N81 30539

GENERAL ELECTRIC POINT FOCUS SOLAR CONCENTRATOR STATUS

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ABSTRACT

The General Electric Company is currently under contract to the Jet Propulsion Laboratory to design, fabricate, install and test a point focus solar concentrator that, given a high volume of production, will optimize the ratio of performance to cost. The concentrator design approach has evolved by a systemmatic process of examining the operating requirements particular to the solar application, minimizing material content through detail structural design and structurally efficient subsystem features, and utilizing materials and processes compatible with high volume production techniques. This paper briefly describes the design approach, the present concentrator configuration and the status of the hardware development.

INTRODUCTION

The General Electric Company is currently under contract to the Jet Propulsion Laboratory to design, fabricate and test a prototype 12-meter diameter point focus solar concentrator. A feature of the analysis and design phase of the program has been to include a value engineering iteration which has examined the cost and function of the concentrator subsystems and their components relative to the design requirements and the operating environment. Such an iteration was conducted early in the preliminary design phase; however, several important factors necessitated another iteration after completion of the detail design. Early performance and operating environmental requirements were established based on sensitivity studies which incorporated simplified models for both the optical performance of the design and the weight and cost of the subsystems. As the detail design evolved, complex structural/optical relationships arose, necessitating the need for more sophisticated analytical and design tools. Use of these tools soon identified the fact that small decreases in performance could result in large cost reductions and that costs could be reduced by better matching several component designs to both the structural requirements and manufacturing processes.

DETAIL DESIGN ITERATION

The approach for the detailed design "value engineering" iteration consisted of utilizing the first iteration detail design as a baseline description for function, weight, cost and producibility (this baseline design is described briefly in Reference 1). Cost saving designs were incorporated and the resultant performance effects evaluated. In addition, several environmental requirements were relaxed to test the cost sensitivity. Figure 1 depicts the new concentrator design. Major variations from the baseline design that were studied and eventually incorporated include the use of a skinned core gore segment, use of steel corrigated internal ribs with a simplified gore joint design, and implementation of a new mount frame design which utilizes less material, simplified joints, and eliminates the upload structural requirement on the foundation.

The analysis methodology, as depicted in Figure 2, consisted of modelling each of the design changes, determining the optical effects of these changes and then altering the structural stiffness and material content until appreciable performance degradation was indicated. The analytical tools consisted of a detailed finite element structural model (NASTRAN) which determines loads, stresses and deflections for multiple orientations and environmental load cases, a ray trace optical program (POLYPAGOS) which mapped the focal plane flux profile for the deformed concentrator, and an optics program that further spread the focal plane energy due to reflector specularity and finite solar energy distributions. Included in the tradeoff optical studies were the distortion effects due to orientation, seismic loads, asymmetric wind loads, gore manufacturing tolerances and the thermal expansion characteristics of the various materials used throughout the concentrator.

The resultant performance characteristics are shown in Figure 3. These trends show the intercept factor variation with receiver aperture and wind speed and the thermal performance as a function of receiver aperture, wind speed and ambient temperature variation. The thermal performance predictions are based on a receiver loss model that considers radiation, conduction and convection thermal losses. As a result of this design iteration, the rated wind speed has been reduced to 15 mph from 22 mph and the recommended aperture size has been increased from 11.25 inches to 12.5 inches. The resultant usable thermal energy available to the heat engine is 58.5 kW_{TH} versus 60 kW_{TH}, a 2.5% performance decrease.

As shown in Figure 4, however, substantial reductions were made in both the concentrator weight and cost. The baseline design weight was 172 lb/m^2 of concentrator aperture. The prototype weight, which consists of many of the design improvements identified, weighs 123 lb/m^2. The potential weight of 108 lb/m^2 reflects including weight reduction designs that were not incorporated due to the near-term prototypical nature of the concentrator. Similarly, substantial cost reductions were realized as a result of reduced material content, use of lower cost materials and changes in the manufacturing approaches.

Clearly, as a result of this detailed design "value engineering" iteration, significant improvements in the concentrator cost-to-performance ratio were realized.

HARDWARE STATUS

The concentrator design as discussed above is currently in the initial stages of fabrication. The structure and foundations are in the procurement cycle while the control system and gore/reflector development is nearing completion.

A major effort on the program has been the design, material and process development, and tooling fabrication of the molded plastic gores. This activity has been divided into two areas: process development of a parabolic pilot mold facility and the design and fabrication of the prime gore segments and their molds. Figure 5 depicts several aspects of the pilot mold, including the resultant molded gore segment both as molded and with its reflector system applied. This pilot mold has been used to evaluate material and process parameters, and to provide specimens for structural and environmental testing.

The design of the prime gore segment molding facility has been completed, fabrication of the mold handling and support equipment is nearing completion, and fabrication of the master gore segment patterns has begun. Figure 6 depicts the sweep tooling that has been constructed to generate the parabolic contours. Also shown are the early stages of the outer gore segment master pattern fabrication.

Present schedules call for site installation, commencing with the foundations, occurring in the first quarter of 1981, with testing early in the third quarter of 1981. The resultant design alterations will determine the readiness of the concentrator for system applications.

REFERENCES

1. Zimmerman, J. J., "1st Generation Low Cost Point Focus Solar Concentrator," JPL Report 5105-8, pp. 63-67, April 1980.

FIGURE 1

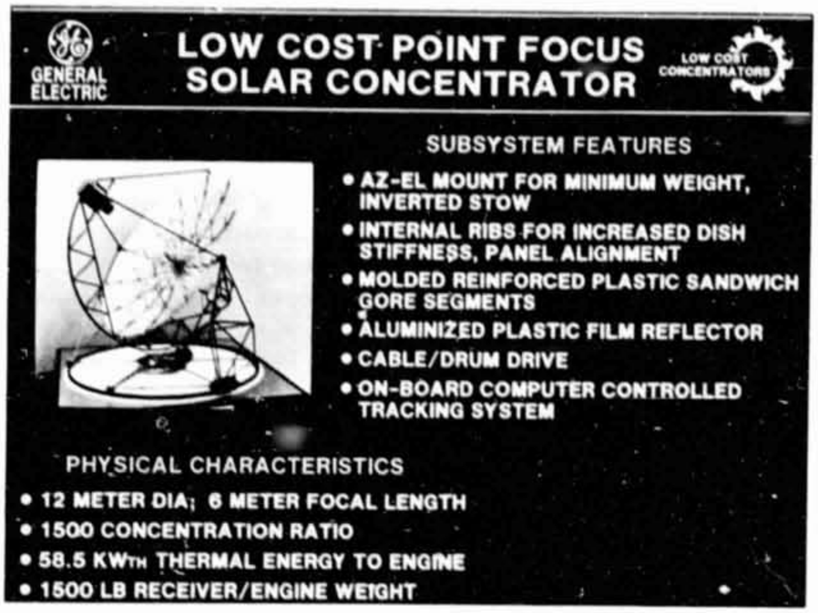


FIGURE 2

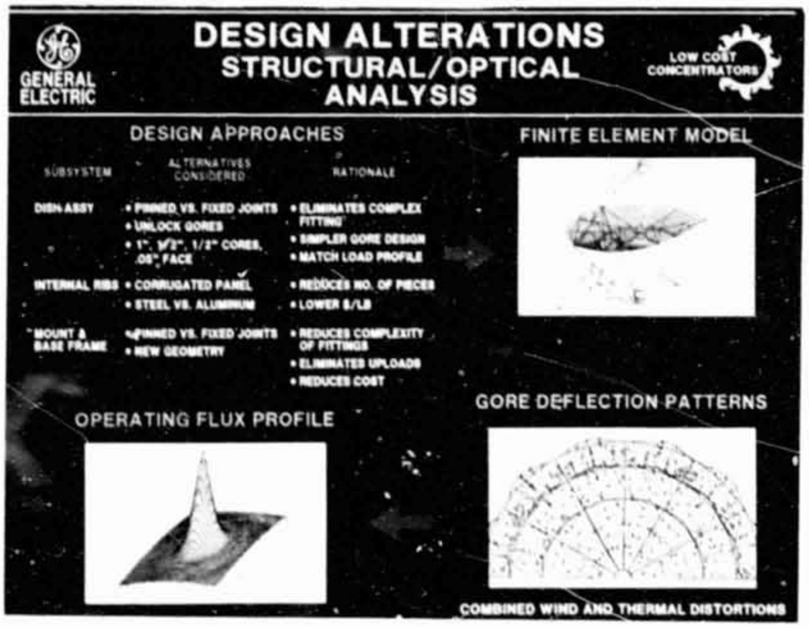
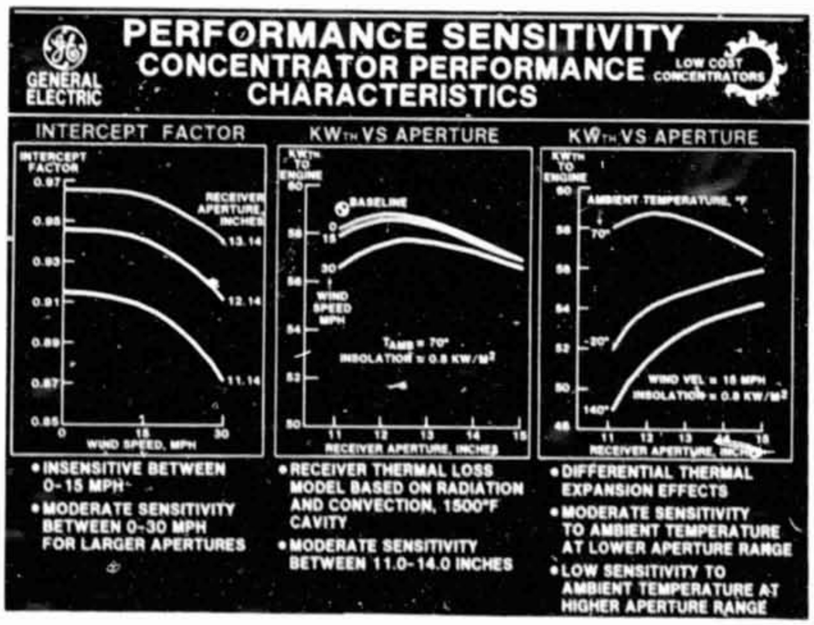


FIGURE 3



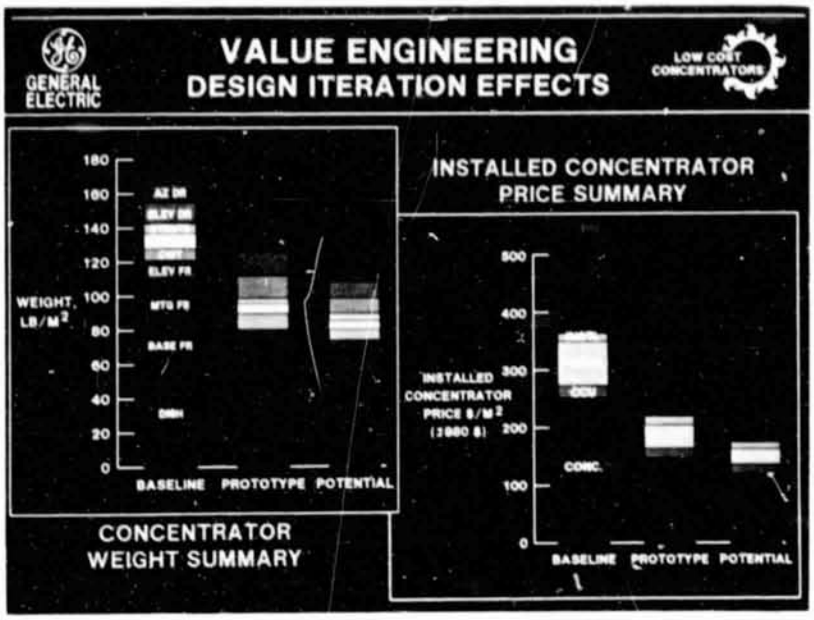


FIGURE 4

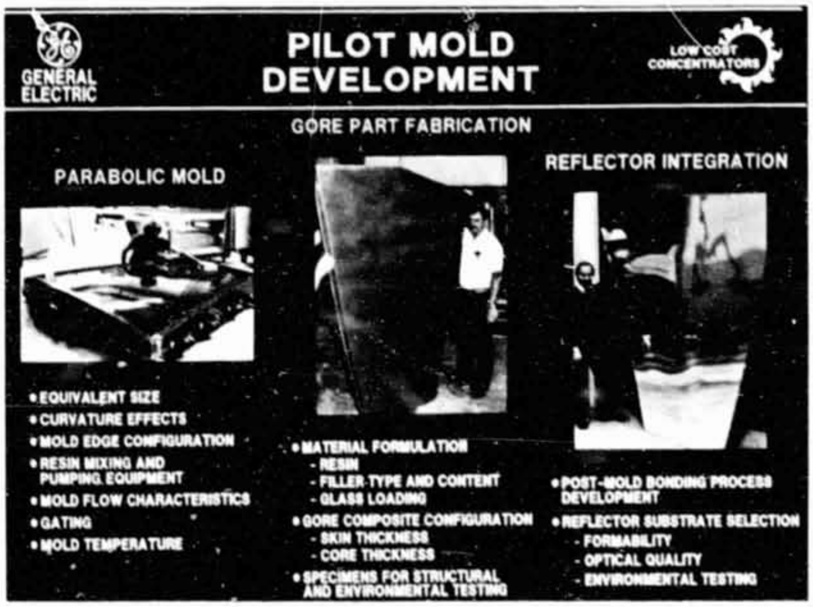


FIGURE 5

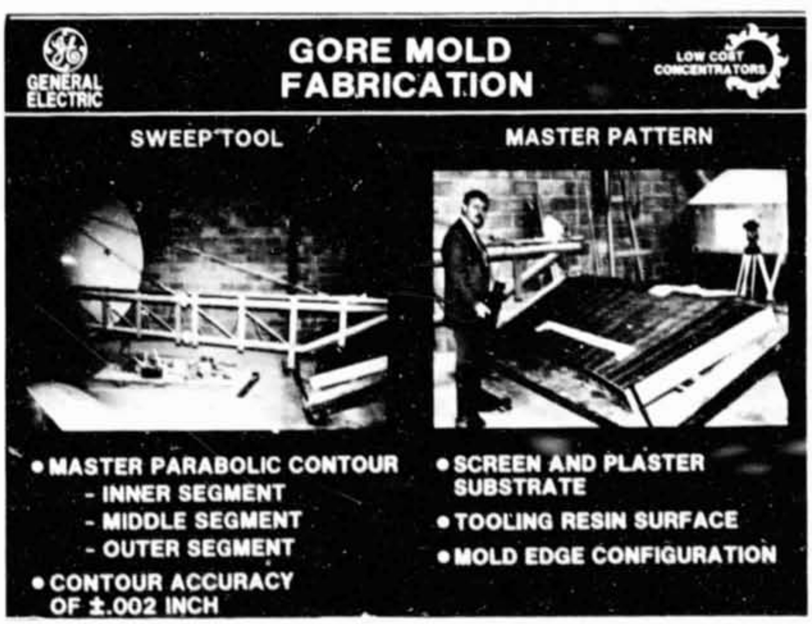


FIGURE 6