VIEW - A MODIFICATION OF THE RAVFAC VIEW FACTOR PROGRAM

FOR USE WITH THE NASTRAN THERMAL ANALYZER

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INTRODUCTION

The NASTRAN Thermal Analyzer will include the capability to perform complete thermal analyses on structures. One of the inputs to NASTRAN required to simulate radiative heat transfer between surfaces will be the view factors (also called shape factors, form factors, configuration factors) between those surfaces. The purpose of the VIEW program is to compute these view factors and produce appropriate RADMTX and RADLST output to be used as NASTRAN Bulk Data.

VIEW assumes that the view factors between surfaces is a function only of their geometries and relative locations in space. The effects of emissivity, absorptivity, transmissivity, and multiple reflections are not taken into account, though provision has been made in the program design for their incorporation in a future version.

The view factor from surface S1 to S2 (these surfaces of area S1 and S2, respectively) may be found by considering the orientation of two infinitesimal surfaces dS_1 and dS_2, located respectively on S1 and S2 (see figure 1).

The derivation of the view factor formula for computing $dF_{dS_1 \rightarrow dS_2}$ (the view factor between dS_1 and dS_2) can be found in reference 1 as:

$$dF_{dS_1 \rightarrow dS_2} = \frac{\cos(\theta_1) \cos(\theta_2)}{\pi r^2_{12}} dS_2 \quad .$$

Integrating over both surfaces the view factor from S_1 to S_2 becomes

$$F_{S_1 \to S_2} = \frac{1}{S_1} \int_{S_1} \int_{S_2} \frac{\cos(\theta_1) \cos(\theta_2)}{\pi \, r^2_{12}} \, dS_1 \, dS_2 \quad .$$

Program VIEW can compute view factors by integrating this equation using either finite difference or contour integration (reference 1). The former method requires less computer time, while the latter gives more accurate solutions in certain cases. The user is allowed three options in selecting the method to be used:

1. He may request finite difference integration only,

2. He may request contour integration only,

3. He may allow the program to make its own selection on the basis of a user specified area-to-distance ratio.

The third option is the most common user selection.

INPUT DESCRIPTION

The majority of the input to the program consists of a description of the surface shapes and their locations in space. The VIEW program allows the user a choice of two distinct input formats. First, one may describe the surface shape and locations using NASTRAN formatted input (that is, using GRID cards, CORD cards, CHBDY cards, etc., see figures 2 and 4). Second, he may describe the problem using the same input format required by the RAVFAC program (see figure 3). Third, he may elect to combine the two types of input data. In addition, several cases may be run at once, as shown in figure 4.

The control cards required are very simple. The first control card of every case is a title card. This consists of any eighty characters and is printed out as the output heading.

The second control card is the VIEW case control card, which is not to be confused with NASTRAN case control cards. On this card the user specifies such items as the method of integration

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to be used, the input data device to be used (cards or tape), the output data device(s), and other program variables. These are all described in greater detail in the program documentation.

The third control card identifies the type of data which is to follow. If NASTRAN data is being used as input, the user punches "NASTRAN DATA" in columns one through twelve. If it is RAVFAC data, he punches "RAVFAC DATA" in columns one through eleven.

This card is followed by either the NASTRAN or RAVFAC bulk data deck, which in turn is followed by a control card specifying the end of the case (the user punches "ENDCASE" in columns one through seven). If no other cases are to follow, the next control card signals the end of the run and has "ENDRUN" punched in columns one through six.

If another case is to follow, the control card following "ENDCASE" would be a new title card. The input format would then repeat itself as described. See figures 2, 3 and 4.

We now come to the heart of the input: those cards which describe the surfaces and their positions in space. The RAVFAC input format will be ignored in this paper but can be found in reference 1. However, it is worth noting that the surface shapes which may be described by RAVFAC input are:

    a.   rectangular

    b.   disk (ring and/or section)

    c.   trapezoidal

    d.   cylindrical (ring and/or section)

    e.   conical (ring and/or section)

    f.   spherical (ring and/or section)

    g.   circular parabolic (ring and/or section)

NASTRAN input allows for the description of the following surface shapes:

    a.   solid disk (POINT element)

    b.   rectangle (LINE element)

    c.   cone or cylinder (REV element)

d. triangle (AREA3 element)

e. quadrilateral (AREA4 element)

At this point it is necessary to define the following terminology:

"elements" - The units in which a structure is modeled (called finite elements in NASTRAN)

"sub-elements" - The units into which an element may be divided (used only, in VIEW).

Therefore, the surface shapes previously defined will henceforth be referred to as element shapes, or just elements.

Basically, the NASTRAN user models (approximates)his structure by reconstructing it in space using NASTRAN elements. For an analysis involving radiation the user is allowed the use of the elements described previously.

The NASTRAN input acceptable to the VIEW program is therefore: *

a. CHBDY cards - which describe the element shape

b. PHBDY cards - which describe properties of the elements

c. GRID, CORD, and GRDSET cards - which describe the location in space of the elements

d. ENDDATA card - defines the end of the surface description cards. Any other type of card (with one exception to be explained later) is ignored by the program, and a message is printed stating how many cards were ignored.

The exception just mentioned is a card designed specifically for the VIEW program called, appropriately, a VIEW card. On this card the user specifies whether an element can be shaded by another element and whether it can shade some other element. This is not required input (as the program can determine such relationships automatically), but its use can save computer time. Also on the VIEW card the user may specify that an element is to be divided into nxn sub-elements. The default is 1x1, meaning

*No double field input allowed.

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that each element is to be considered as a sub-element. View
factors are computed between sub-elements and recombined to yield
view factors between elements. The division of an element into
sub-elements is used to increase the accuracy of the answers. It
should be used whenever two elements share a common boundary and
are known to have a non-zero view factor between them.

Once a run has been made all the NASTRAN Bulk Data cards
may be recovered from the VIEW input deck. These cards, along
with the RADLST and RADMTX cards just produced, may then be used
as input to NASTRAN to provide radiative coupling information for
a heat transfer analysis.

COMPARISON OF VIEW TO CONFAC II

Several of the sample problems presented in the Confac II
manual (reference 2) were modeled with NASTRAN elements and run
using the VIEW program. Excellent agreement was obtained in all
cases, and the results for one of the most complex cases (involv-
ing shading) is shown below (see figure 5 on the following page).

CASE F_1	CONFAC (7x7)	VIEW (10x10) (588 SUB-ELEMENTS)
1PLA10 → 8COPLA	.27337	.27556
1PLA10 → 1PLA11	.21136	.21339
1PLA10 → 1PLA9	.06201	.06157
1PLA12 → 8COPLA	.11370	.11278
1PLA12 → 1PLA9-9R	.07183	.07227
1PLA12 → 1PLA11	.04187	.04051
1PLA11 → 1PLA10	.30435	.30815
1PLA9-9R → 1PLA12	.06733	.06773

These results satisfactorily demonstrate the ability of the VIEW
program to account for shading relationships in view factor
calculation.

PROGRAMMING REMARKS

As a final note, it should be mentioned that the VIEW pro-
gram has been designed to be as much like NASTRAN as possible, in
that it (1) has a restart capability, (2) is organized in over-
lays to minimize the core required to load the program, and
(3) dynamically allocates core space so that the user may run any

size problem he desires, if he requests a sufficient amount of core space. A major difference which remains is that the VIEW program is written in Fortran IV and assembly language for IBM 360 computers, and conversion would be necessary for its use on CDC or Univac machines.

REFERENCES

1. Lovin, J. K., and Lubkowitz, A. W.: User's Manual for 'RAVFAC,' A Radiation View Factor Digital Computer Program. Contract #NAS 8-30154, Huntsville Research and Engineering Center, Huntsville, Ala., 1969.

2. Toups, K. A.: A General Computer Program for the Determination of Radiant Interchange Configuration and Form Factors. SID 65-1043-2, North American Aviation, Inc., October, 1965.
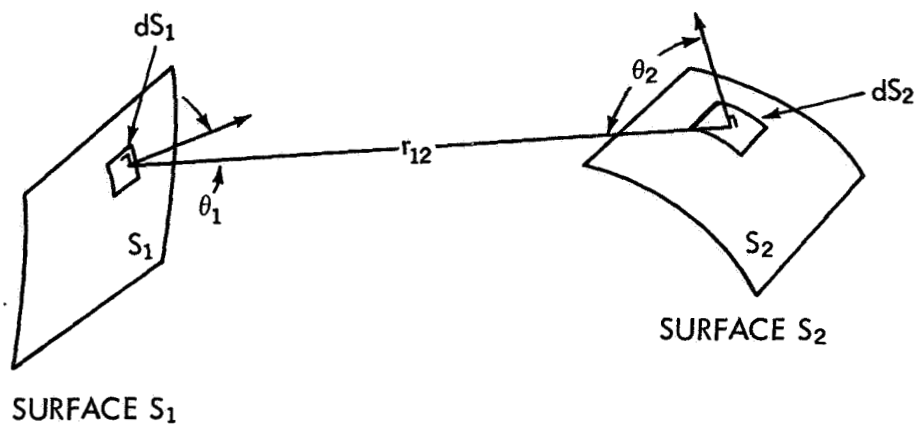
Figure 1. Orientation of Two Arbitrary Surfaces S1 and S2
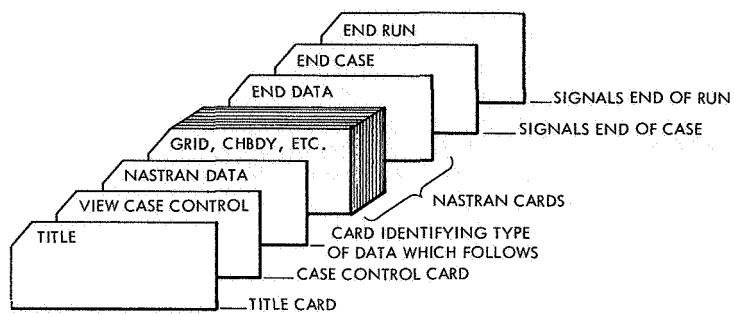
Figure 2. Typical Run, 1 Case, NASTRAN Input Only.
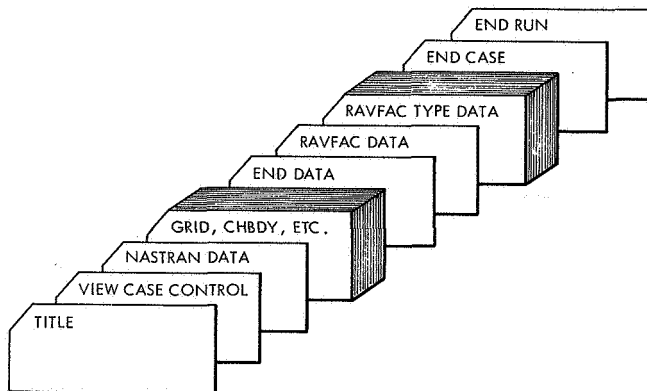

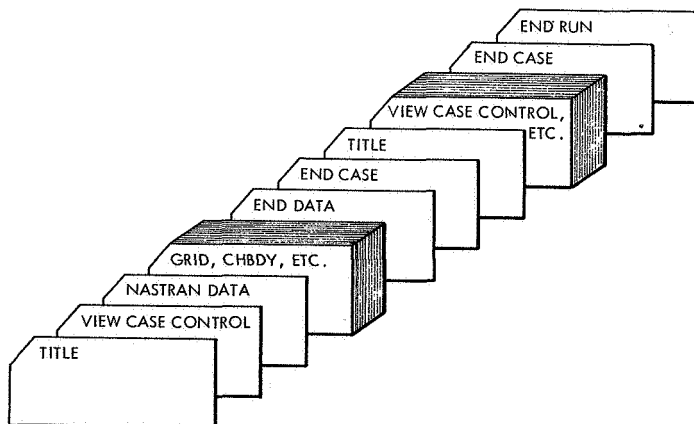Figure 3. Run One Case Using NASTRAN
and RAVFAC Input Combined.
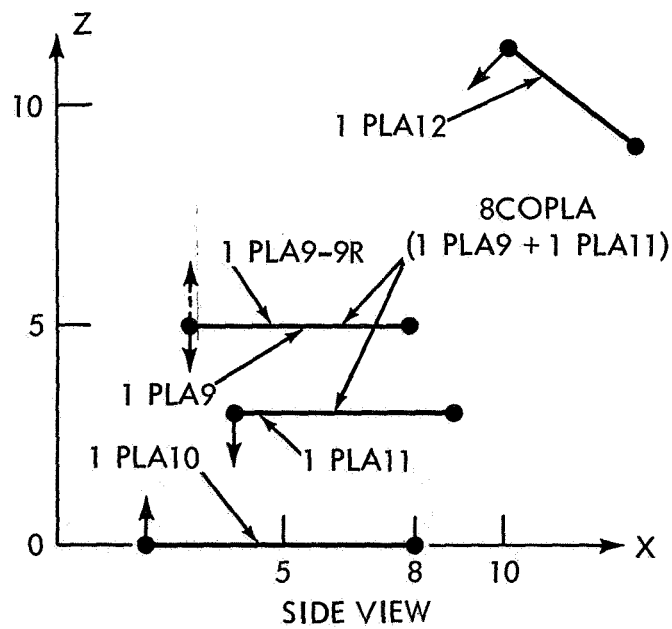

Figure 4. Run 2 Cases, both NASTRAN Input.

Figure 5. Case F1