N80 24768

1ST GENERATION LOW COST POINT FOCUS SOLAR CONCENTRATOR

J. Zimmerman
General Electric Company
Valley Forge, Pennsylvania

ABSTRACT

The General Electric Company is 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 systematic 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 rationale for the configuration and subsystem selections, and the development status.

INTRODUCTION

The General Electric Company is currently under contract to the Jet Propulsion Laboratory to design, fabricate and test prototype 12 meter diameter point focus solar concentrators. Several key objectives were established at the outset of this development program to ensure that the resultant concentrator design represented a cost effective component and that, when coupled with thermal receivers and heat engines, would hold potential for the competitive generation of electricity from solar energy. The first of these objectives was to establish a design that can be optimized for solar applications. The majority of existing point focus concentrators have been derived from the technology of communications and RF antennas where many requirements and desirable features are not necessary for the solar application. Secondly, the design had to maximize the ratio of performance to cost. Thus, while good performance is certainly necessary for total system effectiveness, the cost of that performance must be carefully examined. The third major objective was to select approaches to the subsystem and component designs that were compatible with and derived from accepted and commercially available manufacturing techniques. Low cost can only be achieved with systems of this size and complexity when high production volume techniques can remove much of the fabrication labor cost and let material costs dominate.

CONCENTRATOR DESCRIPTION

The design that has evolved out of an effort to meet the key objectives is depicted in Figure 1. The concentrator is 12 meters in diameter with a focal length to diameter ratio of 0.5 and a geometric concentration ratio of 1800. The concentrator dish is constructed of molded glass reinforced plastic with an integral structural rib pattern on the back side to provide for stiffness. There are twelve internal truss assemblies within the dish to provide for support and alignment of the dish gore segments as well as added strength to the assembled structure. The internal ribs add considerable stiffness to the design while minimizing the loads and thus weight of plastic material in the gores. The additional blockage developed is small and the weight reduction benefits are well worth their inclusion. The baseline reflector material selected is an aluminized plastic film. This film is UV resistant, conforms to the double curvature of the paraboloid, has excellent specularity and very low cost. Silvered glass reflectors are also being investigated as potential high performance options.

The mount subsystem is an azimuth-elevation configuration. A significant advantage of this mount approach is that it permits the stow orientation depicted in Figure 1. The photo does not show the counterweight which has been incorporated into the design. The inverted stow significantly reduces survival wind loads, provides for convenient access to the complex receiver/engine and offers good protection for the reflector surface. The inverted night time stowage of the reflector provides for the minimum cleaning of the reflector film.

The drive subsystem that was selected consists of a cable and a drum. The cable is provided with a rolled guide from receiver to counterweight. Major features of this approach are low cost, low motor parasitic power, high drive stiffness and insensitivity to environmental factors. The drive system provides for a slow tracking rate of 0.1° per second and a fast defocus of 2° per second. The control subsystem is a hybrid system with a position predictive mode for coarse control and a fiber optic based closed loop control on the receiver for final positioning.

The foundation consists of a rolled I-beam section mounted on simple concrete pilings. The foundation has a large foot print and thus concrete is minimized. This approach to the foundation lends itself to quick assembly and a minimum of site preparation.

CONCENTRATOR DESIGN AND ANALYSIS

The concentrator, as it exists in its present configuration, is the product of a systematic approach to maximizing the ratio of cost to performance. This approach consists of a thorough evaluation of the design requirements, minimizing material content through structural efficiency, and judicious choice of component materials and processes to ensure producibility.

The first element, requirements evaluation, is a fundamental step that must be taken to ensure that the concentrator was not overdesigned and that the requirements are met in a cost effective manner. Figure 2 illustrates this point. Much of the material content is the result of the environmental loads. Initial studies concluded that substantial structural requirements were needed depending on the concentrator orientation at survival load conditions. By presenting the low profile stow position to the survival winds, the structure then became designed for stiffness to resist operating deflections. Likewise a careful evaluation was made to choose a realistic operating wind speed. The design specification, shown in Figure 2, represents the result of a relaxation of requirements until performance became expensive.

The second element of achieving cost effective performance involves designing the structure as efficiently as possible. Figure 3 depicts several of the subsystem features that help provide stiffness with a minimum material content and thus low cost potential. The internal ribs, azimuth-elevation mount and integral gore segment ribs all provide high stiffness to weight ratio's.

Perhaps the most important aspect to designing the concentrator structure has involved an in-depth structural analysis. Figure 4 depicts this analytical approach. The concentrator has been modelled on a finite element computer program where many load cases have been examined. The deflections are then input into a solar ray trace program to predict the image flux intensity and spread. The process involves minimizing structure until performance is significantly affected.

The final element involves the careful choice of materials and processes. Figure 5 depicts this process as it relates to the dish gore material. Molded reinforced plastic was chosen due to its accuracy potential, ability to supply high stiffness-to-weight in one rapid, automated production operation and its low material cost. Reinforcement was chosen due to its superior blend of properties needed in this application. Many molding processes have been studied with the final choice depending on the production volume.

A significant material choice involves the reflector. Evaluations are proceeding with two approaches: aluminized plastic film and silverized glass. Each has its own advantages and disadvantages as presented in Figure 6. The films offer low cost and compatibility with relatively soft structures, while lower performance and operating life present drawbacks. Glass is a proven and durable superstrate for silver reflectors and yet it is more costly. The higher cost is both in material and process costs as well as the costs of providing a stiffer structure to control stresses in the glass itself. This latter impact can be significant with unstrengthened glass. Designs are being generated for utilizing both reflectors. A choice is to be made based on application cost effectivity.

DEVELOPMENT STATUS

The concentrator design discussed above is presently in its detailed analysis and design phase. Design of tooling and production planning is in progress. Fabrication of the prototype concentrators are scheduled for mid 1980 with installation and test completed by the end of 1980. Units will be available for solar applications in early 1981.

FIGURE 1

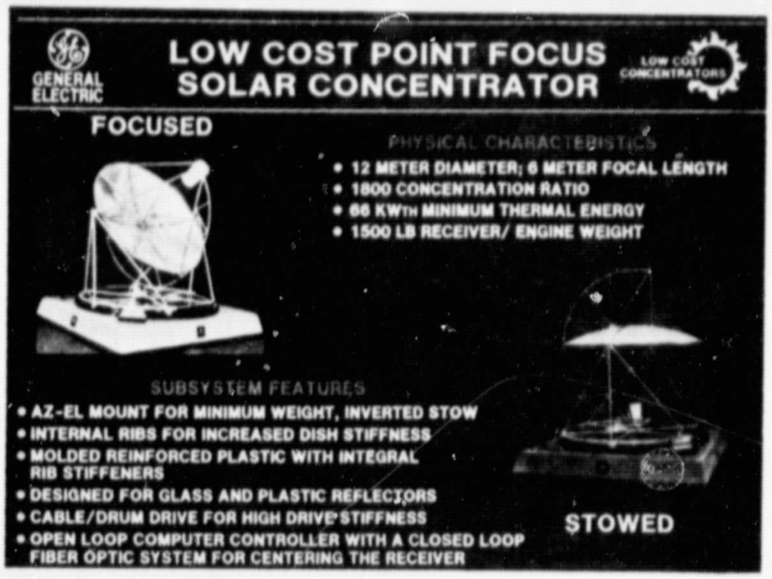


FIGURE 2

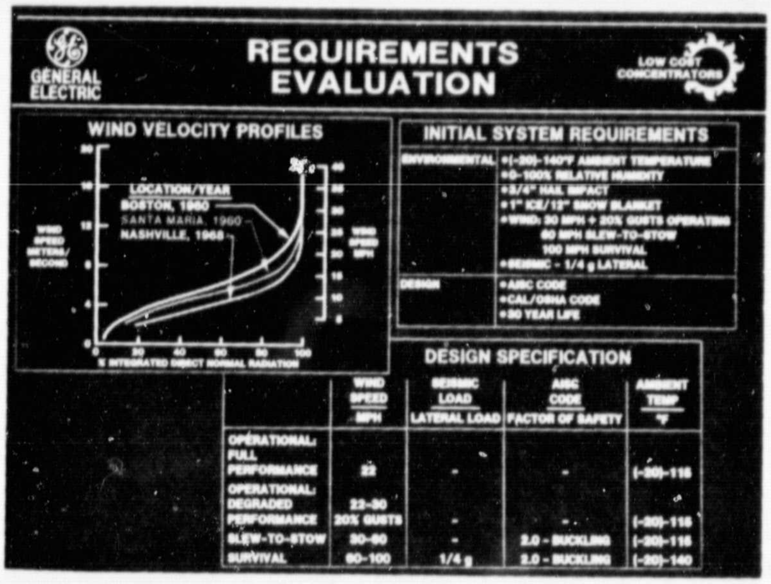


FIGURE 3

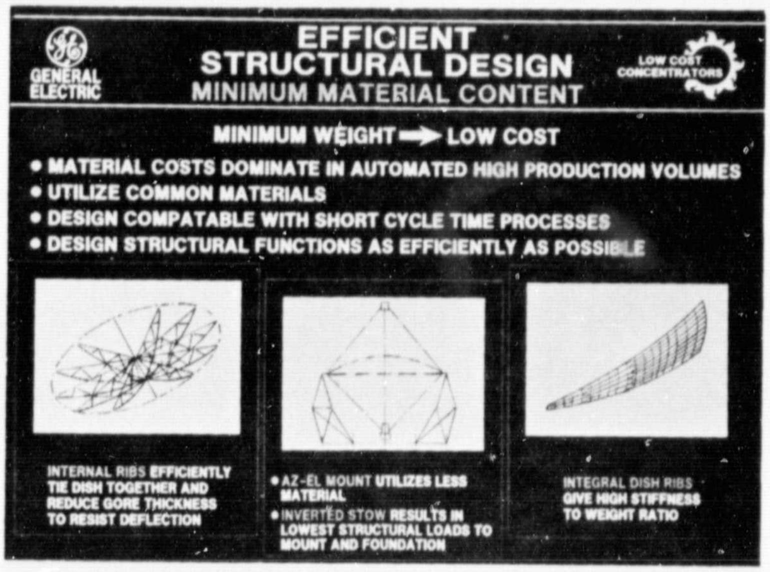
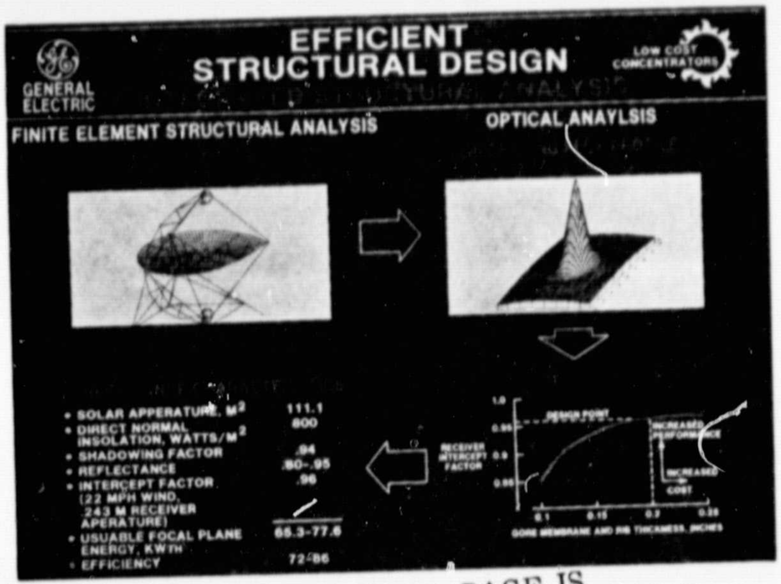


FIGURE 4



ORIGINAL PAGE IS
OF POOR QUALITY

FIGURE 5

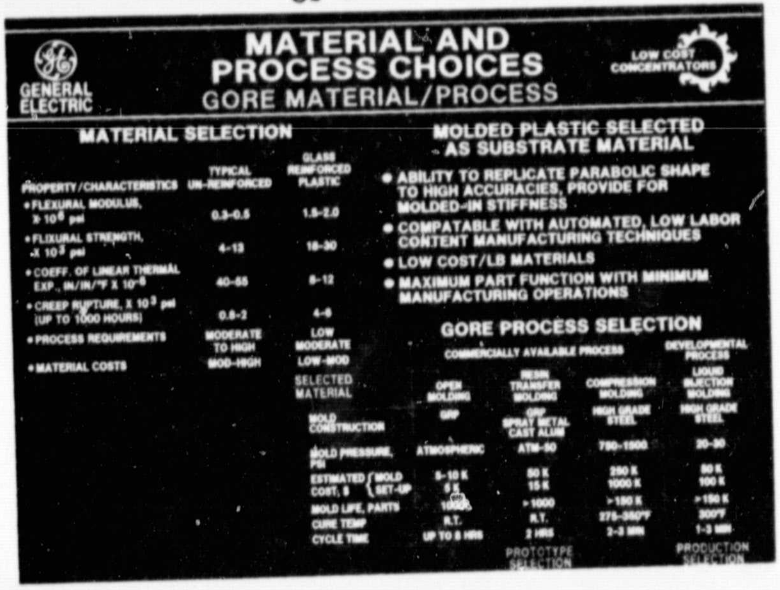


FIGURE 6