# Proposed KPI Revisions for Tool Gauge

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***Abstract*—Tool Gauge business model does not resemble that of the low-mix high-volume manufacturers that often capture public attention. The high-mix low-volume nature of Tool Gauge discourages dedicating excessive amounts of time to a single part and instead encourages reducing the costs associated with switching from one product to the next[1]. As such, it is recommended that Tool Gauge adopt the following KPIs:**

- **Cost of Set-ups**
- **Multiple Scheduling Accuracy KPIs**
- **Labor Hours Available vs. Scheduled vs. Reported**

**There may also be some merit in considering other KPIs such as Overall Equipment Effectiveness (OEE) or Machining Equipment Effectiveness (MEE)[2]. However these may require more sophisticated process monitoring tools.**

## I. Introduction

MANUFACTURING as traditionally presented relies on high volumes with minimal variety between parts:

- Machines and operators make the same parts for days at a time
- Set-up times are a drop in the bucket
- Most presses are running simultaneously, with the next set-up potentially being days away
  - Molders and Engineers tweak the machine mid-process
  - QA is heavily automated and can track the process in real time
- The majority of costs go to many small processing mistakes accumulating over days or weeks

The manufacturing model of Tool Gauge does not neatly fit a traditional framework[1]. Arguably, Tool Gauge is compensated for its flexibility, not for its ability to produce an individual part at a low cost. Tool Gauge at its finest does the following:

- Sets-up and tears down molds in little time
- Leverages the knowledge and expertise of its molding and machining team to transition from last shot to first shot with minimal tweaking
- Has QA inspectors who can quickly look up part requirements and work with the molders to quickly buy-off parts
- Quickly prepares its operators to process and inspect multiple part numbers within the same day and Tool Gauge has a high degree of confidence in the part quality from those operators
- Takes a last-minute order from a customer and adapts its plans to accommodate with minimal schedule sliding
- Oversees project management on behalf of the customer; achieving rapid project deliveries

This model is a high-mix low-volume manufacturing model and emphasizes a different set of skills than traditional manufacturing. Tool Gauge benefits from a wide range of process capabilities and possessing more skills or capabilities than what any one customer needs is built into the price that they are willing to pay.

| Job shops can use these lean tools | Job shops cannot use these lean tools |
|---|---|
| Strategic planning | "The Toyota Way" mindset |
| Top-down leadership | Manual problem-solving |
| Gemba walks by managers | Value stream mapping |
| Employee engagement | One-piece flow cells |
| Workplace design with 6S | Product-specific Kanbans |
| Tpm (total productive maintenance) | Fifo sequencing of orders |
| Setup reduction (smed) | Pacemaker scheduling |
| Error-proofing (poka-yoke) | Inventory supermarkets |
| Quality at source | Work order release based on pitch |
| Visual workplace | Production planning using level loading |
| Product and process standardization | Mixed model "heijunka" scheduling |
| Multi-tasking (= flexible) machines | Right-sized (= inflexible) machines |
| Standard (but flexible!) work | OEM-style pull production |
| Continuous problem-solving | Manual scheduling |

Fig. 1. Some of the Traditional Lean Tools Will Work for Tool Gauge, Some Will Not[1]

The sheer variety of work performed by Tool Gauge also discourages micromanaging a given product if it comes at the cost of flexibility or creates an exception where one need not exist. If we accept this manufacturing model, we assume that Tool Gauge can reduce overhead costs, increase productivity, and secure more contracts by embracing the following priorities:

- Shrinking the time between last shot and first shot as much as possible. This offers the following benefits:
  - Tool Gauge is more productive per day and can handle more contracts without additional equipment
  - The amount of money spent per setup will drop:
    - Currently a setup on a mid-size machine can cost on the order of $100-$150. If that machine has multiple setups in a day, that can amount to $500/day of time spent not producing revenue for Tool Gauge
    - The current machine rates are on the order of $60+/hr for mid-size machines, nearly 3 times the cost to Tool Gauge of an operator or molder. By that metric, an idle machine should be treated with the same gravity as 3 idle molders or operators. This same argument says that Tool Gauge might be earning more revenue if labor occasionally exceeds demand
  - The cost of overhead will drop in proportion to the drop in idle machine time
  - This requires the following improvements
    - A thorough evaluation and investment in a SMED program for all frequently used tools
    - Increased coordination between QA, Setup Technicians, and scheduling

    - Increasing the reliability and accuracy of scheduling and production reporting
    - Investing in the statistical and material analysis tools necessary to reduce the amount of time spent establishing a passing first shot
    - Investing in the inspection tools and automation necessary to allow for rapid inspection, feedback, and approval
- Reducing the days to complete an FAI[1]:
  - This offers the following benefits
    - For many companies, Boeing especially, time to market is a critical priorities. Fast FAI completion increases our appeal to customers struggling in competitive markets
    - Fast FAI completion provides more time for process improvement and adaptation; Tool Gauge spends less time catching up
    - Mistakes made early in the project development are caught sooner and are easier to identify. Time can obscure the root cause of many problems
  - Producing more tooling internally is the easiest way to reduce FAI development time. The benefits are sufficient to merit their own paper but will be quickly summarized as:
    - Internally made tools can shave as much as 75% off our completion time
    - Tooling adjustment needs are identified almost instantly
    - Producing tools internally reduces mistakes due to any language barrier
    - Fewer trips overseas are necessary
    - Tool Gauge made tools are of higher quality than their overseas equivalents
    - Tooling is a potential revenue source if Tool Gauge would like to diversify and can sell other companies on buying domestic tooling
- Building an ERP and planning infrastructure that is robust, dynamic, and consistent:
  - This reduces mistakes and errors; making them self-evident. In this situation quick correction and root cause finding is relatively simple
  - Decisions can be made with greater clarity as the reality on the production floor is better understood and less subject to unexpected change
  - This requires that the system schedule must be closely correlated with future results
- BOMs must be accurate and their degree of accuracy must be understood by the scheduler
- Changing the schedule on the day-of production should be avoided wherever possible
- Multi-day production should revise projections based on past results
- Overproduction should be avoided or planned days before by the scheduler

[1]This already exists as a KPI, however there is merit in emphasizing its significance

  - Labor must be accurately reported to help identify mistakes and improvement opportunities
  - Process information and history must be meticulously documented and easily retrieved/processed. This allows Tool Gauge to leverage statistical inference tools, utilize optimization algorithms, and automate daily decisions
  - Increasing the quantification of many aspects of daily work at Tool Gauge. Tool Gauge relies on the ability to make decisions based on costs, revenue, and projections. Advocating for necessary changes can be impossible if retrieving the information needed to make a point is difficult or impossible[2]

## II. KPIs

The KPIs listed below are intended to encourage growth in a direction that Tool Gauge is already headed.

### A. Existing KPIs that Support High-Mix Low-Volume

Some of the KPIs already adopted by Tool Gauge encourage the changes and improvements mentioned above:

- Downtime
- Days to Complete FAI
- BOM Verification Accuracy

### B. Proposed KPIs

To encourage improvement and transition from a traditional manufacturing environment to a dynamic environment with improved transparency and market appeal, Tool Gauge should consider the following additional KPIs:

1) The Speed of Station Changeovers
   a) Average Set-up Time (by Press) vs. last week, last month, etc
   b) Average Set-up Time (by Machine) vs. last week, last month, etc
   c) Cost of set-ups; aka net $setuphrs * machinerate$
2) Scheduling Accuracy
   a) Day-of-production schedule changes per wk, per month, etc
   b) Number of molds loaded in machine more than once per quarter[3]
   c) Average of actual run length/projected run length per week, month, etc
3) Compare labor hours scheduled to labor hours consumed (ie: the schedule says that $\frac{40hrs}{wk*N_{operators}}$, how many hours of labor were reported?)

[2]I say this, fully aware of the fact that many points in this document rely on a degree of speculation. Historically, accurate information can be difficult to retrieve from IQMS, making speculation an unfortunate necessity

[3]This sentence is a mouthful, basically I'm trying to say that we record how often a mold is set-up, as opposed to a cavity change. From there, if the number of set-ups is greater than 1 it's captured by the KPI

## III. Setting Tool Gauge Up for Long Term Process Improvements

There are other opportunities for improvement that, while difficult to capture with a KPI, should not be forgotten:

1) Graphing scrap rates for a given job beyond the last scrap rate
2) Documenting molding parameters and storing them according to work order; performing statistical analysis on higher volume jobs
3) Tracking movements/patterns in the quality of parts
4) Quantifying part quality as much as possible $\rightarrow$ performing statistical analysis on higher volume parts to predict and improve future performance
5) Looking for additional opportunities for quantification[4]

## IV. Future KPIs

There is some research into adapting Low-Mix High-Volume metrics into a High-Mix Low-Volume environment. Specifically, adapting Overall Equipment Effectiveness (OEE). OEE describes the production of a station relative to a theoretically perfect station. The formulas for OEE are shown below[2]:

$$OEE = A * P * Q * 100\% \tag{1}$$

$$A = \frac{t_{operating}}{t_{planned\ production}} \tag{2}$$

$$P = \frac{t_{net\ operating}}{t_{operating}} \tag{3}$$

$$Q = \frac{t_{value\ operating}}{t_{net\ operating}} \tag{4}$$

The similar terms in P could be confusing, P is typically calculated by divided the theoretical output by the operating time. In Tool Gauge terms this is the efficiency rate. Jauregui recommends a more sophisticated set of algorithms summing the performance of many different work centers to create a machine equipment effectiveness (MEE)[2]. The algorithms are not replicated here but can be looked up as necessary.

## References

[1] Shahrukh A. Irani *Production System Design for High-Mix, Low-Volume Manufacturing*, n.d., 4.

[2] J. M. Jauregui Becker, J. Borst, and A. van der Veen, *Improving the overall equipment effectiveness in high-mix-low-volume manufacturing environments*, CIRP Annals, vol. 64, no. 1, pp. 419–422, Jan. 2015, doi: 10.1016/j.cirp.2015.04.126.

[4]There are some academic concerns about over-embracing quantification: it can de-emphasize values that resist quantifying. While such concerns should not be ignored, they should not come before the significant improvement in process management that quantifying would represent.