**Formulation:**

**Indexed Sets:**

i: plant # (i=1,2,3,4,5)

j: warehouse # (j=1,2,3,4)

k: retail # (k=1,2,3,4,5,6,7,8)

t: time (t=1,2,3,4,5,6,7,8,9,10)

(Note, we will use two derived indexed sets: ij and jk)

**Data: (Hint – look at the tables!)**

Plant capacity

Ui = the capacity of plant i in units

Retail demand

Dkt = demand for retail k in units in year t

If k=1,2,4,5,8, Dkt=Dk1+0.2\*Dk1(t-1)

If k=3,6,7, Dkt=Dk1+0.25\*Dk1(t-1)

Shipping cost

Cijt = Cijt shipping cost from plant i to warehouse j in year t

Sjkt= Sjkt shipping cost from warehouse j to retail k in year t

Plant cost

Qit = construction cost for plant i in year t

Oit = Operational cost for plant i in year t

Rit = reopening cost for plant i in year t

Pit = shutdown cost for plant i in year t

Product cost

At = Cost for 1 pound of alloy in year t

Wit = Cost for each widget from plant i in year t

(For every single cost variable, e.g. Cijt=Cijt)

**Variables:**

Amounts

Xijt = # of Flugels produced at plant i and shipping to warehouse j in year t

Yjkt = # of Flugels shipped from warehouse j to retail k in year t

Vjt = # of Flugels stored at the end of year t at warehouse j

Ait = # of Alloys produced from plant i in year t

BINARY for 4 costs for plant i

Zit=1 if plant i has construction cost in year t, 0 otherwise,

Nit=1 if plant i has operating cost in year t, 0 otherwise

Hit=1 if plant i has reopening cost in year t, 0 otherwise

Git=1 if plant i has shutdown cost in year t, 0 otherwise

BINARY for widgets (L(1,2)=1/0 and B(1,2,3)=1/0)

L1=1 if segment 1(when 0<=Xijt<=3000) is used, 0 otherwise

L2=1 if segment 2(when Xijt>3000) is used, 0 otherwise

Continuous

B1=0~1 if convex combination 1 is used

B2=0~1 if convex combination 2 is used

B3=0~1 if convex combination 3 is used

**Objective:**

Minimize cost: ++At\*4.7\*+[0\*B1+1350\*B2+(1152t+4878)\*B3]+ +++

**Constraints:**

Demand and Capacity:

**{Products vs. Demand for retail k}**

**{Product vs. Capacity for plant i}**

= for all j and t if t>=1 **{Balance Node}**

= for all j and t if t=0 **{Balance Node}**

Plant Constraints:

Nit <= for all i **{check the construction status}**

Ni(t-1)-Nit <= Git **{check the shutdown status}**

Nit-Ni(t-1) <= Hit+Zit, t>=3 **{check the reopening status}**

Hit + Zit <= 1, t>=3 **{check the reopening status}**

for all i

for all i

for all i

Warehouse Constraints:

(Vj(t-1)+Vjt)/2 <= 4000 for all j and t **{Storage limits of products for warehouse j for 4000}**

for all j and t

for all k and t

Alloy Constraints:

for all i, j and t

Widgets Constraints:

B1+B2+B3=1

L1+L2=1

B1<=L1

B2<=L1+L2

B3<=L2