**Optimization Final Project (Updated)**

*Indexed Sets*

i = plant (i = 1...5)

j = warehouses (j = 1,...4)

k = retail center (k = 1,...8)

t = year (t = 1….10)

*Data:*

Dkt = demand for retail center k in year t

Ci = capacity (units) of plant i

Kit = construction cost of plant i in year t

Oit = annual operating cost of plant i in year t

Rit = reopening cost of plant/production line i in year t

Sit = shutdown cost of plant/production line i in year t

Aijt = cost of shipping a Flugel from Plant i to Warehouse j in year t

Bjkt = cost of shipping a Flugel from Warehouse j to Retail Center k in year t

Lit = cost of alloy of plant i in year t

Uit = cost of subassemblies of plant i in year t

Dit = cost of discounted subassemblies of plant i in year t

*Objective:* minimize the total cost of meeting the expected demand over the next 10 years

min Aijt + Bjkt + Plant Costs + Cost of Alloy + Cost of Widget Subassemblies

*Decision Variables:*

zit = units of Flugels produced by plant i in year t (500 variables)

xijt = units of Flugels shipped from plant i to warehouse j in year t (200 variables) (note: it represents inflow)

yjkt = units of Flugels shipped from warehouse j to retail center k in year t (320 variables) (note: it represents outflow)

Ijt = amount of inventory stored in warehouse j in year t (40 variables)

(keep this, cause we still will have inventory each year. For example, warehouse 1 receives 100 products in year 1, and it ships 80 products to retail centers that year, then it will have an inventory of 20, which will be used in the future)

e1it and e2it = will be used for cost structure part. Let e1 = 1 if segment 1 is used; 0 otherwise; Let e2 = 1 if segment 2 is used; 0 otherwise. Each plant in each year have their own e (binary)

λ1it,λ2it, λ3it = will be used for the cost structure when calculating the weighted units of purchased raw materials of plant i in year t.

Pit = whether the plant i’s production line is open at the beginning of year t. 1: open, 0: close (binary) (I deleted the ‘m’ because I deleted the production line index before!)

Fit = whether the production line in the plant i is going to be shut down at the end of year t or not. 1: shut down, 0: close (binary)

Git = whether the production line in the plant i in year t is the initial construction year. 1: initial, 0: not initial (binary) (This one helps calculating reopening cost. After I read through the case again, it looks like reopening cost will occur in the initial construction of each opening period. For example, if a plant opens in year 2,3,4 and shut down in 4, and reopen in 7,8, then both year 2 and year 7 are the initial construction year and will have reopening costs)

Hit = whether the production line in the plant i was never opened before year t or not. 1: not opened before, 0: opened before (binary) (This one helps calculating the construction cost)

***Plant Cost:***

+ + + (partial obj function)

\*Note:

First part: operating cost

Second part: shut down cost

Third part: reopening cost

Fourth part: construction cost

(\*\*We need to set constraints to identify the open/close conditions!)

Constraints:

If Pit-1 == 0: Git=1. Else: Git=0 (helps identify if it is the initial construction year)

Updated: Git = 1-Pit-1 for each i and t

If >=1: Hit=0. Else: Hit=1 (if the sum of all previous Pit are >= 1 then it means the plant has operated before year t)

If Pit+1==0: Fit=1. Else: Fit=0 (If the next year the plant’s production line is not operating, then it means it has been shut down in the previous year)

Updated: Fit = 1-Pit+1 for each i and t

If Pit==0: zit=0. Else: zit>0 (a production line cannot be allowed to remain idle in a given year)

Updated: zit <= PitCi  for each i and t (Don’t exceed capacity)\

Pi0 = 0 for each I (new, cause we need to allow gurobi track the Pit in year 1, so I think we need to have a year 0 column)

**Material cost:**

Widget:

ait = total number of widget will be ordered

f(ait) = cost function

f(a) = Uit\*ait 0<=ait<=9,000

9000\* Uit+ Dit\*(ait-9000) 9,000<ait<=1,000,000

Three boundaries: 0 9,000 1,000,000

ait = 0 λ1it+9000 λ2it+1000000 λ3it  (number of widgets should be ordered by plant i in year t)

f(ait) = (0\*Uit) λ1it+(9000\*Uit) λ2it+[9000\* Uit+ Dit\*(1000000-9000)] λ3it (partial obj function)

Constraints:

λ1it +λ2it +λ1it=1 for each i and t

λ1it<= e1it for each i and t

λ2it<= e1it+e2it for each i and t

λ3it<= e2it for each i and t

e1it+e2it=1 for each i and t

0 λ1it+9000 λ2it+1000000 λ3it /3 = zit (the amount of widget purchased by plant i in year t divided by three equals to the unit of flugels produced by plant i in year t)

Alloy:

Lit\*zit (partial obj function)

Constraint:

4.7\* zit<=60000 for each i and t

**Shipping cost:**

+ (partial obj function)

Constraint:

for each i and t (sum of products shipped from each plant in year t equals to the amount of flugels produced by it in year t) Wilck said each plant can ship products to multiple warehouses, that’s why I sum up j for each i

~~for each j and t (sum of products received by warehouse j in year t equals to sum of products shipped from warehouse j in year t) cause each warehouse can ship products to multiple retail centers~~

Updated: for each j and t (sum of inflow and previous inventory equals to sum of outflow and this year’s inventory)

~~<= 4000\*10 for each j (average inventory in any year to be no more than 4000 items (among all Warehouses))~~

Updated: for each j (average inventory in any year to be no more than 4000 items (among all Warehouses))

Ij0 = 0 for each j (new, cause the previous inventory at year one should always be 0)

<= 12\*1000 for each j and t

<= 12\*1000 for each j and t (both the flow into a warehouse and the flow out of a warehouse should not exceed an average of 1000 units per month)

for each k and t (Meet demand)

zit <= PitCi  for each i and t (Don’t exceed capacity) (added from the meeting)