PNC TN841 75-06

TWO DIMENSIONAL FUEL TEMPERATURE CALCULATION CODE, SPOT-C

July, 1975

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POWER REACTOR & NUCLEAR FUEL DEVELOPMENT CORPORATION

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Abstract

A computer code "SPOT-C" was developed to calculate the two dimensional temperature distribution around the plutonium spot in the mixed oxide fuel pin. Numerical calculations were carried out by using the iteration method. The emphasis was placed on the calculation of temperature distribution in the fuel pin which have the large plutonium spot in the vicinity of the cladding. The results of the calculations were useful for the safety assessment of fuel pin irradiation.

CONTENTS

Introduction

Two dimensional temperature calculations in a nuclear fuel is very important to know and analyze the fuel irradiation behaviour. Usually fuel temperature is calculated in the R-Z plane. However, sometimes temperature distribution in the R-θ plane is needed in the case that the heat generation has θ-dependency, as seen in a fuel which has a large PuO_2 spot.

It is impossible to calculate the two dimensional (R-Θ) temperature distribution analytically. Therefore a numerical calculation should be used. "Iteration method" which is one of the numerical calculations is used to develope the R-Θ temperature calculation code here.

1. Calculation Geometry

Fuel transverse section is shown in Fig. 1. R and Θ-direction should be divided into meshes. Θ direction is first divided in large meshes, K=1 to NN and each mesh angle is not necessary to be equal. The large meshes are again divided into small equal angle meshes, J=1 to NK(K). R-direction is divided in meshes by co-axial circles. Each mesh width can be selected arbitrarily.

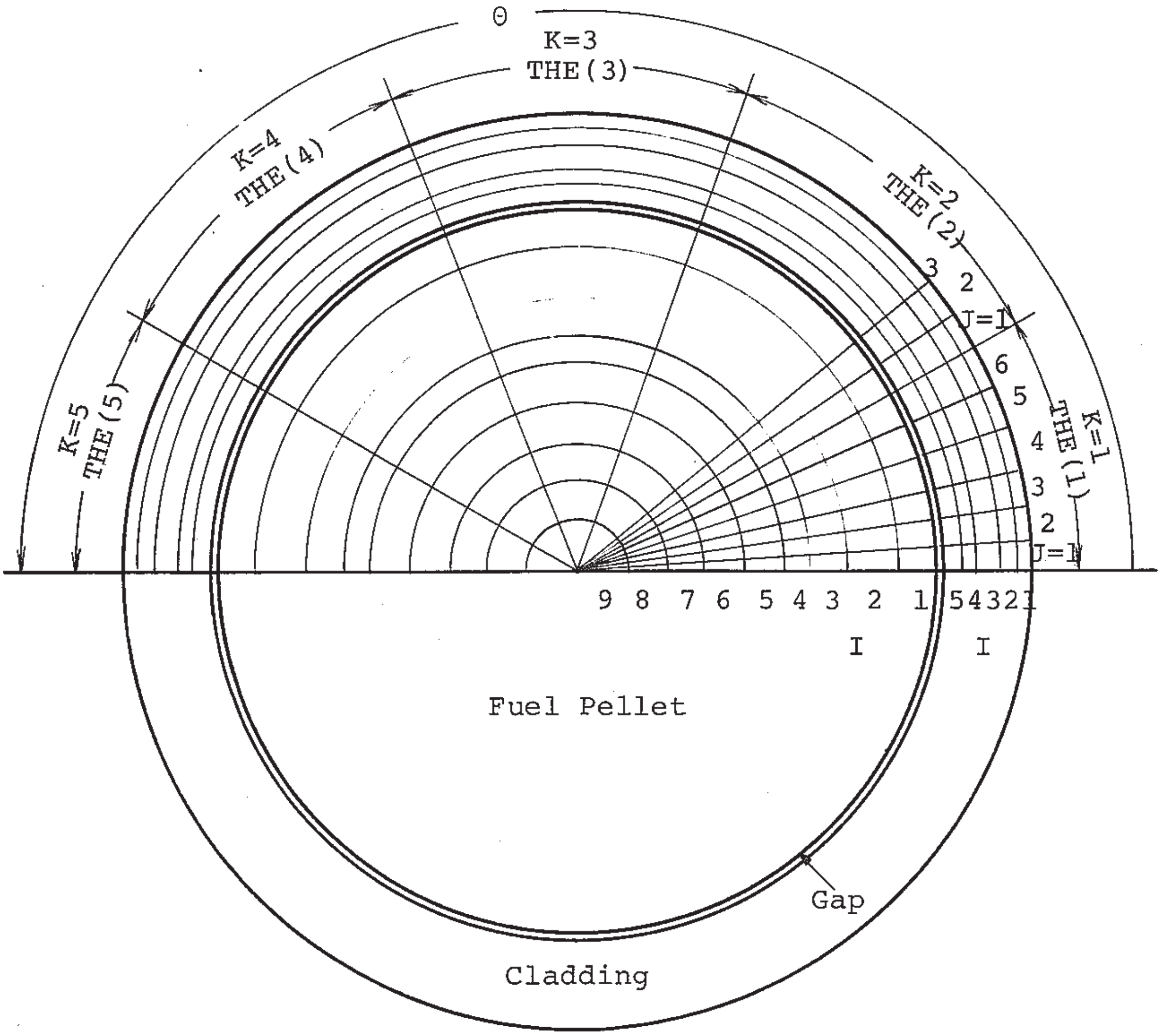

Fig. 1 Calculation geometry Θ is arbitrary

2. Iteration Method

R and θ-direction meshes divide fuel and cladding into many cells. Each cell should have initial temperature guess. As shown in Fig. 2, the cell 1 is surrounded by four cells 2 5. It is supposed that the cell 1 can give heat to or get heat from only four cells 2 5. Therefore heat balance can be written as follows.

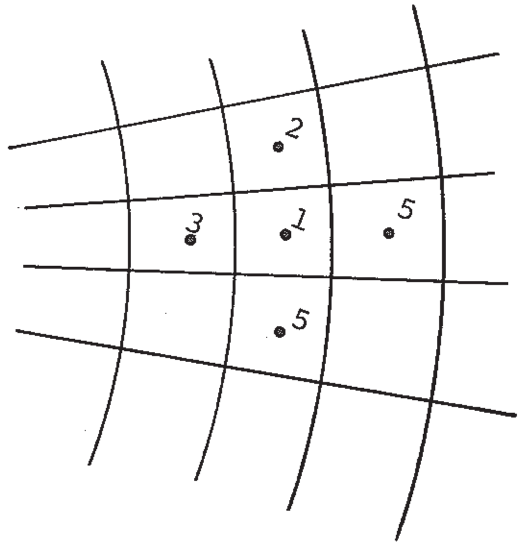

Fig.2 Relation among the cells in the fuel and clad matrix

$$\frac{dT_1}{dt} = \sum_{i=2}^{5} \frac{Si}{\ell i} k \, (T_i - T_1) + Q_1 \cdot V_1 \qquad (1)$$

where T_i : Temperature of No. i cell

k : Thermal conductivity of matrix

Si : Contact area between cells 1 and i

ℓ_i : Distance between the centers of cells 1 and i

Q_1 : Power generation density of the cell 1

V_1 : Volume of the cell 1

t : Time

In the steady state, $\frac{dT_1}{dt} = 0$

Therefore

$$\sum_{i=2}^{5} \frac{Si}{\ell i} K \, (T_i - T_1) + Q_1 \cdot V_1 = 0 \qquad (2)$$

$$T_1 = \frac{\sum_{i=2}^{5} \frac{Si}{\ell_i} k \, T_i + Q_1 . V_1}{\sum_{i=2}^{5} \frac{Si}{\ell_i} k} \qquad (3)$$

The cell 1 has a initial temperature guess T_{10}. This T_{10} should be replaced by T_1 determined by equation (3). Temperatures of all cells is replaced one by one using the equation (3), and after one-through calculation, temperature distribution in the fuel can be obtained. This procedure will be repeated until the converged solution will be gotten.

In the case of cladding temperature calculation, $Q_1 \cdot V_1$ term in the equation (3) should be vanished because of no power generation. Then equation (3) should be rewritten for cladding as follows.

$$T_1 = \frac{\sum_{i=2}^{5} \frac{Si}{\ell i} k \, T_i}{\sum_{i=2}^{5} \frac{Si}{\ell i} k} \tag{4}$$

3. Temperature Calculation between Cladding and Coolant

The treatment of the boundary between cladding and coolant is as follows.

One of the outermost cell in the cladding is named cell 1, which is surrounded by cells 2, 3 and 4 shown in Fig. 3. Coolant is thought to be the fifth cell whose temperature is equal to the coolant bulk

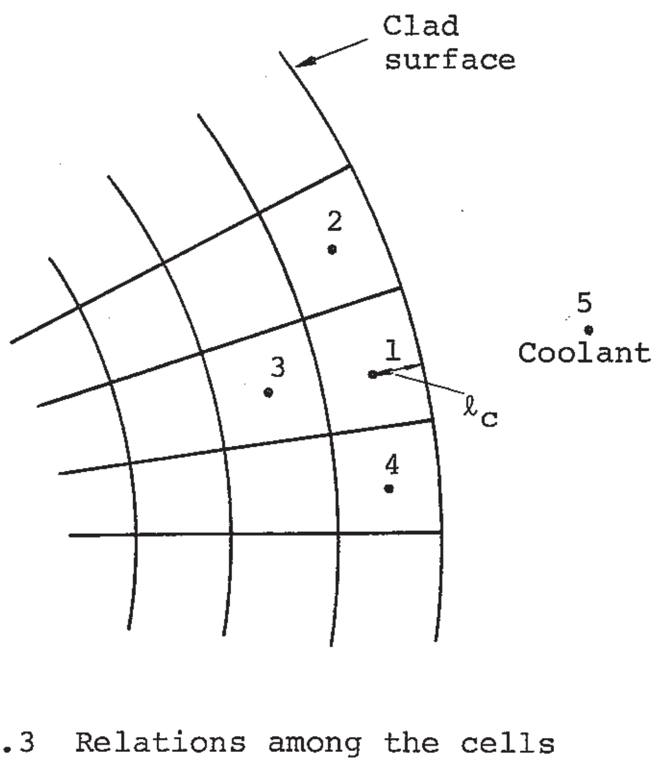

Fig.3 Relations among the cells at the clad surface

temperature.

The effective thermal conductivity between cell 1 and cell 5 is written as follows.

$$k_{cc} = \frac{\ell_c}{\frac{\ell_c}{k_c} + \frac{1}{h}} \tag{5}$$

where ℓ_c : Distance between cladding surface and temperature point of cell 1

k_c : Thermal conductivity of cladding

h : Heat transfer coefficient between clad and coolant

The temperature of the cell 1, T_1 is

$$T_1 = \frac{\sum_{i=2}^{5} \frac{Si}{\ell_i} T_1 + \frac{k_{cc}}{k_c} \cdot \frac{S_5}{\ell_c} \cdot T_5}{\sum_{i=2}^{4} \frac{Si}{\ell_i} + \frac{k_{cc}}{k_c} \cdot \frac{S_5}{\ell_c}} \tag{6}$$

4. Temperature Calculations between Fuel and Cladding

4-1 Clad Inner Surface

The temperature of the inermost cell in the cladding is expressed by equation (7).

$$T_1 = \frac{\sum_{i=2}^{4\ 5} \frac{Si}{\ell_i} T_i + \frac{k_{fs}}{k_c} \cdot \frac{S_3}{\ell_{fc}} \cdot T_3}{\sum_{i-2}^{4\ 5} \frac{Si}{\ell_i} + \frac{k_{fc}}{k_i} \cdot \frac{S_3}{\ell_{fc}}} \tag{7}$$

where k_{fc} is the effective thermal conductivity between temperature points of cell number 1 and 3 in Fig. 4. ℓ_{fc} is the sum of ℓ_f and ℓ_c shown in Fig. 4. k_{fc} is shown in equation (8).

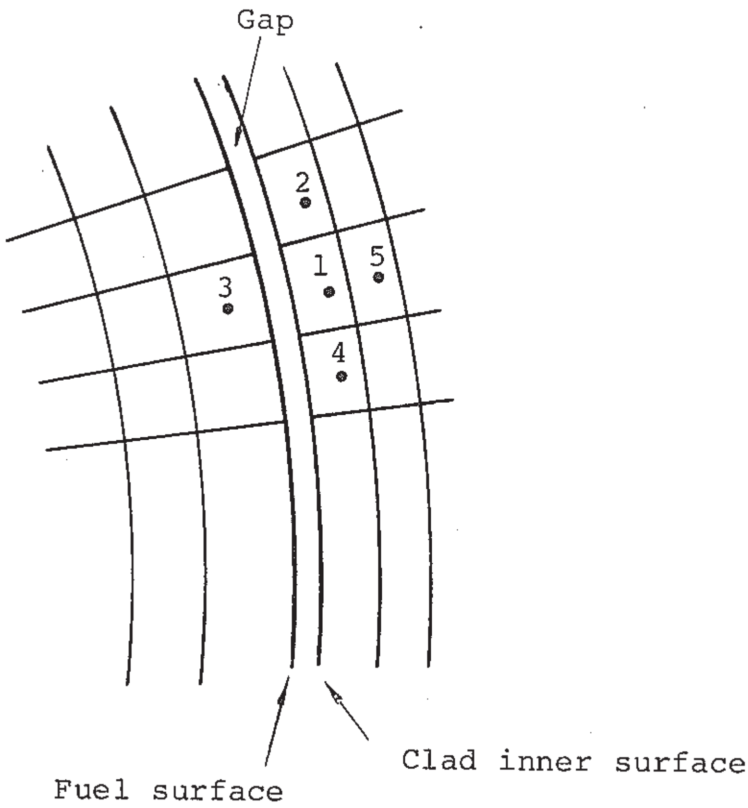

Fig. 4 Relations among the cells at the clad inner surface

$$k_{fc} = \frac{\ell_{fc}}{\dfrac{\ell_f}{k_f} + \dfrac{\ell_c}{k_c} + \dfrac{1}{G}} \tag{8}$$

where k_f : thermal conductivity of fu l pellet

k_c : thermal conductivity of cladding

G : gap conductance between clad and fuel

4-2 Fuel Outer Surface

The temperature of the outermost cell in the fuel pellet is

$$T_1 = \frac{\sum_{i=2}^{4} \dfrac{S_i}{\ell_i} T_i + \dfrac{k_{fc}}{k_f} \cdot \dfrac{S_5}{\ell_{fc}} \cdot T_5 + \dfrac{Q_1 \cdot V_1}{k_f}}{\sum_{i=2}^{4} \dfrac{S_i}{\ell_i} + \dfrac{k_{fc}}{k_f} \dfrac{S_5}{\ell_{fc}}} \tag{9}$$

In this case, T_5 is the temperature in the cladding as shown in Fig. 5.

k_{fc} in the equation (9) has the same definition with that in equation (7).

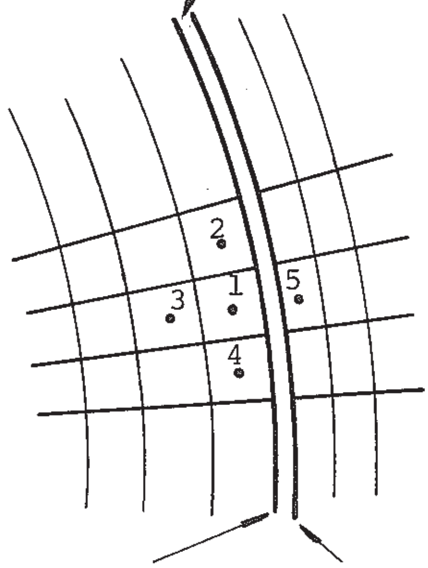

Fig. 5 Relations among the cells at the fuel surface

5. Fuel Center Treatment

As shown in Fig. 6, cell 3 is not necessary to be considered. Therefore, the temperature of innermost cell in the fuel is written by following equation;

$$T_1 = \frac{\sum_{i=2}^{4,5} \frac{Si}{\ell_i} T_i + \frac{Q_1 \cdot V_1}{k_f}}{\sum_{i=2}^{4,5} \frac{Si}{\ell}} \qquad (10)$$

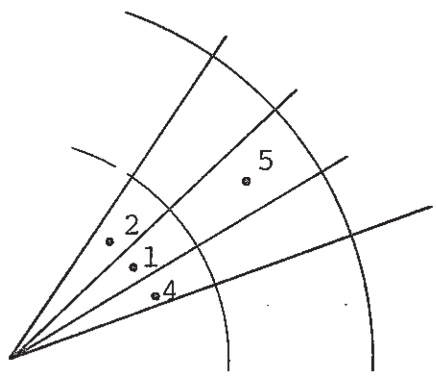

Fig.6 Relations among the cells at the fuel center

Appendix A Input Format of SPOT-C Code

CARD NO.	FORMAT	I.D.	DESCRIPTION
1	20 A4	TITLE(I) I=1,20	Title card. Arbitrary sentence (less than 80 columns)
2	2I5	LMESR	=0; equal distance mesh for r-direction 1; arbitrary mesh for r-direction
		LMESS	=0; equal angle mesh for θ-direction =1; arbitrary angle mesh for θ-direction
3	2I5	NRF	Number of cells of r-direction for fuel
		NRC	Number of cells of r-direction for cladding

In the case of LMESR=0, skip 4 and 5.

CARD NO.	FORMAT	I.D.	DESCRIPTION
4	8F10.3	RF(I) I=1,NRF+1	Radius of each fuel radial mesh boundary (cm)
5	8F10.3	RC(I) I=1,NRC+1	Radius of each clad radial mesh boundary (cm)
6	I5	NN	Number of circumferential big meshes
	F10.5	THEA	Circumferencial angle of calculation system (radian)

In the case of LMESS=0, skip 7

CARD NO.	FORMAT	I.D.	DESCRIPTION
7	8F10.5	THE(K) K=1,NN	Angle of each circumferencial big mesh (radian)
8	16I5	NK(K) K=1, NN	Number of equal angle meshes in each circumferential big mesh
9	4F10.3	RFO	Fuel pellet radius (cm)
		RCO	Clad outer radius (cm)
		RCI	Clad Inner radius (cm)
		DEN	Fuel density (Fraction to T.D.)

CODE NO.	FORMAT	I.D.	DESCRIPTION
L)	2F10.3	TCOOL HF	Coolant bulk temperature (°C) Heat flux at the clad surface(w/cm^2)
11		NR	=0; Initial temperature guesses for each cell should be read from card =1; should be read from tape
12	2F10.3	GAP PRE	Gap conductance between fuel and cladding (watts/cm^2•°C) Coolant pressure (Atom)
13	2I5	LLLL MA	Maximum Iteration number Midway temperature distribution will be written for each MA times iteration
14	2I5	II JJ	For the cells determined by I=1∿II, J=1∿JJ and K=1, special power generation rate can be input.
15	8F10.3	Q(I,J,1) J-1,JJ	Special power generation rates for the cells determined by I-1,II, J=1, JJ and K=1 (watts/cm^3)
	Item 15 are repeated II times		
	8F10.3	P(I) I=1,NRF	Radial distribution of power generation rate (watt/cm^3)

IF NR=1, skip No. 17, 18

17	8F10.3	TEMP(I)	Initial temperature guesses for fuel cells (°C)
18		TEMC(I)	Initial temperature guesses for clad cells (°C)
19	I5	LR	=0 Next case will be read. =1 End

Appendix 2 List of SPOT-C Code

The listing of the code is as follows.

```
            74/74   OPT=1                          FTN 4.1+P373     12/14/74  10.27.56.     PAGE    1

      SET1
      PROGRAM SPOTC(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=(OUTPUT,TAPE3,TAPE7)
C                     ******************
C                     * PROGRAM SPOT-C *
C                     ******************
C
      COMMON / LABEL / DEN
      DIMENSION NK(20),W(20,20,10),P(20),TEMP(20),TEMC(10),TF(20,20,10)
      DIMENSION TC(10,20,10),TF1(20,20,10),TC1(10,20,10),RF(20),RC(10)
      DIMENSION THE(10),TITLE(20)
      RHOF(T)=0.1293+2.964E-5*T+1.061E-7*T**2
      NIN=5
      NOUT=6
    5 READ(NIN,1040) (TITLE(I),I=1,20)
      READ(NIN,1000) LMESR,LMESS
      READ(NIN,1000) NRF,NRC
      NRC1=NRC+1
      NRF1=NRF+1
      IF(LMESR.EQ.0) GO TO 3
      READ(NIN,1020) (RF(I),I=1,NRF1)
      READ(NIN,1020) (RC(I),I=1,NRC1)
    3 READ(NIN,1010) NN,THEA
      IF(LMESS.EQ.0) GO TO 4
      READ(NIN,1050) (THE(K),K=1,NN)
    4 READ(NIN,1000) (NK(K),K=1,NN)
      READ(NIN,1020) RFO,RCO,RCI,DEN
      READ(NIN,1020) TCOOL,HF
      READ(NIN,1000) NR
      READ(NIN,1020) GAP,PHE
      READ(NIN,1000) LLLL,MA
      READ(NIN,1000) II,JJ
      DO 50 I=1,II
      READ(NIN,1030)(W(I,J,1),J=1,JJ)
   50 CONTINUE
      READ(NIN,1030)(P(I),I=1,NRF)
      IIP1=II+1
      NNK=NK(1)
      DO 51 I=IIP1,NRF
      DO 51 J=1,NNK
      W(I,J,1)=P(I)
   51 CONTINUE
      JJP1=JJ+1
      DO 52 I=1,II
      DO 52 J=JJP1,NNK
      W(I,J,1)=P(I)
   52 CONTINUE
      DO 53 I=1,NRF
      DO 53 K=2,NN
      NNK=NK(K)
      DO 53 J=1,NNK
      W(I,J,K)=P(I)
   53 CONTINUE
      IF(NR) 6,6,7
    6 READ(NIN,1020)(TEMP(I),I=1,NRF)
      READ(NIN,1020)(TEMC(I),I=1,NRC)
      DO 55 I=1,NRF
      DO 55 K=1,NN
```

```
PROGRAM SPJIC        74/74   OPT=1                    FTN 4.1+P373        12/14/74  10.27.56.       PAGE    2

            NNK=NK(K)
            DO 55 J=1,NNK
            IF(I,J,K)=TEMF(I)
   55       CONTINUE
            DO 86 I=1,NC
            DO 86 K=1,NN
            NNK=NK(K)
            DO 86 J=1,NNK
            IF(I,J,K)=TEMC(I)
   86       CONTINUE
            GO TO 6
    7       DO 100 I=1,NMF
            DO 100 K=1,NN
            NNK=NK(K)
            DO 100 J=1,NNK
            READ(7,7001) IF(I,J,K)
  100       CONTINUE
            DO 110 I=1,NMC
            DO 110 K=1,NN
            NNK=NK(K)
            DO 110 J=1,NNK
            READ(7,7001) IC(I,J,K)
  110       CONTINUE
    6       HT=HF*80./2/Z*910/(EXP(PRE/61.241)
            [illegible](N1,1000) LM
            PI=3.14159
            IF(LMESS) 87,87,88
   87       FNN=FLOAT(NN)
C     DEFINITION OF RF(I) AND RC(I)
            SRF=RFO/FLOAT(NRF)
            DO 114 I=1,NRF
            RF(I)=RFO-SRF*FLOAT(I-1)
  114       CONTINUE
            RF(NRF1)=0.0

            SRC=(RCO-RCI)/FLOAT(NRC)
            DO 310 I=1,NRC
            RC(I)=RCO-SRC*FLOAT(I-1)
  310       CONTINUE
            RC(NRC1)=RCI
   88       IF(LMESS) 92,92,93
C     DEFINITION OF THE(K) IN THE CASE OF EQUAL MESH
   92       ANN=THE/FNN
            DO 411 K=1,NN
            TH(K)=ANN
  411       CONTINUE
C           INPUT DATA LISTING
   93       WRITE(NOUT,2031)(TITLE(I),I=1,20)
            WRITE(NOUT,2000)
            WRITE(NOUT,2001)
            WRITE(NOUT,2002)NRF,NRC
            WRITE(NOUT,2030)NN
            WRITE(NOUT,2003)(NK(K),K=1,NN)
            WRITE(NOUT,2004)
            WRITE(NOUT,2005)
            WRITE(NOUT,2025)THE
            WRITE(NOUT,2026)(THE(K),K=1,NN)
```

```
      WRITE(NOUT,2006)RFO
      WRITE(NOUT,2007)RCI
      WRITE(NOUT,2008)RCO
      ODEN=100.*OEN
      WRITE(NOUT,2009)ODEN
      WRITE(NOUT,2027)(RF(I),I=1,NRF1)
      WRITE(NOUT,2028)(RC(I),I=1,NRC1)
      WRITE(NOUT,2010)
      WRITE(NOUT,2011)TCOOL
      WRITE(NOUT,2012)PRO
      WRITE(NOUT,2013)HF
      WRITE(NOUT,2014)GAP
      WRITE(NOUT,2015)Q(1,1,1)
      WRITE(NOUT,2016) (P(I),I=1,NRF)
      WRITE(NOUT,2017)
      WRITE(NOUT,2015)(TEMC(I),I=1,NRC)
      WRITE(NOUT,2017)(TEMP(I),I=1,NRF)
      IF(NR.EQ.0) GO TO 501
      IF(NR.EQ.1) GO TO 502
      GO TO 503
  501 WRITE(NOUT,2020)
      GO TO 503
  502 WRITE(NOUT,2021)
  503 WRITE(NOUT,2022)II,JJ
      WRITE(NOUT,2023)
      WRITE(NOUT,2024)LLLL
      WRITE(NOUT,2024)MA
 2031 FORMAT(1H1/,10X,20A4/,10X,40(1H=)/,//)
 2000 FORMAT(56X,12(2H* )/,56X,1H*,21X,1H*/,56X,1H*,3X,5HINPUT,3X,
     17HLISTING,3X,1H*/,56X,1H*,21X,1H*/,56X,12(2H* ))
 2001 FORMAT(10X,7HMESHING)
 2002 FORMAT(12X,6HRADIAL,22X,4HFUEL,3X,I2,6X,4HCLAD,3X,I2)
 2003 FORMAT(30X,5HSMALL,2X,17(2X,I2))
 2004 FORMAT(1H0,9X,8HGEOMETRY)
 2005 FORMAT(12X,15HCIRCUMFERENTIAL,2X,5HANGLE)
 2025 FORMAT(20X,5HTOTAL,14X,8H(RADIAN),3X,10(2H- ),F10.3)
 2026 FORMAT(20X,12HEACH  REGION,7X,8H(RADIAN),3X,10(2H- ),6F10.3/,
     170X,6E10.3)
 2006 FORMAT(12X,12HFUEL  RADIUS,15X,4H(CM),7X,10(2H- ),F10.3)
 2007 FORMAT(12X,12HCLAD  RADIUS,4X,5HINNER,6X,4H(CM),7X,10(2H- ),F10.3)
 2008 FORMAT(25X,5HOUTER,6X,4H(CM),7X,10(2H- ),F10.3)
 2009 FORMAT(12X,13HFUEL  DENSITY,14X,7H(O/OTD),4X,10(2H- ),F10.3)
 2027 FORMAT(12X,16HFUEL  RADIAL  MESH,5X,4H(CM),3X,4(2H- ),8F10.3/,
     13(50X,8F10.3/))
 2028 FORMAT(12X,16HCLAD  RADIAL  MESH,5X,4H(CM),3X,4(2H- ),8F10.3/,
     150X,8F10.3)
 2010 FORMAT(1H0,9X,17HTHERMAL  CONDITION)
 2011 FORMAT(12X,20HCOOLANT  BULK  TEMP.,7X,7H(DEG.C),4X,10(2H- ),F10.3)
 2012 FORMAT(21X,8HPRESSURE,10X,5H(ATM),6X,10(2H- ),F10.3)
 2013 FORMAT(12X,25HCLAD  SURFACE  HEAT  FLUX,2X,7H(W/CM2),4X,10(2H- ),
     1F10.3)
 2014 FORMAT(12X,21HF-C  GAP  CONDUCTANCE,6X,13H(W/CM2-DEG.C),2X,
     1(2H- ),F10.4)
 2015 FORMAT(12X,15HPU  SPOT  POWER,8X,7H(W/CM3),2X,3(2H- ),F10.3)
 2016 FORMAT(12X,13HMATRIX  POWER,10X,7H(W/CM3),2X,3(2H- ),8F10.3/,
     13(50X,8F10.3/))
 2017 FORMAT(1H0,11X,34HINITIAL  GUESS  OF  TEMP.  (DEG.C))
```

```
PROGRAM SPLIC      74/74   OPT=1                    FTN 4.1+P373       12/14/74  10.27.56.       PAGE   4

 2015 FORMAT(20X,6HCLADDING,2X,10(2H- ),8F10.3/,3(50X,8F10.3/))
 2017 FORMAT(20X,4HFUEL,6X,10(2H- ),8F10.3/,3(50X,8F10.3/))
 2020 FORMAT(40X,50HINITIAL   TEMPERATURE  GUESS  WAS  READ  FROM  CARD)
 2021 FORMAT(40X,50HINITIAL   TEMPERATURE  GUESS  WAS  READ  FORM  TAPE)
 2022 FORMAT(1H0,7X,14HPO  SPOT  MESH,16X,5HI= 1,,I2,3X,5HJ= 1,,I2)
 2023 FORMAT(1H0,7X,20HITERATION  CONDITION)
 2024 FORMAT(12X,23HMAXIMUM  ITERATION  NO.,7X,9(2H- ),I5)
 2029 FORMAT(12X,27HITERATION  STEP  FOR  WRITE,3X,9(2H- ),I5)
 2030 FORMAT(12X,15HCIRCUMFERENTIAL,3X,3HHIG,6X,I2)
      LL=0
  131 LL=LL+1
C   CLADDING OUTER SURFACE
C
      FC=0.5*(RC(1)-RC(2))
      DIS3=0.5*(RC(1)-RC(3))
      DIS5=FC
      S2=RC(1)-RC(2)
      S4=S2
      TS=TCOOL
      DO 120 K=1,NK
      DISTA=0.5*(RC(1)+RC(2))*THE(K)
      FNK=FLOAT(NK(K))
      DIST=DISTA/FNK
      S3=RC(2)*THE(K)/FNK
      S5=RC(1)*THE(K)/FNK
      FNK1=FLOAT(NK(K-1))
      FNKP1=FLOAT(NK(K+1))
      NNK=NK(K)
      DO 120 J=1,NNK
      DIS2=DIST
      DIS4=DIST
      IF(J.EQ.NK(K).AND.K.NE.NN) GO TO 115
      GO TO 116
  115 DISTA=0.5*(RC(1)+RC(2))*THE(K+1)
      DIS2=0.5*(DIST+DISTA/FNKP1)
  116 IF(J.EQ.1.AND.K.NE.1) GO TO 117
      GO TO 118
  117 DISTA=0.5*(RC(1)+RC(2))*THE(K-1)
      DIS4=0.5*(DIST+DISTA/FNK1)
  118 IF(J.EQ.NK(K)) GO TO 9
      T2=TC(1,J+1,K)
      GO TO 11
    9 IF(K.EQ.NN) GO TO 10
      T2=TC(1,1,K+1)
      GO TO 11
   10 T2=TC(1,J,NN)
   11 T3=TC(2,J,K)
      IF(J.EQ.1) GO TO 12
      T4=TC(1,J-1,K)
      GO TO 14
   12 IF(K.EQ.1) GO TO 13
      IJK=NK(K-1)
      T4=TC(1,IJK,K-1)
      GO TO 14
   13 T4=TC(1,1,1)
   14 A2=S2/DIS2
```

```
      A4=S4/DIS4
      TT=TC(I,J,K)
      RAMCC=FC/(FC/RAMC(II)+1./HTC)
      A5=S5/DIS5*RAMCC/RAMC(II)
      ASH=A2*T2+A3*T3+A4*T4+A5*T5
      ASU=A2+A3+A4+A5
      TC(I,J,K)=ASH/ASU
  120 CONTINUE
C   CLADDING MATRIX
C
      NRCM1=NRC-1
      DO 130 I=2,NRCM1
      DIS3=0.5*(RC(I)-RC(I+2))
      DIS5=0.5*(RC(I-1)-RC(I+1))
      S2=RC(I)-RC(I+1)
      S4=S2
      DO 130 K=1,NN
      DISTA=0.5*(RC(I)+RC(I+1))*THE(K)
      FNK=FLOAT(NK(K))
      DIST=DISTA/FNK
      S3=RC(I+1)*THE(K)/FNK
      S5=RC(I)*THE(K)/FNK
      FNK1=FLOAT(NK(K-1))
      FNKP1=FLOAT(NK(K+1))
      NNK=NK(K)
      DO 130 J=1,NNK
      DIS2=DIST
      DIS4=DIST
      IF(J.EQ.NK(K).AND.K.NE.NN) GO TO 121
      GO TO 122
  121 DISTA=0.5*(RC(I)+RC(I+1))*THE(K+1)
      DIS2=0.5*(DIST+DISTA/FNKP1)
  122 IF(J.EQ.1.AND.K.NE.1) GO TO 123
      GO TO 124
  123 DISTA=0.5*(RC(I)+RC(I+1))*THE(K-1)
      DIS4=0.5*(DIST+DISTA/FNK1)
  124 IF(J.EQ.NK(K)) GO TO 15
      T2=TC(I,J+1,K)
      GO TO 17
   15 IF(K.EQ.NN) GO TO 16
      T2=TC(I,1,K+1)
      GO TO 17
   16 T2=TC(I,J,NN)
   17 T3=TC(I+1,J,K)
      IF(J.EQ.1) GO TO 18
      T4=TC(I,J-1,K)
      GO TO 20
   18 IF(K.EQ.1) GO TO 19
      IJK=NK(K-1)
      T4=TC(I,IJK,K-1)
      GO TO 20
   19 T4=TC(I,1,1)
   20 T5=TC(I-1,J,K)
      A2=S2/DIS2
      A3=S3/DIS3
      A4=S4/DIS4
      A5=S5/DIS5
```

```
      ASH=A2*T2+A3*T3+A4*T4+A5*T5
      A9H=A2+A3+A4+A5
      TC(I,J,K)=ASH/A9H
  130 CONTINUE
C
C   CLADDING INNER SURFACE
      FL=0.5*(RF(1)-RF(2))
      FC=0.5*(RC(NRC)-RC(NRC1))
      DIS3=0.5*(RC(NRC)-RC(NRC1)+RF(1)-RF(2))
      DIS5=0.5*(RC(NRC-1)-RC(NRC1))
      S2=RC(NRC)-RC(NRC1)
      S4=S2
      DO 140 K=1,NN
      DISTA=0.5*(RC(NRC)+RC(NRC1))*THE(K)
      FNK=FLOAT(NK(K))
      DIST=DISTA/FNK
      S3=RCI*THE(K)/FNK
      S5=RC(NRC)*THE(K)/FNK
      FNKM1=FLOAT(NK(K-1))
      FNKP1=FLOAT(NK(K+1))
      NNK=NK(K)
      DO 140 J=1,NNK
      DIS2=DIST
      DIS4=DIST
      IF(J.EQ.NK(K).AND.K.NE.NN) GO TO 133
      GO TO 134
  133 DISTA=0.5*(RC(NRC)+RC(NRC1))*THE(K+1)
      DIS2=0.5*(DIST+DISTA/FNKP1)
  134 IF(J.EQ.1.AND.K.NE.1) GO TO 135
      GO TO 136
  135 DISTA=0.5*(RC(NRC)+RC(NRC1))*THE(K-1)
      DIS4=0.5*(DIST+DISTA/FNK1)
  136 IF(J.EQ.NK(K)) GO TO 21
      T2=TC(NRC,J+1,K)
      GO TO 23
   21 IF(K.EQ.NN) GO TO 22
      T2=TC(NRC,1,K+1)
      GO TO 23
   22 T2=TC(NRC,J,NN)
   23 T3=TF(1,J,K)
      IF(J.EQ.1) GO TO 24
      T4=TC(NRC,J-1,K)
      GO TO 26
   24 IF(K.EQ.1) GO TO 25
      IJK=NK(K-1)
      T4=TC(NRC,IJK,K-1)
      GO TO 26
   25 T4=TC(NRC,1,1)
   26 T5=TC(NRCM1,J,K)
      A2=S2/DIS2
      TT=TC(NRC,J,K)
      TTT=TF(1,J,K)
      RAMFC=DIS3/(FL/RAMF(TTT)+FC/RAMC(TT)+1./GAP)
      A3=S3/DIS3*RAMFC/RAMC(TT)
      A4=S4/DIS4
      A5=S5/DIS5
      ASH=A2*T2+A3*T3+A4*T4+A5*T5
```

```
      ABD=A2+A3+A4+A5
      TC(NRC,J,K)=ASH/ABD
  140 CONTINUE
C  FUEL SURFACE
C
C
      DIS3=0.5*(RF(1)-RF(3))
      DIS5=0.5*(RC(NRC)-RC(NRC1)+RF(1)-RF(2))
      S2=RF(1)-RF(2)
      S4=S2
      DO 150 K=1,NN
      DISTA=0.5*(RF(1)+RF(2))*THE(K)
      FNK=FLOAT(NK(K))
      DIST=DISTA/FNK
      S3=RF(2)*THE(K)/FNK
      S5=RF(1)*THE(K)/FNK
      FNK1=FLOAT(NK(K-1))
      FNKP1=FLOAT(NK(K+1))
      NNK=NK(K)
      DO 150 J=1,NNK
      DIS2=DIST
      DIS4=DIST
      IF(J.EQ.NK(K).AND.K.NE.NN) GO TO 141
      GO TO 142
  141 DISTA=0.5*(RF(1)+RF(2))*THE(K+1)
      DIS2=0.5*(DIST+DISTA/FNKP1)
  142 IF(J.EQ.1.AND.K.NE.1) GO TO 144
      GO TO 146
  144 DISTA=0.5*(RF(1)+RF(2))*THE(K-1)
      DIS4=0.5*(DIST+DISTA/FNK1)
  146 IF(J.EQ.NK(K)) GO TO 27
      T2=TF(1,J+1,K)
      GO TO 29
   27 IF(K.EQ.NN) GO TO 28
      T2=TF(1,1,K+1)
      GO TO 29
   28 T2=TF(1,J,NN)
   29 T3=TF(2,J,K)
      IF(J.EQ.1) GO TO 30
      T4=TF(1,J-1,K)
      GO TO 32
   30 IF(K.EQ.1) GO TO 31
      IJK=NK(K-1)
      T4=TF(1,IJK,K-1)
      GO TO 32
   31 T4=TF(1,1,1)
   32 T5=TC(NRC,J,K)
      A2=S2/DIS2
      A3=S3/DIS3
      A4=S4/DIS4
      TT=TF(1,J,K)
      TTT=TC(NRC,J,K)
      RAMFC=DIS5/(FL/RAMF(TT)+FC/RAMC(TTT)+1./GAP)
      A5=S5/DIS5*RAMFC/RAMF(TT)
      FNK=FLOAT(NK(K))
      VOL=(RF(1)**2-RF(2)**2)*THE(K)/(2.*FNK)
      ASH=A2*T2+A3*T3+A4*T4+A5*T5+VOL*Q(1,J,K)/RAMF(TT)
```

```
PROGRAM SPJTC      74/74   OPT=1                        FTN 4.1+P373     12/14/74  10.27.56.     PAGE    8

          ABO=A2+A3+A4+A5
          TF(I,J,K)=ASH/ABO
      150 CONTINUE
C     FUEL MATRIX
          NRFM1=NRF-1
          DO 160 I=2,NRFM1
          DIS3=0.5*(RF(I)-RF(I+2))
          DIS5=0.5*(RF(I-1)-RF(I+1))
          S2=RF(I)-RF(I+1)
          S4=S2
          DO 160 K=1,NN
          DISTA=0.5*(RF(I)+RF(I+1))*THE(K)
          FNK=FLOAT(NK(K))
          DIST=DISTA/FNK
          S3=RF(I+1)*THE(K)/FNK
          S5=RF(I)*THE(K)/FNK
          FNK1=FLOAT(NK(K-1))
          FNKP1=FLOAT(NK(K+1))
          NNK=NK(K)
          DO 160 J=1,NNK
          DIS2=DIST
          DIS4=DIST
          IF(J.EQ.NK(K).AND.K.NE.NN) GO TO 152
          GO TO 154
      152 DISTA=0.5*(RF(I)+RF(I+1))*THE(K+1)
          DIS2=0.5*(DIST+DISTA/FNKP1)
      154 IF(J.EQ.1.AND.K.NE.1) GO TO 156
          GO TO 158
      156 DISTA=0.5*(RF(I)+RF(I+1))*THE(K-1)
          DIS4=0.5*(DIST+DISTA/FNK1)
      158 IF(J.EQ.NK(K)) GO TO 33
          T2=TF(I,J+1,K)
          GO TO 35
       33 IF(K.EQ.NN) GO TO 34
          T2=TF(I,1,K+1)
          GO TO 35
       34 T2=TF(I,J,NN)
       35 T3=TF(I+1,J,K)
          IF(J.EQ.1) GO TO 36
          T4=TF(I,J-1,K)
          GO TO 38
       36 IF(K.EQ.1) GO TO 37
          IJK=NK(K-1)
          T4=TF(I,IJK,K-1)
          GO TO 38
       37 T4=TF(I,1,1)
       38 T5=TF(I-1,J,K)
          A2=S2/DIS2
          A3=S3/DIS3
          A4=S4/DIS4
          A5=S5/DIS5
          VOL=(RF(I)**2-RF(I+1)**2)*THE(K)/(2.*FNK)
          IT=TF(I,J,K)
          ASH=A2*T2+A3*T3+A4*T4+A5*T5+VOL*Q(I,J,K)/RAME(IT)
          ABO=A2+A3+A4+A5
          TF(I,J,K)=ASH/ABO
      150 CONTINUE
```

```
      C   FUEL CENTER
      C
          DIS5=0.5*(RF(NRF-1)-RF(NRF1))
          S2=RF(NRF)-RF(NRF1)
          S4=S2
          DO 170 K=1,NN
          DISTA=0.5*RF(NRF)*THE(K)
          FNK=FLOAT(NK(K))
          DIST=DISTA/FNK
          S5=RF(NRF)*THE(K)/FNK
          FNK1=FLOAT(NK(K-1))
          FNKP1=FLOAT(NK(K+1))
          NNK=NK(K)
          DO 170 J=1,NNK
          DIS2=DIST
          DIS4=DIST
          IF(J.EQ.NK(K).AND.K.NE.NN) GO TO 162
          GO TO 164
      162 DISTA=0.5*RF(NRF)*THE(K+1)
          DIS2=0.5*(DIST+DISTA/FNKP1)
      164 IF(J.EQ.1.AND.K.NE.1) GO TO 166
          GO TO 168
      166 DISTA=0.5*RF(NRF)*THE(K-1)
          DIS4=0.5*(DIST+DISTA/FNK1)
      168 IF(J.EQ.NK(K)) GO TO 39
          T2=TF(NRF,J+1,K)
          GO TO 41
       39 IF(K.EQ.NN) GO TO 40
          T2=TF(NRF,1,K+1)
          GO TO 41
       40 T2=TF(NRF,J,NN)
       41 IF(J.EQ.1) GO TO 42
          T4=TF(NRF,J-1,K)
          GO TO 44
       42 IF(K.EQ.1) GO TO 43
          IJK=NK(K-1)
          T4=TF(NRF,IJK,K-1)
          GO TO 44
       43 T4=TF(NRF,1,1)
       44 T5=TF(NRF-1,J,K)
          A2=S2/DIS2
          A4=S4/DIS4
          A5=S5/DIS5
          TT=TF(NRF,J,K)
          VOL=RF(NRF)**2*THE(K)/(2.*FNK)
          ASH=A2*T2+A4*T4+A5*T5+VOL*Q(NRF,J,K)/RAMF(TT)
          ABO=A2+A4+A5
          TF(NRF,J,K)=ASH/ABO
      170 CONTINUE
      C
      C
          ALL=FLOAT(LL)
          AMA=FLOAT(MA)
          AB=ALL/AMA
          LAB=AB+0.0001
          ABC=FLOAT(LAB)
          HAN=ABC-AB
```

```
      AHAN=ABS(HAN)-0.0001
      IF(AHAN) 610,610,630
  610 WRITE(NOUT,9002) LL
      DO 620 K=1,NN
      NNK=NK(K)
      DO 620 J=1,NNK
      WRITE(NOUT,9003) (TF(I,J,K),I=1,NRF)
  620 CONTINUE
      DO 621 K=1,NN
      NNK=NK(K)
      DO 621 J=1,NNK
      WRITE(NOUT,9003) (TC(I,J,K),I=1,NRC)
  621 CONTINUE
C     CONVERSION CHECK
  630 IF(LL.EQ.1) GO TO 47
      SAI=0.0
      DO 180 I=1,NRC
      DO 180 K=1,NN
      NNK=NK(K)
      DO 180 J=1,NNK
      HAN=TC1(I,J,K)-TC(I,J,K)
      AHAN=ABS(HAN)
      IF(AHAN-SAI) 180,180,45
   45 SAI=AHAN
  180 CONTINUE
      IF(SAI.GT.0.002) GO TO 47
C
      SAI=0.0
      DO 190 I=1,NRF
      DO 190 K=1,NN
      NNK=NK(K)
      DO 190 J=1,NNK
      HAN=TF1(I,J,K)-TF(I,J,K)
      AHAN=ABS(HAN)
      IF(AHAN-SAI) 190,190,46
   46 SAI=AHAN
  190 CONTINUE
      IF(SAI.GT.0.002) GO TO 47
      GO TO 49
   47 DO 200 I=1,NRC
      DO 200 K=1,NN
      NNK=NK(K)
      DO 200 J=1,NNK
      TC1(I,J,K)=TC(I,J,K)
  200 CONTINUE
      DO 210 I=1,NRF
      DO 210 K=1,NN
      NNK=NK(K)
      DO 210 J=1,NNK
      TF1(I,J,K)=TF(I,J,K)
  210 CONTINUE
      IF(LL.GT.LLLL) GO TO 51
      GO TO 131
   49 WRITE(NOUT,9004)
      WRITE(NOUT,9005)
      DO 220 K=1,NN
      NNK=NK(K)
```

```
PROGRAM SPDIC     74/74    OPT=1                    FTN 4.1+P373      12/14/74  10.27.56.      PAGE    11

          DO 220 J=1,NNK
          WRITE(NOUT,9003) (TF(I,J,K),I=1,NRF)
      220 CONTINUE
          WRITE(NOUT,9006)
          DO 230 K=1,NN
          NNK=NK(K)
          DO 230 J=1,NNK
          WRITE(NOUT,9003) (TC(I,J,K),I=1,NRC)
      230 CONTINUE
C
       51 DO 240 I=1,NRF
          DO 240 K=1,NN
          NNK=NK(K)
          DO 240 J=1,NNK
          WRITE(3,7001) TF(I,J,K)
      240 CONTINUE
          DO 250 I=1,NRC
          DO 250 K=1,NN
          NNK=NK(K)
          DO 250 J=1,NNK
          WRITE(3,7001) TC(I,J,K)
     7001 FORMAT(8F10.4)
      250 CONTINUE
          IF(LR) 990,5,990
      990 ENDFILE 3
          REWIND 3
          IF(NR) 992,992,991
      991 REWIND 7
      992 STOP
     9002 FORMAT(1H1,/,10X,16HNO. OF ITERATION,I5)
     9003 FORMAT(5X,10(2X,F8.3))
     9004 FORMAT(1H1,5X,25HFINAL CALCULATION RESULTS)
     9005 FORMAT(1H0,23HTEMPERATURE IN THE FUEL)
     9006 FORMAT(1H0,23HTEMPERATURE IN THE CLAD)
     1000 FORMAT(16I5)
     1010 FORMAT(I5,F15.5)
     1020 FORMAT(8F10.3)
     1030 FORMAT(3F10.3)
     1040 FORMAT(20A4)
     1050 FORMAT(5F10.5)
     8000 FORMAT(/)
     8010 FORMAT(16I5)
     8020 FORMAT(16I5)
     8030 FORMAT(8F10.3)
     8040 FORMAT(8F10.3)
     8050 FORMAT(8F10.3)
          END
$JK  SET2
```

PROGRAM SPJIC 74/74 OPT=1 FTN 4.1+P373 12/14/74 10.27.56. PAGE 12

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
10214 SPJIC

VARIABLES		SN TYPE	RELOCATION				
14121	AB	REAL		14123	ABC	REAL	
14110	ABU	REAL		14125	AHAN	REAL	
14053	AKK	REAL		14117	ALL	REAL	
14120	AMA	REAL		14107	ASH	REAL	
14101	A2	REAL		14102	A3	REAL	
14103	A4	REAL		14106	A5	REAL	
14054	DDEN	REAL		0	BEN	REAL	LABEL
14066	DIS1	REAL		14064	DISTA	REAL	
14073	DIS2	REAL		14057	DIS3	REAL	
14074	DIS4	REAL		14060	DIS5	REAL	
14056	FC	REAL		14112	FL	REAL	
14065	FNK	REAL		14072	FNKP1	REAL	
14071	FNK1	REAL		14050	FNN	REAL	
14033	GAP	REAL		14124	HAN	REAL	
14031	HF	REAL		14045	HTC	REAL	
14013	I	INTEGER		14037	II	INTEGER	
14042	IIP1	INTEGER		14100	IJK	INTEGER	
14041	J	INTEGER		14040	JJ	INTEGER	
14044	JJP1	INTEGER		14024	K	INTEGER	
14122	LAK	INTEGER		14055	LL	INTEGER	
14035	LLLL	INTEGER		14014	LMESH	INTEGER	
14015	LNESS	INTEGER		14046	LR	INTEGER	
14036	NA	INTEGER		14011	NIN	INTEGER	
14127	NK	INTEGER	ARRAY	14022	NN	INTEGER	
14043	NNK	INTEGER		14012	NOUT	INTEGER	
14032	NR	INTEGER		14017	NRC	INTEGER	
14111	NRCM1	INTEGER		14020	NRC1	INTEGER	
14016	NRF	INTEGER		14116	NRFM1	INTEGER	
14021	NRF1	INTEGER		24013	P	REAL	ARRAY
14034	PRE	REAL		14047	PY	REAL	
14153	R	REAL	ARRAY	14105	RAMCC	REAL	
14114	RAMEC	REAL		53461	RC	REAL	ARRAY
14027	RCI	REAL		14026	RCO	REAL	
53435	RF	REAL	ARRAY	14025	RFO	REAL	
14126	SAI	REAL		14051	SM	REAL	
14052	SMC	REAL		14061	S2	REAL	
14067	S3	REAL		14062	S4	REAL	
14070	S5	REAL		33735	TC	REAL	ARRAY
14030	TCOOL	REAL		47515	TC1	REAL	ARRAY
24063	TEMC	REAL	ARRAY	24037	TEMP	REAL	ARRAY
24075	TF	REAL	ARRAY	37655	TF1	REAL	ARRAY
53473	THE	REAL	ARRAY	14023	THEA	REAL	
53505	TITLE	REAL	ARRAY	14104	TT	REAL	
14113	TTT	REAL		14075	T2	REAL	
14076	T3	REAL		14077	T4	REAL	
14063	T5	REAL		14115	VOL	REAL	

FILE NAMES		MODE							
0	INPUT		2041	OUTPUT		4102	TAPE3	FMT	0 TAPE5
2041	TAPE6		6143	TAPE7	FMT				

```
PROGRAM SPOIC     74/74  OPT=1                FTN 4.1+P373     12/14/74  10.27.56.     PAGE  13

 EXTERNALS        TYPE   ARGS
     EXP          REAL      1 LIBRARY                          RAMF       REAL       1

 INLINE FUNCTIONS   TYPE   ARGS
     ABS          REAL      1  INTRIN                          FLOAT      REAL       1  INTRIN
     RAMC         REAL      1    SF

 STATEMENT LABELS
 10247   3                         10261   4                          10217   5
     0   6          INACTIVE       10466   7                          10540   8
 11070   9                         11074  10                          11075  11
 11102  12                         11111  13                          11112  14
 11251  15                         11255  16                          11256  17
 11263  18                         11273  19                          11275  20
 11427  21                         11435  22                          11443  23
 11456  24                         11466  25                          11470  26
 11650  27                         11655  28                          11662  29
 11672  30                         11702  31                          11704  32
 12076  33                         12104  34                          12112  35
 12123  36                         12133  37                          12135  38
 12304  39                         12312  40                          12320  41
 12327  42                         12337  43                          12341  44
     0  45          INACTIVE           0  46          INACTIVE        12560  47
 12623  49                         12677  51                              0  80
     0  81                             0  82                              0  83
     0  85                             0  86                              0  87          INACTIVE
 10610  88                             0  92          INACTIVE        10621  93
     0 100                             0 110                          11042 115
 11051 116                         11056 117                          11065 118
     0 119                             0 120                          11225 121
 11233 122                         11240 123                          11246 124
     0 130                         10773 131                          11373 133
 11403 134                         11410 135                          11420 136
     0 140                         11616 141                          11625 142
 11632 144                         11641 146                              0 150
 12042 152                         12052 154                          12057 156
 12067 158                             0 160                          12252 162
 12261 164                         12266 166                          12275 168
     0 170                         12516 180                          12547 190
     0 200                             0 210                              0 220
     0 230                             0 240                              0 250
     0 310                             0 411                          10755 501
 10760 502                         10762 503                              0 610          INACTIVE
     0 620                             0 621                          12473 630
     0 990          INACTIVE           0 991          INACTIVE        12760 992
 13743 1000   FMT                  13745 1010   FMT                   13747 1020   FMT
 13751 1030   FMT                  13753 1040   FMT                   13755 1050   FMT
 13352 2000   FMT                  13364 2001   FMT                   13367 2002   FMT
 13374 2003   FMT                  13400 2004   FMT                   13403 2005   FMT
 13424 2006   FMT                  13432 2007   FMT                   13441 2008   FMT
 13446 2009   FMT                  13473 2010   FMT                   13477 2011   FMT
 13506 2012   FMT                  13513 2013   FMT                   13522 2014   FMT
 13532 2015   FMT                  13540 2016   FMT                   13550 2017   FMT
 13556 2018   FMT                  13564 2019   FMT                   13572 2020   FMT
 13601 2021   FMT                  13610 2022   FMT                   13616 2023   FMT
 13622 2024   FMT                  13410 2025   FMT                   13415 2026   FMT
 13454 2027   FMT                  13464 2028   FMT                   13630 2029   FMT
 13636 2030   FMT                  13346 2031   FMT                   13710 7001   FMT
```

PNC – PU

Appendix 3 Sample Input

INPUT DATA FORM

PAGE ____ OF ____

JOB NUMBER ____ MAIN PROGRAM LABEL ____ KEYPUNCH RECORD DATE ____ NO. OF CARDS ____

PROBLEM ____ MODIFICATION ____ KEYPUNCHED BY ____

CODED BY ____ DATE ____ VERIFIED BY ____

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
01	2060.	2200.	2300.	2400.	2500.	2560.		
02	280.	300.	340.	360.				
03	/ (col. 5)							
04								
05								
06								
07								
08								
09								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

PNC - PU

INPUT DATA FORM

PAGE ____ OF ____

JOB NUMBER	MAIN PROGRAM LABEL	KEYPUNCH RECORD	DATE	NO. OF CARDS
PROBLEM	MODIFICATION	KEYPUNCHED BY		
CODED BY	DATE	VERIFIED BY		

Card	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
01	PU SPOT D	IA. 400MICR	ON 10%PUO2	S. 49. 12.	13	F. HATAKEYA	MA	
02	1 1							
03	14 4							
04	0.72	0.695	0.68	0.66	0.63	0.602	0.55	0.491
05	0.45	0.4	0.348	0.30	0.20	0.10	0.0	
06	0.823	0.801	0.779	0.757	0.735			
07	6	3.142						
08	0.0873	0.611	0.611	0.611	0.611	0.611		
09	4 4	3 3	3 3					
10	0.72	0.823	0.735	0.95				
11	240.	118.						
12	0							
13	0.852	34.						
14	5000 200							
15	2 1							
16	15511.3							
17	15511.3							
18	399.87	399.87	379.78	379.78	379.78	361.75	361.75	346.45
19	346.45	346.45	332.13	332.13	332.13	332.13		
20	740.	900.	1200.	1400.	1550.	1700.	1800.	1940

Appendix 4 Sample Output

```
PU SPOT  DIA.  400MICRON  1000/0 PUO2  S49.12.14.   F. HATAKEYAMA
===========================================================================

                                   * * * * * * * * * * * *
                                   *                     *
                                   *   INPUT   LISTING   *
                                   *                     *
                                   * * * * * * * * * * * *
MESHING
  RADIAL                         FUEL   14    CLAD    4
  CIRCUMFERENTIAL    BIG         6
                     SMALL       4   4   3   3   3   3

GEOMETRY
  CIRCUMFERENTIAL  ANGLE
      TOTAL                (RADIAN)  - - - - - - - - - - -    3.142
      EACH  REGION         (RADIAN)  - - - - - - - - - - -     .087      .611      .611      .611      .611      .611

  FUEL  RADIUS             (CM)      - - - - - - - - - - -     .720
  CLAD  RADIUS    INNER    (CM)      - - - - - - - - - - -     .735
                  OUTER    (CM)      - - - - - - - - - - -     .823
  FUEL  DENSITY            (O/OTD)   - - - - - - - - - - -   95.000
  FUEL  RADIAL  MESH   (CM)   - - - -     .720      .695      .680      .660      .630      .602      .550      .491
                                          .450      .400      .368      .300      .200      .100     0.000
  CLAD  RADIAL  MESH   (CM)   - - - -     .823      .801      .779      .757      .735

THERMAL  CONDITION
  COOLANT  BULK  TEMP.     (DEG.C)   - - - - - - - - - - -  240.000
           PRESSURE        (ATM)     - - - - - - - - - - -   34.000
  CLAD  SURFACE  HEAT  FLUX (W/CM2)  - - - - - - - - - - -  118.000
  F-C  GAP  CONDUCTANCE    (W/CM2-DEG.C)  - - - - - - - -     .8520
  PU  SPOT  POWER      (W/CM3)  - - -  15511.300
  MATRIX  POWER        (W/CM3)  - - -   399.870   399.870   379.780   379.780   379.780   361.750   361.750   346.450
                                        346.450   346.450   332.130   332.130   332.130   332.130

  INITIAL  GUESS  OF  TEMP.  (DEG.C)
           CLADDING  - - - - - - - - - -   280.000   300.000   340.000   360.000
           FUEL      - - - - - - - - - -   740.000   900.000  1200.000  1400.000  1550.000  1700.000  1800.000  1940.000
                                          2060.000  2200.000  2300.000  2400.000  2500.000  2560.000
                              INITIAL  TEMPERATURE  GUESS  WAS  READ  FROM  CARD

PU  SPOT  MESH                I= 1, 2   J= 1, 1

ITERATION  CONDITION
  MAXIMUM  ITERATION  NO.        - - - - - - - - - -   5000
  ITERATION  STEP  FOR  WRITE    - - - - - - - - - -    200
```

```
FINAL CALCULATION RESULTS

TEMPERATURE IN THE FUEL
          895.592  1000.973  1020.146  1094.165  1200.980  1354.503  1560.247  1726.561  1864.766  1973.808
 2094.497  2257.038  2362.916  2444.316
          822.213   933.552   997.764  1087.426  1198.226  1353.444  1559.861  1726.380  1864.673  1973.751
 2094.466  2257.024  2382.910  2444.312
          778.435   893.020   974.366  1077.302  1193.361  1351.428  1559.108  1726.024  1864.490  1973.638
 2094.405  2256.999  2382.898  2444.304
          752.250   867.277   955.051  1066.228  1187.139  1348.615  1558.025  1725.506  1864.220  1973.472
 2094.313  2256.961  2382.883  2444.295
          693.416   803.424   896.364  1022.811  1159.123  1334.909  1552.572  1722.852  1862.821  1972.603
 2093.836  2256.764  2382.804  2444.252
          673.563   778.947   869.550   995.554  1134.506  1315.722  1540.483  1715.118  1857.879  1969.232
 2091.833  2255.914  2382.498  2444.148
          667.436   770.958   860.214   984.886  1123.306  1304.851  1531.599  1708.324  1852.839  1965.453
 2089.327  2254.730  2382.055  2444.017
          664.922   767.582   856.151   979.995  1117.767  1298.628  1525.813  1703.299  1848.663  1962.056
 2086.829  2253.396  2381.514  2443.862
          663.490   765.625   853.756   977.036  1114.274  1294.782  1521.504  1699.194  1844.946  1958.819
 2084.230  2251.830  2380.817  2443.660
          662.702   764.536   852.413   975.345  1112.227  1292.314  1518.676  1696.286  1842.108  1956.177
 2081.909  2250.213  2379.995  2443.404
          662.270   763.936   851.669   974.401  1111.068  1290.888  1516.969  1694.441  1840.215  1954.326
 2080.171  2248.649  2379.208  2443.146
          662.012   763.577   851.222   973.831  1110.363  1290.008  1515.889  1693.234  1838.934  1953.027
 2078.890  2247.741  2378.492  2442.884
          661.848   763.348   850.937   973.467  1109.910  1289.439  1515.177  1692.421  1838.049  1952.105
 2077.948  2246.663  2377.864  2442.633
          661.739   763.196   850.747   973.224  1109.607  1289.056  1514.692  1691.859  1837.427  1951.444
 2077.254  2246.177  2377.331  2442.400
          661.665   763.092   850.617   973.058  1109.399  1288.792  1514.356  1691.463  1836.984  1950.967
 2076.742  2245.649  2376.890  2442.191
          661.614   763.020   850.528   972.942  1109.255  1288.608  1514.120  1691.184  1836.667  1950.622
 2076.367  2245.249  2376.536  2442.011
          661.578   762.971   850.465   972.863  1109.155  1288.481  1513.955  1690.987  1836.444  1950.376
 2076.097  2244.953  2376.262  2441.863
          661.554   762.937   850.424   972.809  1109.087  1288.395  1513.844  1690.854  1836.291  1950.207
 2075.911  2244.744  2376.063  2441.750
          661.539   762.916   850.398   972.776  1109.046  1288.341  1513.775  1690.771  1836.196  1950.102
 2075.793  2244.612  2375.933  2441.674
          661.532   762.907   850.385   972.760  1109.026  1288.316  1513.742  1690.732  1836.151  1950.051
 2075.736  2244.547  2375.869  2441.635

TEMPERATURE IN THE CLAD
          280.377   310.905   343.190   378.296
          280.113   310.354   342.112   375.827
          279.638   309.432   340.436   372.733
          279.024   308.279   338.535   369.720
          276.241   303.241   330.820   358.587
          274.270   299.875   326.127   353.030
          273.608   298.755   324.589   351.139
          273.366   298.344   324.019   350.430
          273.245   298.138   323.731   350.064
          273.185   298.035   323.585   349.877
          273.154   297.981   323.509   349.778
          273.136   297.950   323.465   349.720
          273.125   297.931   323.437   349.684
          273.118   297.918   323.418   349.660
          273.113   297.909   323.406   349.643
          273.109   297.903   323.397   349.632
          273.107   297.899   323.391   349.624
          273.105   297.896   323.387   349.619
          273.104   297.894   323.385   349.616
          273.104   297.894   323.384   349.614

    12/14/74   C R C  SCOPE 3.4.16  PSR373  12/04/74

10.27.44.$ SPD$MOJ AT JOT NO.24 -------- UEOJ
10.27.44.$   000578 CARDS READ.  0200.
10.27.44.SPD$MOJ  FROM AM
10.27.44.IP  00002304 WORDS - FILE INPUT  , DC 00
10.27.44.SPD,CM40,T280,P4,MT1.
10.27.45.$ID4,51/101,HATAKE  .                       P=4
10.27.45.FILE OPENED -(AB) OUTPUT
10.27.47.AUTOFL.
10.27.47.LABEL,TAPE3,W,L=SPUTC*DATA,T=7.
10.27.47.( MT51 ASSIGNED)
10.27.52. MT 51  LFN=TAPE3    (W)  VSN=0P4538**
10.27.52. MT 51  LABEL NAME =SPUTC*DATA
10.27.52. MT 51  E=01, T=005, C=74348, V=0001
10.27.52.FTN.
10.28.07.FILE OPENED -(AM) LGO
10.28.10.      7.153 CP SECONDS COMPILATION TIME
10.28.11.LGO.
10.28.20.      9.188 RT SECONDS LOAD TIME
10.35.48.MT51  BLOCKS WRITTEN -000014
10.35.51.     STOP
10.35.51.    204.631 CP SECONDS EXECUTION TIME
10.35.51.RETURN,TAPE3.
10.35.53.OP  00015296 WORDS - FILE OUTPUT , DC 40
10.35.53.SC  00002496 WORDS - FILE LGO     , EO AM
10.35.53.MS   16000  WORDS  (    31488 MAX USED)
10.35.53.CP      214.279 SEC.       214.279 ADJ.
10.35.53.IO       13.145 SEC.
10.35.53.CM      258.277 KWS.         2.017 ADJ.
10.35.53.AVFL     20      KW
10.35.53.SS                         216.296 SEC.
10.35.53.$ ACC#T SYSTEM TIME=    3.7 MIN. (P=4)
10.35.53.CH        5 SEC. USIO    2159 PRU
10.35.53.RC      228 TIMES.   TS0400A      UST194
10.35.53.PP       28.905 SEC.     DATE 12/14/74
10.35.53./10J0F0JSP0041006A0051/101         0037
10.35.53./20J0215001405Z HATAKE        741214
10.35.53.EJ  END OF JOB, AM
 0043 PAGES PRINTED
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