, generators and control systems. The company has over 8,000 employees, has 10 manufacturing and testing facilities, and over 70 sales offices and over 20 service centers worldwide. In 1998, Dresser-Rand had sales of approximately $1.3 billion US.

It is estimated that there are over 90,000 pieces of operating equipment world wide carrying one of the Dresser-Rand brand names.

Dresser-Rand has been increasing its focus on after market services for equipment originating from any manufacturer, not just the D-R brand names. These services include maintenance, operation, upgrades and revamps. Field services by BMA promise to make these services more cost effective for the equipment owner.

For Beta Machinery Analysis, this affiliation with a leading equipment supplier is an exciting opportunity to increase our exposure and reach world wide. Since the signing of the agreement, a number of joint assignments have been completed and several more are in progress.

The Role of Condition Monitoring in Machinery Asset Management

In the context of production machinery, references to “asset management” are now quite frequent in the literature. The Society of Maintenance and Reliability Professionals even proposes a “physical asset management” profession [1]. There does not appear to be a precise definition; however, the phrase generally refers to maximizing the economic performance of the machinery over its lifetime.

According to Bradley Peterson [2] we are *not* referring to “fixing the maintenance function” or to “starting a reliability program”. In fact, he claims that attempts to improve maintenance alone are seldom worth the efforts involved.

Life cycle cost is a related concept, but seems to focus on the cost side only, leaving out emphasis on the revenue produced by the machinery. This apparent oversight can be addressed if we include opportunity cost as one of the costs.

Here we suggest that the corporate objectives will be more clearly seen if we view each piece of equipment as a profit center. Then asset management refers to designing, operating, maintaining and even revamping the equipment so as to maximize the profit over some time period.

Maximizing Profit from Machinery

The challenges include:

1) Designing for best economic performance over the lifetime. Design decisions build in characteristics that determine potential economic performance.
2) Operating practice. Best bottom line performance requires operating at the maximum throughput or load that does not disproportionately decrease availability or increase maintenance costs.
3) Maintenance practice – the minimum consumption of maintenance resources consistent with meeting (or exceeding) production objectives.
4) Revamping – during the operating life, profitability may be increased by making improvements in the machine.

The Profit Equation

The overall objective in operating production machinery should be to generate as much profit as possible, while maintaining proper safety, environmental and any other non-monetary factors. Below is a simple, but helpful look at the problem.

Profit = Revenue - Expenses

Revenue = production * unit value added

Expenses = energy costs + operating costs + maintenance costs

Profit = production * unit value added
- (energy costs + operating costs + maintenance costs)

Figure 1 The Profit Equation

This version of the profit equation considers only variable and controllable costs; it is most useful for existing machinery. For planned new machinery installations, a term representing cost of capital should be added. This would allow comparing alternative designs.

Calculating the economic performance historically would be a simple task if we had the required inputs and doing so would provide useful information. Most organizations do not have all the required cost data at the individual unit level. Moreover, historical profit accounting will at best reveal losses that have already occurred and are probably not recoverable.

A more valuable measure would be "real time" profit such as that given by the equation below. The "profit rate" would be literally the dollars per hour we are making with the machine under the current operating conditions.

Production = availability * time * rate of production

Revenue = availability * time * rate of production * unit value added

Profit rate = availability * rate of production * (unit value added
- **energy costs per unit of production**
- **maintenance cost per unit of production**
- **operating costs per unit of production)**

Figure 2 Profit Rate Equation

Note that the equation expresses costs per unit of production. This is a better measure of costs than is total cost. Rather than minimum absolute maintenance cost, we really want minimum maintenance cost per unit of throughput. We could reduce maintenance cost by loading the unit below its capability, but this works against profit.

A major difficulty in trying to apply this equation is that availability and maintenance costs only have meaning from a longer-term perspective. The way we load and operate the equipment now will have a future impact on these key variables – and we do not know how to predict that impact quantitatively. In addition, as illustrated in Figure 1, the maintenance strategy adopted also affects these variables.

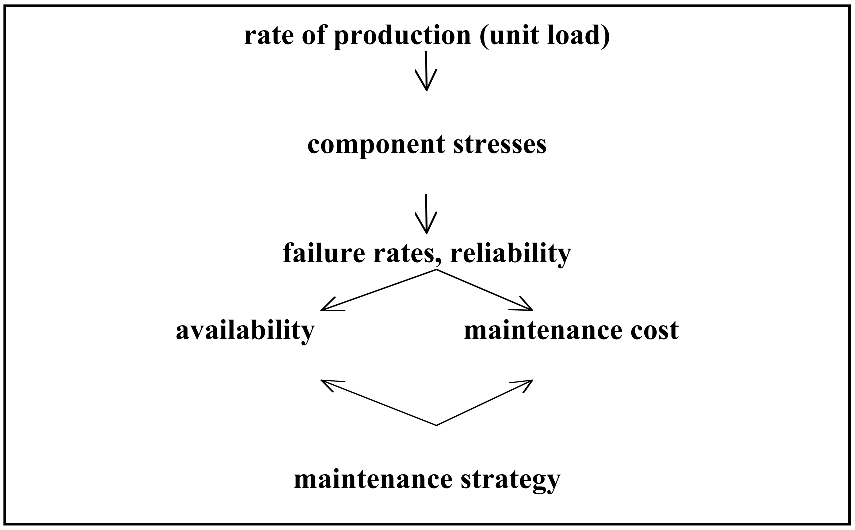


Figure 3 Availability and maintenance cost are determined by operating decisions and maintenance strategy

Therefore we will not actually be able to implement a profit measure in real time, but we can draw some useful conclusions.

Lessons from the Profit Equation

1. The factors determining economic performance (production rate or load, availability, maintenance costs, energy costs, operating costs) interact with each other; optimizing any one does not necessarily maximize the bottom line performance.

2. Maximum profit rate is achieved by loading the unit to the maximum production rate or load which does not cause disproportionate increases in costs (especially maintenance) and a disproportionate decrease in availability. This load will not necessarily be 100% of rated load.

3. Maximum efficiency, meaning the ratio of work out to energy in, is a valid objective.

4. Maximum availability is a more valid objective than maximum reliability, since total production is determined by *availability* and throughput rate. Be wary of "reliability at any cost"; the single-minded pursuit of reliability could *reduce* economic performance by increasing maintenance costs and decreasing availability.

5. We should measure and try to reduce costs per unit of throughput rather than in absolute/aggregated terms.

The Role of Condition Monitoring

Condition monitoring is necessarily central to any real asset management effort, since "you can't improve what you don't measure". Although we will not be able to measure real time profit rate, we will be able to measure many related attributes including a number of economic measures. These results can be used to drive better operations, maintenance and engineering decisions, ultimately leading to improved bottom line results.

In general terms, we need the following measures:
- baseline capabilities for each unit; capacity, efficiencies, mechanical condition
- load on the equipment, indirectly assessing stresses and wear rates
- current efficiencies
- current throughput rate and capacity utilization
- current mechanical condition
- deviations from baselines
- economic consequences of deviations from baselines

Fully implemented, these measures would enable and support prioritized maintenance actions and operating decisions based on economic impact. In addition, decisions on machinery upgrades or revamps would benefit from these measures of potential improvement.

Engine/Compressor Asset Management Measures

Technicians who routinely inspect engine driven reciprocating compressors using an engine/compressor analyzer are in a good position to deliver numerous measures of the types listed above.

baselines	performance	horsepower, capacity versus Ps, Pd, load step; HP/MMSCFD versus compression ratio
	fuel consumption	BSFC versus load, speed
	component loading	peak firing pressures, rod loads
	mechanical condition	vibration, pressure signatures
current measures	performance	horsepower, capacity
	fuel consumption	BSFC
	component loading	peak firing pressures, rod loads
	mechanical condition	vibration, pressure signatures
deviations from baselines	performance	HP/MMSCFD
	fuel consumption	deviation in BSFC
	component loading	compare with limits
	mechanical condition	flow balances; vibration versus baseline
economic consequences	performance	cost of wasted HP
	fuel consumption	cost of excess fuel
	component loading	risk of accelerated wear
	mechanical condition	risk = $consequences * probability of failure

Condition Monitoring in Support of Asset Management

Extending condition monitoring programs to directly support asset management is a major challenge. At one end of the range, the process could be largely manual. In this case, specialist personnel would acquire raw data, provide interpretation including economic consequences and take or recommend ROI driven actions. At the other end of the range, control or automation systems could automatically provide closed loop optimization.

In practice, when asset management depends on manual intervention, results tend to be limited. The amount of data to be analyzed is too large and the skills required to derive required measures are in short supply. Tools are needed to automate the process to the degree practical. A typical situation today is that plant personnel are "data rich-information poor"; in other words, they do not have tools which adequately help them complete the process; too much manual intervention is required.

The good news on this front is that, with proper setup and implementation, there are commercially available products that can be used to support asset management.

After a lengthy period of incubation, it appears that machinery asset management is a movement that is now real. And there are probably people other than the writer who thinks it's long overdue.

References

(1) Gino Palarchio, "Physical Asset Management Profession in 2010", SMRP Solutions, Fall 1999

(2) S. Bradley Peterson, "Defining Asset Management", Maintenance Technology, January, 1999

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