Material Quality System in Solar Cell Manufacturer

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Extended Abstract

Keywords: material quality control, data science, optimal computing budget allocation (OCBA), simulation optimization, vendor selection and order allocation.

I. Introduction

Inspection of the material quality during the procurement process is frequently challenging. In many instances, the true quality might not become apparent after several manufacturing processes have been completed or until the final test of the finished product. This study takes into account the manufacturing parameters and, using a simulation optimization technique called optimal computing budget allocation (OCBA), calculates the probability distribution of the material quality. Then, we optimize the material feeding portfolio for the production process based on the customer's order specifications and requirement. In our numerical study of the solar cell manufacturer, the results show that the proposed model improves the solution quality of material quality estimation and potentially reduces the procurement cost.

II. System Architecture

The proposed model shows an analytics framework including the four components. The analytics framework is shown in Figure 1. Customer orders, supplier materials, the process recipe, and the process cost are recorded in the database. The fundamentals of the proposed framework demonstrate the simulation optimization algorithms that are used to estimate the distributions of material quality (MQ) and process quality (PQ) in the MQ and PQ modules, respectively, and to capture the stochastic effects of the quality characteristics influenced by the supplier's material (for example, silicon wafer) and process recipes. As a result of the output from the MQ and PQ modules, the model introduces the MA module to optimize the portfolio cost of material allocation (MA) given the customer's needs (for example, average specification). The benchmarking and negotiation pricing for the material bargaining (MB) are provided by the MB module, which encourages the supplier to improve.

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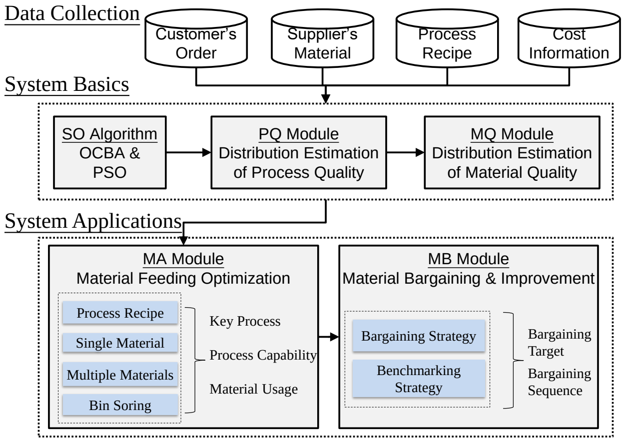

Figure 1. The proposed analytics framework (Lee et al., 2022).

III. Numerical Analysis

A numerical analysis of a solar cell factory is carried out to validate the proposed framework and compare it to earlier work in literature. This study attempts to produce a cost-effective solar cell that meets the customer's conversion efficiency (CE) while optimizing the suppliers' material allocations in an uncertain environment. The conversion rate of solar energy to electrical energy, or CE, is defined as the ratio; the greater the CE, the more electricity can be produced. Investigating the CE of the raw material—in this case, the silicon wafers—that was obtained from the supplier is challenging because it can only be checked at the end of the production flow line. Typically, average quality determines the price of the raw wafers. The probability distribution may, however, have a variable skewness given the same average value of the CE, causing the material price should vary and be justified.

The findings have some intriguing managerial insights: (1) understanding the probability distribution of the material quality and saving on material procurement costs are the benefits; (2) this study discovered that the quality distribution of the material from one specific supplier, which was more expensive, did not outperform the material from the other supplier, which was cheaper; (3) the result suggests the preferred order of the material usage (i.e. the portfolio) for meeting CE specification for customer; (4) we also found that the total cost with a high CE is lower than the total cost with a low CE, which is against our intuition and offers a valuable managerial insight; (5) we suggest the potential procurement cost reduction due to the quality benchmarking of the best practice; (6) we also demonstrates that one supplier provides the better quality than its expectation (i.e., the material with lower cost) for certain CE categories, and therefore the manufacturer should bargain with other specifications.

REFERENCES

[1] C.-Y. Lee, Y.-L. Lin, S.-H. Lin, and T. Yang, "Virtual material quality investigation system," IEEE Transactions on Engineering Management, 2022.