**Aggregation. Denim Arizona a contract manufacturer. They often outsource workers to handle business activities. They signed the contracts with several companies for the next six months, they have to produce: 4000 denim pants in month 1; 7000 denim pants in month 2; 8000 denim pants in month 3; 8500 denim pants in month 4; 5000 denim pants in month 5; 4500 denim pants in month 6. It takes a worker 40 minutes to produce a denim pant. Each worker works 200 hours per month plus up to 30 hours per month of overtime. A worker is paid a regular salary of $2800 per month plus $25 per hour for overtime. At the beginning of each month, Denim Arizona can either hire or fire workers. It costs the company $800 to hire a worker and $900 to fire a worker. The monthly holding cost per denim pant is 5% of the cost of producing a denim pant with regular-time labor. The raw materials in a denim pant cost $30. At the beginning of month 1, Denim Arizona has 10 workers and 800 denim pants in inventory. Determine how to minimize the cost of meeting (on time) the contract of the next six months**

**Discussion.**

**In this problem, we have to determine the workforce levels as well as production levels over a multiperiod time horizon. Hence, we need balancing equations for both the workforce as well as production units. The balancing equation for the workforce, ensures the flow of workers through the years after hiring and firing at the beginning of each year as we have seen before. The balancing equation for production levels ensure that the newly produced units in a month and the units from inventory of the previous month can be used to satisfy the demands of that particular month, and any left-over units again flows into the next month.**

Again, here we have two types for production methods, (1) the units can be produced by employees working in regular time and/or (2) the units can be produced by employees working in over time. Each of the above methods have a different cost associated with them. And each worker has a fixed number of regular hours he can serve and a maximum limit for the overtime hours he can serve. This gives us a maximum available hour to produce pants for a month depending on the number of workers working in that month. This poses a constraint on the number of pants that can be produced in a month. Hence to understand how many workers need to work in a month and how many units need to be produced satisfy demand and to minimize overall production cost, we must decide numbers of workers to hire and fire in each month, number of overtime hours used in each month and the number of units to be produced in each month. Hence, we have 4 \* 6 (number of months) = 24 decision variables. The workers and the denim pants produced are related through the number of hours available to produce the pants and the number of hours needed to produce a pant. The number of pants to be produced each month along with the inventory from previous month must satisfy the demands of that month, and the number of pants produced each month must be within the capacity of the workers available in that month. The objective is straight forward, i.e. to minimize the overall cost due to firing, hiring and paying the workers each month, overtime salary for the workers, cost incurred due to raw material cost to produce a pant and the holding cost of pants in inventory.

**Model.**

Parameters:

: Demand for each month i , ,i {1,2,3,4,5,6}

: Max Regular Working Hours

: Max Overtime Working Hours

: labor hours needed to make a pair of pant= 30/60 hrs.

S : Fixed Monthly Salary

: Overtime Salary per hour worked overtime

: Cost to hire a worker

: Cost to fire a worker

Raw material cost for a denim pant

Workers available at the beginning of month 1

Pants available at the beginning on month 1

Holding cost

[k=5% of regular making charge of one denim pant = 0.05\*(((60/30) \*(2800/200))+30)]

Decisions:

: Number of workers hired in month i,i {1,2,3,4,5,6}

Number of workers fired in month i, ,i {1,2,3,4,5,6}

Number of denim pants produced each month i,,i {1,2,3,4,5,6}

Number of overtime labor hours used each month i, ,i {1,2,3,4,5,6}

Calculated Parameters:

Inventory of pants at the end of each month i , ,i {1,2,3,4,5,6}

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month i , ,i {1,2,3,4,5,6}

Objective: *Minimize Cost*

min

Constraints:

, and workforce

\*l 

Notes:

1. Constraint (2) ensures that number of pants produced in a month is within the capacity that can be produced by the number of workers working in that month
2. Constraint (3) ensures that the overtime hours used in a month is within the maximum overtime hours available due to the workers working in that particular month

Optimal Solution:

A minimum cost of $ 1361670 can be attained by producing pants over the 6 months as shown below:

