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A White Paper on the Benefits of utilizing OEE in a Job Shop:

Job Shop companies tend to believe that no two products are the same and so must be designed and built individually. The reality is that, although every end product may be unique, most of the individual operations that go into making a product are very similar. These operations depend on the two most expensive assets that any manufacturing company has: the equipment located on the shop floor and the people that operate it. Some operators and machines tend to perform much better than others regardless of the nature of the job itself. A Job Shop can optimize its overall performance by applying Overall Equipment Effectiveness (OEE) techniques that focus on manufacturing operations that are similar or repetitive. Having such OEE data permits the determination of why certain machines or teams perform better than others, and can allow a company to zero in on how to make all its assets perform better. It is not uncommon to see an overall 10–50% increase in efficiency on the shop floor after OEE is implemented. Considering the already-incurred fixed costs of equipment and labor**,** this gain translates into an even greater percentage increase in profitability.

A Job Shop that implements OEE will:

- Improve the efficiency of each underlying manufacturing operation.
- Improve throughput and reduce lead time.
- Record accurate costs for each manufacturing step, improving job cost estimates.
- Maximize utilization of each machine, optimizing steps between operations.
- Ensure that each machine is performing to its rated performance.
- Monitor, manage and reduce setup and teardown times.
- Monitor the Shop Floor from the Top Floor for competitive advantage.

Take the case of a custom cabinet manufacturer who cut turnaround time from 3 weeks to 2 days by breaking down each operation and improving overall throughput. A cutting operation is always the same, as is drilling, edging and so forth. By focusing on each operation and making it more efficient, the cabinet manufacturer enhanced the efficiency of the entire job process.

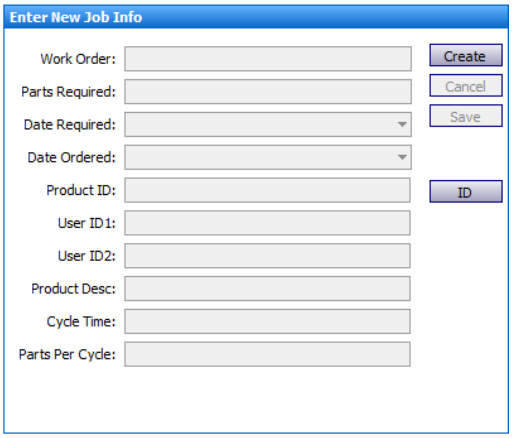
I. Break down each job into its measurable components

Manufacturing processes fall into one of three activity categories: 1) add material – such as raw material processing, packing, assembly, welding, painting, plating, etc.; 2) remove material – such as cutting, drilling, milling, grinding, etching, etc.; or 3) reposition material - such as forging, casting, molding, bending, etc. The complexity of any process involving any one or more of these three activities is a design issue chosen by the manufacturer. Smart companies design their processes to be maximally efficient with least cost, which means the efficiency of each operation must be tracked and managed.

OEE metrics are a tool to measure efficiency. If you can measure a process or a machine's operating characteristics, then you can manage the process or machine to obtain optimal results. As a definition, *OEE = Availability x Performance x Quality*; or, put another way, *OEE = Utilization x Standard Rate x Yield*. In a Job Shop where only one finished good part is processed at a time, the Quality (Yield) is theoretically 100% (in reality there is a measurable degree of waste with scrap and/or rework). Thus, for

the typical Job Shop, *OEE = Availability x Performance.* Based on this definition, any Job Shop can benefit by monitoring Availability and Performance. A manager can ask questions such as: "Are the machines being utilized effectively?", "Are machines and/or operators achieving the desired performance characteristics?" and "Can operations be aggregated to optimize a machine's utilization?". Machines are expensive: they should be put to maximum use and, once running should be operating at their optimal performance at all times.

Many factors can affect machine performance, including operator overrides, material flow, wasted time in loading and unloading material, or even retrieving operating programs or work order specifications. A Universal Machine Interface (such as that available from Memex; illustrated at the right) allows a wealth of information to be manually entered or captured automatically at the machine.



Along with specific job-related data such as work order number (WO#), total parts required, date required, and specific product identification (ID), data for accurate OEE calculation can be recorded, including cycle time for an operation, compared to standard, and parts per cycle.

Two additional information fields are also provided by OEE software: a Tool ID field and a Material ID field. These fields allow specific tool and material identifier information to be included to aid operators and provide reporting criteria. For example, if a specific tool is used each time an operation is performed, the use of the Tool ID field permits the determination of the total operation time of that tool, which can then be used to track tool life. In other words, implementation of Memex's OEE Software by a Job Shop automatically supports tool life management as it increases the efficiency of product manufacture.

II. **Multi-Operation Manufacturing in a Job Shop**

A typical product has many operations associated with its manufacture from start to finish. For example, a crankshaft requires 32 operations to produce the final product. In a Job Shop equipped with Memex's OEE software, the "Bill of Material and Routing" system would export the list of 32 operations into the job queue in the OEE software, creating 32 separate sub-work orders that comprise the master work order (WO). Each operation would be assigned a master WO# followed by a hyphen and a unique identifier. Given that the field properties for a WO# allow 18 alpha-numeric characters, there are well over 10 million combinations of characters that can be used to define sub-work orders and, hence, individual manufacturing operations. In the above example, the work order sequence would appear as master WO# 123456 followed by unique numbers for each manufacturing step, such as op 10, op 20, op 30, op 40, etc. This sequence would appear as: WO# 123456-010, 123456-020, 123456-030, 123456-040, etc.

Each work order imported automatically or entered manually into the OEE software should include the specific information noted above, as well as product standards information. As each operation or sub-work order is completed, the information derived from that operation is stored in the Memex historical SQL database and can be used to prepare reports. The OEE software not only tracks the time

consumed by each separate operation, it also tracks the lost time between operations, allowing the Job Shop to take steps towards optimizing its processes and achieving lean manufacturing.
OEE software is especially valuable to Job Shops where product specifications change frequently. Although the products being manufactured may differ, the associated operational steps are finite and granular and thus can be monitored. With this monitoring, a succession of different operational sequences can be managed effectively.

III. How Monitoring OEE Delivers Benefits to Job Shops

The benefits of achieving high levels of OEE can be seen in a continuing profit stream that delivers, year after year. Any efficiency gained in the manufacture of one job can be applied to all future jobs that use similar operations. Continuing our example of the 32-operation crankshaft, a Job Shop employing OEE software could provide a user with the total time taken to produce the product because the system can aggregate the time taken for each of the 32 operations. The OEE software makes it easy to account for all operations and to acquire information on the total of all operations, or only some operations, or an individual operation. This intimate knowledge of each step required to complete a job brings many benefits to a job shop, as follows:

1. Improve the efficiency of each underlying manufacturing operation.
   The level of detail collected by OEE software allows for comparisons such as shift-to-shift, machine-to-machine, operator-to-operator, and operation-to-operation to identify areas for improvement. In other words, the OEE software facilitates a system performance analysis that evaluates the effectiveness of each and all steps of the manufacturing operation, leading to rational optimization decisions. This analysis may also identify opportunities to share resources among different operations.

2. Improve throughput for lead time reduction and optimize steps between operations.
   Identifying time taken between work order/operation submissions to the start of operation allows for the calculation of the non-operational time accumulated for each work order/operation. This queuing time correlates directly with the ability of a Job Shop to reduce lead time.

3. Record accurate costs for each manufacturing step and improve job cost estimates.
   The operational detail recorded by OEE software allows the product costing department to validate its “cost to manufacture” estimates by comparing the time estimated for each operation in the manufacturing cycle to the actual time taken.

4. Maximize utilization of each machine.
   The ability to record machine utilization based on operations tracking definitively identifies planned vs. actual time of machine use. Monitoring of each operation specifically allows for the identification of unscheduled events that have an impact on machine performance. Identifying a bottleneck, such as over-lengthy material preparation, pre-prepared processing or post-processing, can assist in improving efficiency.

5. Ensure each machine is performing to its rated performance
   With the granular operational information provided by OEE software, the accepted operation standards of a given machine and its actual operation performance can be compared. Accepted standards for specific operations can be formulated or adjusted dynamically based on real data obtained directly from the machine as it runs.

6. Manage and reduce setup and teardown times
   Because every machine event is recorded by OEE software, actual tool change, setup and teardown times can be compared against the expected times for such tasks. Identical tasks performed on different machines by different operators can be compared, providing critical information for improvement initiatives. Real-time communication by operators can alert key personnel to unpredictable setup issues. In many Job Shops, new part program files may never have been run before on a given machine, requiring engineering help. Real-time email and SMS text message alerts sent from an operator can greatly reduce time wasted in setup because engineering resources are alerted proactively.

7. Monitor the Shop Floor from the Top Floor for competitive advantage
   Automated machine monitoring provides shop floor visibility and transparency that allows management to also be proactive rather than reactive. Real-time event monitoring with email notifications on sub-standard performance allows corrective action to be taken before lengthy and costly unplanned downtime accumulates beyond acceptable thresholds. OEE metrics are a proven, validated method of monitoring the manufacturing process and provide a significant competitive advantage when customers are looking for a low cost base coupled with reliable and high quality manufacturing.

IV. OEE Benefit Case Studies

i. OEE Metrics

Issue: ROI & PAYBACK

A common concern with implementing an automated OEE data collection system is whether the investment will have a speedy payback period and represent significant Return On Investment (ROI).

Solution: Once you can measure a process, then you can manage it. This management often translates into a 10-50% ROI and full payback within a few months. For example, a company had a multiple step operation in which the OEE of one machine was only 30%. This poorly functioning machine caused a bottleneck that led to backlogged parts and starvation of downstream production. By monitoring the machine using OEE software capable of tracking time-stamped events, and addressing problems with material loading/unloading and operator actions, the company was able to improve the efficiency of that particular operation by over 100% in just a few days. As a result, overall production efficiency skyrocketed and the company benefitted hugely.

Another example can be found in the *Modern Machine Shop* cover story “From Job Shop Chaos To Lean Order”, November 2010. This article showcased a company whose adoption of lean manufacturing principles greatly increased productivity and proved to be extremely valuable. It was the first time that this Job Shop had tracked and reviewed OEE metrics, which helped management to develop a new work

cell approach. Productivity increased by 20%, lead times were cut by 40%, and scrap and rework times were halved. OEE metrics were critical to making and understanding the impact of the required changes.

ii. Machining and Fabrication -- Complex operations

Issue: UNCERTAIN OR EXCESSIVE LEAD TIME

A client's sales orders were considered custom fabrication in that the assembly order required a minimum of 100 operations comprised of both machining steps and manual fabrication steps. The prime concern of the manufacturer was to be able to calculate lead time from order to delivery. Historically, as an order went into production, the actual lead time would vary considerably due to commitment of operation resources available at the time of submitting the order.

Solution: OEE software was implemented on the manufacturer's machines and fabrication stations to document the current process, adjust the "fudge factors", and reduce lead time. OEE software calculated the actual time for each operation performed at each machine or station for each work order. This information provided a true cycle count for comparison against estimates, thus allowing the lean team to adjust standards to reflect real cycle information. Setup and teardown times were also documented through OEE software and similar revisions to standards for these processes were made. Because the manufacturer obtained actual data for each operation on the shop floor, it could calculate the time expended on the product in staging or queues, waiting for the next operation to be executed. This historical information provided an accurate timeline of product manufacture from order to shipping. Areas where previously unknown staging and queuing bottlenecks were identified were then addressed, reducing overall lead times considerably and providing much more accurate estimates for customers.

iii. Multi-step Manufacturing -- Low volume/High value

Issue: INACCURATE COST ESTIMATES – ERODING PROFITABILITY

In this example, the manufacturer provided high performance crankshafts to the car racing industry. The specifications on the product were always being modified, so that each run of production could vary considerably. A typical crankshaft required up to 35 operations to complete, and the cost of each operation was estimated based on past experience. The manufacturer was concerned that inaccurate cost estimates were reducing profitability on sales orders.

Solution: OEE software was installed to automate data collection and provide highly granular information on each operation performed. Although product specifications changed constantly, the required series and sequence of operations were the same. Data for each operation were collected and compared to cost estimates to identify inaccuracies. The manufacturer's costing formulae were adjusted to reflect actual data and lean initiatives were implemented, thereby greatly improving the estimation process and increasing profitability.

iv. Capacity Manufacturing

Issue: CAPACITY LIMITATIONS

A manufacturer was having difficulty in processing orders because there were several bottlenecks on the shop floor that caused downstream shortages and material backlogs. The traditional solution would have been to purchase more high value assets to improve productivity; however, the manufacturer could not afford to do so.

Solution: OEE software was installed to identify hidden capacity and improve the productivity of the existing machines. Through OEE data collection, real OEE efficiencies were calculated and information was gained that enabled lean personnel to make fundamental adjustments to processes. As a result, 10-

50% productivity improvements were added at the machine level, and an overall 25% improvement in productivity occurred at the plant level. Half of the bottlenecks were eliminated and the rest were minimized, drastically reducing backlogs and improving turn-around times on every order.
In another example, a Job Shop performed precision machining of components using 28 machines. After installation of OEE software, production efficiency increased by 25%. The company saved both the purchase price of several new machines and the cost of having to expand the building footprint to accommodate them.

v. Engineered Manufacturing

Issue: FREQUENT SETUP AND TEARDOWN
A contract manufacturer produced short run orders almost exclusively. These orders were high value one-offs or "strangers", both of which required frequent setup and teardown and the introduction of new part programs. Accurate estimation of the time consumed by non-operations such as setup and teardown was almost impossible, given the nature of the business. The company was forced to charge exaggerated setup costs to cover frequent unforeseen issues.
Solution: OEE software was implemented to obtain accurate data and facilitate lean manufacturing techniques. Real-time machine monitoring through the OEE software recorded times for tool change, setup and teardown. These times were then compared against expected task times, providing critical information for improvement initiatives. Lost time was minimized because operators had real-time information that could alert key personnel to unpredictable setup issues. Time wasted on problematic part program files requiring engineering assistance was greatly reduced through proactive instant email and SMS text message alerts sent from the operator. Furthermore, the ability to instantly communicate facilitated elimination of material shortages at the machine and improved responses by maintenance and supervisory personnel when needed. Indeed, OEE software made the operator a key part of the overall solution to the "lost time" problem.

Are you leaving money on the table?

Most managers have a "gut feel" that their plant can be more efficient but have trouble pointing to specific area(s) where actual data and a sound analysis show that room for improvement exists.
If you could improve OEE by 10%, what would it mean to your operation? For the typical Job Shop, such an improvement would mean 10% more products could be made per week, utilizing all of the same resources of labor, time and equipment. Assuming the product price remains the same, and the only expenses are material and distribution costs, which also remain the same, the difference in pre-OEE and post-OEE revenues is pure profit: money that is being left on the table EACH WEEK. Moreover, for each week that pre-OEE manufacturing that slips by, that money is also lost. A world class level of OEE is considered to be 85%: divide this optimal level by your current level of OEE and you clearly define your opportunity gap. Implementing OEE software ensures that you fill that gap and leave as little money as possible on the table in the form of inefficiency.

Conclusion

Just as is true for a repetitive manufacturing facility, a Job Shop must be able to measure the effectiveness of each of its operations. OEE software and automated data collection tools, such as Memex's Universal Machine Interface, allow a company to collect real-time and historical data that it can use to refine its manufacturing process and optimize efficiency. The company reduces its overall costs and increases its competitiveness just by making the Shop Floor talk to the Top Floor.