BAB 6

KESIMPULAN DAN SARAN

6.1. Kesimpulan

Dari hasil penelitian yang telah dilakukan, dapat diambil kesimpulan bahwa nilai parameter Tawal yang paling baik (menghasilkan nilai *makespan* paling mendekati optimal) baik untuk kasus Ta005 (5 mesin - 20 *job*), kasus Ta045 (10 mesin - 50 *job*), dan kasus Ta075 (10 mesin - 100 *job*) yaitu 0,025 dengan jumlah iterasi yang dilakukan pada setiap nilai T sebanyak 7 * *job*.

6.2. Saran

Saran yang dapat diberikan untuk mengembangkan penelitian selanjutnya adalah sebagai berikut :

a. Algoritma *Simulated Annealing* perlu dicoba pada kasus-kasus yang lebih kompleks lagi dengan jumlah mesin dan jumlah *job* yang lebih besar untuk mengetahui apakah algoritma ini memiliki performansi yang baik pada kasus dengan jumlah mesin dan *job* yang besar.
b. Memodifikasi metode penentuan jadwal (urutan *job*) awal yang lain untuk digunakan sebagai awal iterasi algoritma *Simulated Annealing*.
c. Ukuran performansi yang dijadikan sebagai fungsi tujuan dapat dicoba dengan fungsi objektif selain *makespan*.

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Lampiran : Listing Program Quick Basic 4.5.

```
DECLARE SUB cds ()
DECLARE SUB bestcds ()
DECLARE SUB mkspn ()
DIM SHARED s(10, 100) AS DOUBLE
DIM SHARED waktu(10, 100) AS DOUBLE
DIM SHARED F(10, 100) AS DOUBLE
DIM SHARED FINISH(10, 100) AS DOUBLE
DIM SHARED zc AS DOUBLE, zbestcds AS DOUBLE, zn AS DOUBLE, makespan
AS DOUBLE
DIM SHARED mesin AS INTEGER, job AS INTEGER, T(100) AS DOUBLE
DIM SHARED waktubestcds(10, 100) AS DOUBLE, urutbestcds(100) AS
DOUBLE
DIM SHARED t1(10, 101) AS DOUBLE, t2(10, 101) AS DOUBLE
DIM SHARED urut(100) AS DOUBLE, urut1(100) AS DOUBLE, urut2(100) AS
DOUBLE
DIM SHARED a(10, 100) AS DOUBLE, b(10, 100) AS DOUBLE, c(10, 100) AS
DOUBLE
DIM SHARED d(10, 100) AS DOUBLE, e(10, 100) AS DOUBLE, g(10, 100) AS
DOUBLE
DIM SHARED r1 AS INTEGER, r2 AS INTEGER, r3 AS DOUBLE
DIM SHARED zbestsa AS DOUBLE, zbantu AS DOUBLE, zbestakhir AS DOUBLE
DIM SHARED waktubestsa(10, 100) AS DOUBLE, urutbestsa(100) AS DOUBLE
DIM SHARED waktubestakhir(10, 100) AS DOUBLE, urutbestakhir(100) AS
DOUBLE
DIM SHARED zbestfinal AS DOUBLE, tawal AS DOUBLE, itr AS INTEGER


CLS
mesin = 5
job = 20
itr = 1

PRINT " DATA WAKTU PROSES"
FOR i = 1 TO mesin
    FOR j = 1 TO job
        READ waktu(i, j)
    NEXT j
NEXT i

PRINT " Job :";
FOR j = 1 TO job
    urut(j) = j
    PRINT USING "####"; urut(j);
NEXT j
PRINT
PRINT

'DATA 20 JOB - 5 MESIN
DATA 61, 86, 18, 42, 14, 92, 67, 77, 46, 41, 78, 3, 72, 95, 53, 59,
34, 66, 42, 63
DATA 27, 92, 8, 65, 34, 6, 42, 39, 2, 7, 85, 32, 14, 74, 59, 95, 48,
37, 59, 4
DATA 42, 93, 32, 30, 16, 95, 58, 12, 95, 21, 74, 38, 4, 31, 62, 39,
97, 57, 9, 54
```

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DATA 13, 47, 6, 70, 19, 97, 41, 1, 57, 60, 62, 14, 90, 76, 12, 89,
37, 35, 91, 69
DATA 55, 48, 56, 84, 22, 51, 43, 50, 62, 61, 10, 87, 99, 40, 91, 64,
62, 53, 33, 16

'DATA 50 JOB - 10 MESIN
'DATA 16, 90, 63, 73, 57, 17, 29, 16, 94, 47, 24, 39, 2, 5, 75, 7,
74, 96, 94, 44, 63, 38, 22, 76, 2, 11, 71, 94, 77, 57, 45, 58, 16,
96, 41, 52, 57, 39, 74, 35, 52, 42, 82, 43, 47, 34, 96, 13, 33, 58
'DATA 13, 27, 27, 9, 88, 3, 29, 96, 39, 15, 61, 76, 79, 67, 6, 61,
32, 76, 96, 59, 85, 36, 23, 72, 71, 44, 88, 58, 51, 73, 10, 85, 16,
41, 40, 57, 85, 73, 9, 24, 94, 4, 96, 37, 84, 2, 94, 21, 4, 73
'DATA 42, 21, 21, 90, 54, 64, 55, 93, 1, 36, 16, 7, 98, 20, 83, 77,
39, 63, 72, 47, 21, 98, 97, 86, 7, 81, 5, 56, 57, 15, 7, 85, 77, 14,
23, 10, 93, 57, 58, 31, 92, 6, 37, 77, 80, 41, 18, 68, 81, 41
'DATA 37, 43, 87, 77, 39, 35, 49, 66, 35, 2, 38, 73, 28, 97, 20, 46,
85, 53, 78, 73, 72, 82, 59, 24, 6, 94, 67, 66, 30, 33, 32, 51, 38,
8, 82, 63, 77, 73, 66, 65, 75, 17, 22, 34, 3, 8, 87, 50, 76, 16
'DATA 68, 3, 58, 57, 49, 13, 72, 13, 13, 5, 88, 38, 82, 41, 61, 85,
81, 53, 65, 89, 50, 78, 38, 82, 38, 38, 85, 55, 64, 47, 87, 66, 5,
16, 48, 29, 67, 72, 5, 79, 30, 64, 3, 80, 11, 99, 32, 25, 84, 12
'DATA 24, 1, 57, 86, 35, 9, 55, 8, 93, 11, 39, 10, 84, 80, 59, 37,
80, 69, 13, 19, 25, 92, 45, 14, 73, 85, 75, 96, 33, 17, 76, 96, 4,
16, 9, 66, 46, 64, 3, 93, 74, 29, 68, 38, 86, 90, 50, 11, 64, 4
'DATA 51, 57, 82, 47, 82, 14, 79, 57, 88, 79, 22, 72, 58, 78, 18,
48, 72, 38, 71, 82, 61, 73, 50, 56, 95, 16, 6, 7, 86, 21, 27, 44,
64, 32, 46, 37, 39, 96, 44, 70, 41, 56, 44, 27, 41, 66, 87, 42, 7,
54
'DATA 8, 54, 15, 47, 73, 33, 73, 35, 45, 75, 83, 12, 59, 95, 96, 75,
62, 44, 43, 30, 47, 36, 65, 85, 1, 71, 13, 54, 2, 82, 16, 15, 14,
49, 68, 28, 87, 85, 90, 17, 54, 59, 25, 23, 60, 60, 68, 70, 80, 4
'DATA 59, 85, 73, 87, 87, 89, 48, 57, 59, 73, 66, 95, 61, 13, 79,
88, 19, 18, 21, 33, 11, 8, 8, 83, 13, 89, 63, 64, 53, 28, 17, 2, 77,
61, 73, 69, 23, 56, 78, 65, 85, 99, 52, 78, 8, 58, 51, 43, 52, 41
'DATA 67, 99, 57, 47, 93, 35, 32, 77, 28, 75, 95, 15, 18, 97, 37,
53, 97, 73, 60, 39, 48, 9, 17, 83, 10, 2, 66, 50, 36, 45, 86, 8, 47,
52, 98, 22, 55, 62, 23, 82, 32, 20, 38, 23, 40, 55, 79, 66, 97, 29

'DATA 100 JOB - 10 MESIN
'DATA 47, 12, 19, 32, 63, 78, 77, 51, 59, 54, 48, 96, 52, 42, 57,
30, 34, 77, 80, 7, 11, 2, 91, 99, 5, 43, 39, 64, 8, 26, 71, 32, 73,
26, 91, 92, 55, 51, 11, 22, 75, 49, 95, 88, 6, 19, 99, 73, 27, 50,
25, 33, 94, 35, 63, 44, 80, 7, 72, 95, 40, 48, 41, 15, 18, 31, 68,
99, 79, 78, 95, 37, 37, 50, 79, 30, 2, 30, 78, 99, 42, 99, 16, 58,
35, 84, 84, 35, 20, 4, 9, 44, 35, 5, 68, 43, 69, 9, 78, 57
'DATA 94, 93, 53, 63, 41, 81, 74, 37, 52, 24, 45, 19, 72, 62, 78,
83, 98, 83, 58, 61, 47, 16, 28, 48, 63, 74, 45, 36, 29, 38, 66, 62,
96, 22, 95, 81, 92, 20, 51, 71, 30, 23, 77, 20, 1, 96, 32, 13, 8,
36, 18, 64, 58, 1, 72, 10, 20, 6, 40, 91, 56, 39, 68, 50, 93, 71,
79, 57, 5, 95, 41, 12, 84, 81, 88, 32, 94, 37, 31, 25, 92, 74, 49,
10, 76, 11, 44, 32, 89, 56, 69, 76, 65, 47, 53, 39, 41, 89, 39, 20
'DATA 56, 31, 66, 73, 96, 31, 41, 79, 66, 49, 39, 28, 24, 85, 64,
37, 85, 40, 35, 77, 30, 26, 41, 6, 19, 83, 52, 54, 71, 86, 45, 78,
61, 5, 87, 43, 44, 42, 30, 12, 7, 18, 80, 53, 6, 81, 29, 22, 49, 1,
79, 56, 15, 36, 48, 31, 57, 49, 20, 67, 20, 34, 78, 27, 40, 46, 23,
```

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28, 84, 33, 87, 76, 18, 3, 77, 50, 96, 75, 91, 12, 34, 51, 54, 37,
82, 69, 49, 19, 69, 48, 96, 13, 4, 28, 74, 7, 24, 98, 30, 97
'DATA 59, 94, 87, 22, 59, 30, 2, 55, 36, 73, 98, 15, 54, 55, 3, 54,
89, 50, 68, 9, 81, 42, 11, 12, 55, 75, 10, 91, 87, 5, 44, 56, 18,
89, 51, 94, 11, 56, 37, 85, 55, 33, 9, 20, 26, 80, 98, 88, 55, 78,
53, 46, 3, 56, 46, 34, 27, 21, 81, 14, 52, 50, 80, 48, 22, 10, 56,
18, 67, 63, 47, 43, 71, 4, 29, 99, 6, 19, 56, 96, 44, 94, 83, 30,
65, 61, 21, 76, 8, 99, 68, 42, 38, 44, 7, 3, 61, 10, 84, 78
'DATA 74, 26, 84, 41, 3, 46, 39, 90, 62, 63, 74, 4, 37, 75, 72, 30,
43, 95, 41, 97, 70, 92, 36, 70, 37, 36, 42, 34, 29, 80, 91, 56, 71,
14, 31, 75, 80, 73, 32, 56, 84, 20, 64, 44, 69, 63, 94, 86, 66, 97,
25, 90, 12, 62, 83, 32, 12, 38, 22, 92, 63, 61, 46, 6, 83, 49, 78,
84, 97, 56, 76, 9, 38, 21, 80, 47, 24, 95, 80, 65, 72, 91, 21, 70,
12, 67, 65, 90, 47, 82, 62, 3, 84, 30, 91, 5, 11, 41, 14, 28
'DATA 78, 58, 53, 17, 36, 3, 83, 91, 73, 81, 74, 2, 31, 37, 78, 74,
51, 41, 78, 26, 33, 70, 10, 45, 70, 2, 92, 50, 54, 64, 44, 4, 99,
43, 43, 11, 60, 53, 45, 63, 87, 20, 71, 95, 71, 99, 79, 19, 41, 74,
8, 55, 87, 87, 37, 52, 36, 6, 42, 30, 3, 86, 3, 89, 57, 27, 28, 88,
48, 26, 58, 6, 33, 3, 25, 61, 93, 69, 53, 47, 28, 36, 39, 63, 66,
44, 18, 67, 17, 84, 9, 33, 80, 27, 42, 60, 96, 81, 31, 88
'DATA 17, 60, 51, 61, 26, 60, 80, 45, 20, 62, 55, 25, 68, 56, 5, 14,
20, 19, 92, 88, 23, 78, 35, 94, 31, 67, 10, 15, 32, 94, 15, 53, 42,
45, 39, 84, 64, 27, 10, 22, 14, 8, 70, 91, 23, 35, 6, 52, 93, 26,
89, 49, 89, 60, 6, 60, 24, 70, 42, 86, 64, 47, 19, 17, 30, 79, 53,
71, 77, 95, 73, 97, 32, 25, 85, 79, 17, 31, 78, 31, 21, 5, 34, 96,
95, 63, 4, 60, 35, 6, 75, 41, 61, 11, 74, 52, 60, 43, 50, 66
'DATA 74, 71, 89, 81, 59, 62, 64, 62, 67, 68, 87, 47, 60, 10, 76,
46, 56, 48, 61, 13, 13, 38, 37, 11, 12, 63, 97, 26, 27, 89, 74, 80,
83, 49, 79, 49, 44, 30, 30, 53, 46, 26, 31, 1, 43, 27, 91, 70, 89,
68, 2, 82, 72, 29, 12, 37, 46, 50, 93, 77, 6, 77, 7, 63, 21, 85, 67,
77, 95, 52, 97, 79, 21, 20, 7, 54, 71, 79, 22, 77, 59, 11, 69, 85,
7, 85, 42, 44, 74, 69, 68, 64, 37, 4, 89, 96, 92, 74, 33, 90
'DATA 12, 5, 15, 16, 64, 6, 65, 53, 19, 93, 21, 38, 54, 46, 33, 38,
32, 12, 90, 46, 8, 78, 95, 28, 47, 10, 16, 45, 18, 4, 98, 35, 85,
77, 4, 33, 87, 47, 5, 81, 25, 31, 83, 45, 23, 30, 89, 40, 92, 48,
63, 63, 76, 90, 1, 24, 1, 77, 91, 78, 93, 32, 97, 85, 91, 40, 67,
84, 31, 5, 89, 59, 69, 68, 46, 4, 90, 76, 97, 33, 23, 46, 36, 70,
98, 45, 49, 50, 52, 67, 6, 58, 71, 53, 36, 80, 8, 27, 21, 66
'DATA 98, 97, 69, 24, 10, 7, 79, 84, 50, 86, 24, 28, 73, 72, 19, 20,
8, 20, 45, 59, 51, 54, 58, 16, 38, 94, 72, 69, 14, 83, 86, 58, 61,
77, 63, 67, 1, 59, 18, 26, 45, 82, 78, 43, 61, 2, 70, 52, 99, 60,
97, 1, 76, 8, 15, 69, 5, 31, 39, 34, 9, 81, 34, 16, 14, 13, 36, 73,
6, 43, 29, 68, 59, 76, 86, 43, 12, 18, 55, 21, 9, 47, 17, 49, 28,
12, 84, 12, 62, 15, 7, 26, 58, 30, 5, 7, 40, 50, 30, 64

FOR i = 1 TO mesin
     PRINT " M"; i; SPC(1);
     FOR j = 1 TO job
          PRINT USING "####"; waktu(i, j);
     NEXT j
     PRINT
NEXT i
PRINT

INPUT "", q
```

```
'Solusi awal dicari dengan menggunakan metode CDS
CALL cds
CALL bestcds

zc = zbestcds
zbantu = zbestcds
zbestsa = zbestcds

FOR i = 1 TO mesin
     FOR j = 1 TO job
          waktubestsa(i, j) = waktubestcds(i, j)
     NEXT j
NEXT i

FOR j = 1 TO job
     urutbestsa(j) = urutbestcds(j)
NEXT j

'ALGORITMA SIMULATED ANNEALING
awal = TIMER
CLS
RANDOMIZE TIMER
x = 0
p = 0
DO
zbestakhir = zbestsa
iterasi = 0
p = p + 1

IF p = 1 THEN
     FOR j = 1 TO job
          urut(j) = urutbestcds(j)
     NEXT j

     FOR i = 1 TO mesin
          FOR j = 1 TO job
               waktu(i, j) = waktubestcds(i, j)
          NEXT j
     NEXT i
ELSE
     zc = zbestsa
     FOR i = 1 TO mesin
          FOR j = 1 TO job
               waktu(i, j) = waktubestsa(i, j)
          NEXT j
     NEXT i
     FOR j = 1 TO job
          urut(j) = urutbestsa(j)
     NEXT j
END IF

tawal = .025
T(p) = tawal * zbantu * (.5 ^ (p - 1))

DO
iterasi = iterasi + 1
```

```
DO
r1 = INT(RND * job) + 1
r2 = INT(RND * job) + 1
LOOP UNTIL r1 <> r2
PRINT
PRINT " Bilangan random : "; r1; "dan"; r2
PRINT

FOR i = 1 TO mesin
     SWAP waktu(i, r1), waktu(i, r2)
NEXT i

PRINT " Job :";
SWAP urut(r1), urut(r2)
FOR j = 1 TO job
     PRINT USING "####"; urut(j);
NEXT j
PRINT
PRINT

FOR i = 1 TO mesin
     PRINT " M"; i; SPC(1);
     FOR j = 1 TO job
          PRINT USING "####"; waktu(i, j);
     NEXT j
     PRINT
NEXT i

CALL mkspn

IF p <> 1 AND iterasi = 1 THEN zc = zbestsa

IF zn <= zc THEN
     zc = zn
     IF iterasi = 1 THEN
          zbestsa = zn
          FOR j = 1 TO job
               urutbestsa(j) = urut(j)
          NEXT j
          FOR i = 1 TO mesin
               FOR j = 1 TO job
                    waktubestsa(i, j) = waktu(i, j)
               NEXT j
          NEXT i
     ELSE
          IF zn <= zbestsa THEN
               zbestsa = zn
               FOR i = 1 TO mesin
                    FOR j = 1 TO job
                         waktubestsa(i, j) = waktu(i, j)
                    NEXT j
               NEXT i
               FOR j = 1 TO job
                    urutbestsa(j) = urut(j)
               NEXT j
```

```
          END IF
     END IF
ELSEIF zn > zc THEN
     prob = EXP((zc - zn) / T(p))
     r3 = RND
     PRINT
     PRINT " Nilai probabilitas : "; prob
     PRINT " Bilangan random    : "; r3
     IF r3 < prob THEN
          PRINT " Karena bilangan random < probabilitas maka jadwal
baru diterima"
          zc = zn
     ELSE
          PRINT " Karena bilangan random > probabilitas maka jadwal
baru ditolak"
          FOR i = 1 TO mesin
               SWAP waktu(i, r1), waktu(i, r2)
          NEXT i
               SWAP urut(r1), urut(r2)
     END IF
END IF

DO

LOOP UNTIL INKEY$ <> ""

LOOP UNTIL iterasi = itr * job

CLS
PRINT " BEST "; "ke-"; p; " : "
PRINT
PRINT " Job :";
FOR j = 1 TO job
     PRINT USING "####"; urutbestsa(j);
NEXT j
PRINT
PRINT
FOR i = 1 TO mesin
     PRINT " M"; i; SPC(1);
     FOR j = 1 TO job
          PRINT USING "####"; waktubestsa(i, j);
     NEXT j
     PRINT
NEXT i
PRINT
PRINT " Makespan : "; zbestsa

INPUT "", q

IF zbestsa = zbestakhir THEN
     x = x + 1
ELSE
     x = 1
END IF

IF p = 1 THEN
```

```
        zbestfinal = zbestsa
        FOR j = 1 TO job
            urutbestakhir(j) = urutbestsa(j)
        NEXT j
        FOR i = 1 TO mesin
            FOR j = 1 TO job
                waktubestakhir(i, j) = waktubestsa(i, j)
            NEXT j
        NEXT i
END IF

IF zbestsa < zbestfinal THEN
        zbestfinal = zbestsa
        FOR j = 1 TO job
            urutbestakhir(j) = urutbestsa(j)
        NEXT j
        FOR i = 1 TO mesin
            FOR j = 1 TO job
                waktubestakhir(i, j) = waktubestsa(i, j)
            NEXT j
        NEXT i
END IF

LOOP UNTIL x = 3 OR p = job
akhir = TIMER
waktu = akhir - awal

CLS
PRINT " SOLUSI MAKESPAN MINIMUM :"
PRINT
PRINT " Job :";
FOR j = 1 TO job
    PRINT USING "####"; urutbestakhir(j);
NEXT j
PRINT
PRINT
FOR i = 1 TO mesin
    PRINT " M"; i; SPC(1);
    FOR j = 1 TO job
        PRINT USING "####"; waktubestakhir(i, j);
    NEXT j
    PRINT
NEXT i
PRINT
PRINT " Makespan        : "; zbestfinal
PRINT
PRINT " Waktu komputasi : "; waktu
PRINT " Banyaknya T     : "; p
END

SUB bestcds
CLS
PRINT " URUTAN JOB TERBAIK DENGAN METODE CDS:"
PRINT
PRINT " Job :";
FOR j = 1 TO job
```