Solar Module Line Ramp

Case Study: Process Integration for Manufacturing Demonstration

Mountain View Energy

Introduction

Producing relevant and timely results is critical in every endeavor. Monitoring organizational status towards this goal is a key for judging performance and driving success. The stage of the program, the complexity of the equipment and processes, the cost profile of materials, and maturity of the technology all define risk, but in different ways. Large clients with high-readiness technologies, typically have a large capital resources little time.

Challenge

We were asked to manage product development (product integration) for a 60 MW solar cell line using a high-performance but challenging material system. Our responsibility was to ensure that we quickly identify gaps in product performance, and develop the experimental plan for product performance and yield improvement. It soon became apparent that this program was critically understaffed in the process development area. Since success of the entire effort hinged on this portion of the operation, we redeployed half of the product integration team. In addition, the program was 18-months into a 24-month schedule was six-months behind, so the client decided to take a tiger-team approach catch-up. On top of this, the product integration team was to provide continuous coverage over a five-month period. We were responsible for line disposition and reporting 24x7 basis when the line was running, and failure analysis and experimental reporting and planning on and 14 hour per day cycle when the line was maintained.

Action

To manage the time shortfall, we defined a methodology (we named “flying tiger-team”) in which we would leap-frog program goals by sample scale. We would start with cell performance goals, once those were met, move to module performance goals, and finally line performance. Once goals from one scale were met, work in that area was frozen and subsequent goals were defined for the next scale. This allowed for order-of-magnitude improvement in throughput as we moved from

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Mountain View Energy: +1-650-996-1243, mvwenergy@gmail.com

scale-to-scale, but was predicated on the assumption we knew the physics of the technology very well. The risk was that if in later stages we ran into a mistaken assumption, we would have to circle back to a finer scale to determine the issues and enhance our understanding, thus eliminating the chance of catching up on the schedule.

Since we were well-below critical levels, we managed the personnel shortfall by 1) focusing our team on material deposition and data analysis during runs, 2) product debugging between runs, and 3) drafting staff from other parts of the organization to handle a few critical tasks that enabled near-term progress. For critical team functions, we delegated critical responsibilities to remaining team members. We deprioritized less critical measurements to be done on an as-approved basis, and trained other client staff to handle some tasks.

To handle line coverage, we automated report generation and drafted client engineers to run and distribute these reports when our team was not available. They were trained to identify certain patterns in the data so they could escalate line deviations and call in our team in emergencies. We met daily to examine results, and plan for the next 24 hours. We reported to senior management daily findings and recommendations. Additionally, we structured experiments and technical goals following the flying tiger team methodology to move quickly from small-scale tasks to full-scale focus as quickly as line stability allowed.

During any large program, no matter how well planned, unexpected incidents occur. Two crises arose during the program, the first solving the issue when solar cells were non-functional. In this instance it was the first line experiment and the cells were expected to work. Also there was no prior history upon which to draw we designed short-loop experiments using a binary search method to isolate the problem. Doing so quickly led to isolating the problem, which meant changing the specifications on one process step.

The other crisis arose during the second module scale-level of the program, when we hit a plateau in performance, and our primary control parameters were not producing the expected improvements. In this case, metrology and MIS systems were functional and through data-mining could uncover trends. We ran a series of queries, protocol assessments, and physical analyses to narrow the cause. By using the line-date, and physical data to form a coherent description, we isolated the interactions that were causing the issue.

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Results

In the six months that the we operated the line, cell efficiency improved from 0.1% to 16%, peak module efficiency of 13% (our goal was 10%), all at full production rates and module size. The team worked efficiently, solving each module problem encountered fast enough we were never a program limiter (very rare for process integration). In fact, as an organization we surpassed all technical goals, and did so with two months to spare. The team was recognized by the client for meeting team performance goals with only 50% staffing.