CHAPTER I

INTRODUCTION

1 Statement of the Problem.

An internally stiffened cylindrical shell is a structural configuration that is used mostly in aerospace vehicles. As the size of these fuselages increases, it is necessary to design them with minimum weight.

G.J. Simitses and V. Ungbhakorn[1] have presented a method of designing stiffened cylindrical shells under uniform axial compression with minimum weight by using different types of stiffeners, but did not show the effect of load on minimum weight. The purpose of this research is to investigate the effect of load on minimum weight of internally stiffened cylindrical shells subject to uniform axial compression. The stiffening members are tee stringers and rectangular rings.

2 Review of Previous Work.

As the size of the aerospace vehicles increases it is

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[1] Simitses, G. J. and Ungbhakorn, V., Minimum Weight Design of Stiffened Cylinders under Axial Compression (AIAA 12 th. Aerospace Sciences Meeting., Jan.30-Feb.1, 1974).

necessary to design the structures with minimum weight. A stiffened thin cylindrical shell is a configuration that is used widely in aerospace vehicles in the past thirty years. There have been many attempts to attain at the minimum weight of such configuration subject to a uniform axial compression.

One approach is based on the basis that the minimum weight will be obtained if all possible modes of failure occur simultaneously. Thompson and Lewis[2] have proved that this approach is very sensitive to geometric imperfections. Thus, the results of this method are unreliable in terms of load carrying capacity.

The next approach is based on the mathematical search techniques applied to the objective function, which contains all of the constraints as the penalty functions. The objective function is expressed in terms of the design variables. Pappas and Amba Rao[3], and Jones and Hague[4] have reported a multitude for nearly equal weight with different design variables by this method.

Another approach by Rehfield[5] is based on the assumption

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[2] Thompson, J. M. T. and Lewis, G. M., On the Optimum Design of Thin-Walled Compression Members (J. Mech. Phys. Solids, Vol. 20, 1972), pp. 101-109.

[3] Pappas, M. and Amba-Rao, C. L., A Direct Search Algorithm for Automated Optimum Structural Design (AIAA J., Vol. 9, No. 3, Mar. 1971), pp. 387-393.

[4] Jones, R. T. and Hague, D. S., Application of Multivariable Search Techniques to Structural Design Optimization (NASA cr-2038).

[5] Rehfield, L. W., Design of Stiffened Cylinders to Resist Axial Compression (J. Spacecraft and Rockets, May 1973), pp. 346-349.

of simultaneous occurrence of failure modes. This method is an iterative design and the minimum weight is obtained by trial and error.

From the results of these methods, there are many combinations of the design variables which satisfy all behavioral constraints and lead to the same minimum weight. Since, there are various behavioral constraints built into their objective functions, their designs can not avoid the simultaneous occurrence of the various instability failure modes and the resulting design structure may be more imperfection sensitive.

V. Ungbhakorn[6] has proposed the method to design for minimum weight of fuselage type stiffened circular cylindrical shells subject to uniform axial compression. This method is concerned with the minimum weight design of the middle part of the fuselage which the primary consideration is general instability. There are two stages, Phase 1 and Phase 2, in his method. In Phase 1, by a proper grouping of the design variables, the number of parameters that optimizes the weight is reduced to a minimum. Then a mathematical search technique is empolyed to prepare charts and tables. These charts and tables are employed in Phase 2 to arrive at a minimum weight configuration satisfying all constraints.

His method has many advantages over the past attempts as follows:

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[6]Ungbhakorn, V., Minimum Weight Design of Fuselage Type Stiffened Circular Cylindrical Shells Subject to Uniform Axial Compression (Doctoral Thesis , Engineering Science and Mechanics Department, Georgia Institute of Technology, Atlanta, Georgia, 1974).

1) The design charts and tables will provide the necessary information for the designer in order to deviate from the optimum solution when other considerations, such as availability and cost of construction become important.

2) The simultaneous occurrence of various failure modes is avoided. Thus, minimize the possibility of arriving at a configuration which is unnecessarily more imperfection sensitive.

3) This procedure allows the consideration of many different shapes of stiffening members.

3 Purpose and Scope of this Research.

Purpose of this research is to find the effect of load on minimum weight of internally stiffened cylindrical shells under uniform axial compression. V. Ungbhakorn has proposed that the best stiffener shape for stiffened cylindrical shells is a tee stringer and rectangular ring (TSRR), and the best position for stiffener is inside. For TSRR the best shape parameters are

$$C_x = 1.097, \quad c_{fx} = 1.00, \quad k_s = 0.35,$$
$$C_y = 1.00, \quad c_{fy} = 0.00, \quad k_r = 0.00.$$

In this work the author selects the stiffener to be TSRR which is internally stiffened to the cylindrical shell and with shape parameters as mentioned above.

By using V. Ungbhakorn's method , one can design minimum weight of an internally stiffened cylindrical shell under uniform axial compression. Since this work is considered to be continued from the research of V. Ungbhakorn, in this work the author uses the results from his research as a starting point. Then, the author attempts to increase uniform axial load and find the corresponding minimum weight.of the stiffened shell. Load is increased in this way several times until graph of load and the corresponding minimum weight can be drawn. This graph will show the effect of the uniform axial load on the minimum weight of internally stiffened cylindrical shells.

4 Usefullness of this Research.

In designing a modern aerospace vehicle with minimum weight, this result will increase payload and at the same time it will reduce fuel consumption of that vehicle.

The result of this research will be very useful in designing aerospace vehicles in the future, and it will guide or help the designers to predict the minimum weight of the fuselage when the uniform axial load is increased, but the radius and length remain the same. Furthermore, the present work will be the guide line of combined load investigation in the future.