**2020 May Day MCM**

**Problem C. Feed Mixing Processing Problem**

The feed processing factory requires a batch of animal energy feed. Feed processing needs raw materials. For instance, the processing of pig feed involves corn, buckwheat, rice, etc. The processing factory acquires raw materials from different producing areas. Due to transport, freshness retaining, and product attributes during the procurement process, raw materials are found to have efficiency rate problem (for instance, one ton of corn may be processed into around 0.7 ton of corn flour). The statistics may be detected by random sampling upon the import of raw materials in the factory.

Supposing the feed processing factory has 9 processing cellars, and it now needs to pour 16 types of raw materials (as shown in Table 1) into the cellars for processing as per specific mixing proposal. The mixing product in a processing cellar is referred to as a processing package. If the weight of a certain processing raw material is less than 500 kg, then it could be treated as an independent processing package. Affected by product attributes, processing raw materials in code 10 can not serve as a processing package independently. The processing weight of each processing cellar is within a prescribed scope (Table 2). Processing cellar processing cost is composed of ignition cost (also called fixed cost) and processing volume cost (also called variable cost). No other costs involved. Table 1 illustrates the variety code, total weight and efficiency rate of each processing raw materials. Table 2 provides the weight scope, ignition cost, and processing volume unit cost datas for each processing cellar.

Since the quantity of processing cellar is less than that of feed processing raw materials, it is necessary to mix several processing raw materials prior to processing operations. In order to guarantee the quality of processed feed, any two materials for mixing must have an affinity relationship. Therefore, technicians in the factory perform genetic test on each processing raw materials, and derive the gene sequence in ten key positions (as shown Table 1). It is stipulated that if the gene series share identical gene sequence marks in N positions, then the affinity value of the two processing raw materials is N (In condition that N is above 0, it means that there is an affinity relation between the two processing raw materials), the average of affinity value between every two raw materials in a processing package is called affinity degree. For instance, in one processing package comprising variety code 1, 2 and 5 processing raw materials, assuming the affinity value of variety code 1 and 2 is 5, that of variety code 1 and 5 is 3, and that of variety code 2 and 5 is 5, then the affinity degree of the processing package is (5+3+5)/3. Supposing there is just one processing material in the processing package, then the affinity degree is 10. While this question simply considers the quality of mixing processing feed from the perspective of affinity degree. The higher the affinity degree, the higher the feed quality.

Please examine these questions as below:

1. Please observe the affinity value between every two materials of 16 processing raw materials, and perform a statistical analysis.
2. Pour 16 processing raw materials for mixing processing in 9 processing cellars, and establish a mathematical model to find the mixing proposal with maximum feed quality and list the affinity degree of each processing package.
3. Pour 16 processing raw materials for mixing processing in 9 processing cellars, and establish a mathematical model to caculate the mixing proposal with maximum processing packages with an average energy consumption rate exceeding 80%, present the energy efficiency rate of each processing package and fill in the results in Table 3.
4. If the feed processing factory allows for the non-production of some processing cellars, please establish a mathematical model to compute a mixing processing proposal which could complete the entire processing task with the processing cost as low as possible, meanwhile requires processing packages with over 80% average energy consumption rate as much as possible.
5. If the feed processing factory allows for the non-production of some processing cellars, it must finish the whole processing task as usual. Please establish a mathematical model to compute a mixing processing proposal which promises (1) feed quality as high as possible, (2) processing cost as low as possible, (3) processing packages with over 80% average energy consumption rate as much as possible.

Table1 Variety code, total weight, efficiency rate and gene sequence mark of each processing raw materials

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety  code | Total weight  kg | Efficiency  rate | Site gene sequence (Simplify expressions with letters) | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 300 | 0.88 | a | b | c | d | e | f | g | h | i | j |
| 2 | 500 | 0.60 | a | b | c | d | e | o | p | k | l | m |
| 3 | 200 | 0.93 | f | g | h | a | j | o | p | k | l | m |
| 4 | 500 | 0.90 | f | g | h | i | j | l | p | f | o | p |
| 5 | 300 | 0.90 | f | b | h | d | e | o | p | a | o | z |
| 6 | 400 | 0.78 | r | m | t | u | q | f | g | a | f | z |
| 7 | 300 | 0.70 | r | s | t | u | k | f | g | h | f | c |
| 8 | 300 | 0.83 | r | s | t | u | a | b | h | i | j | c |
| 9 | 400 | 0.95 | c | s | a | f | v | w | a | i | j | c |
| 10 | 600 | 0.87 | b | m | n | i | a | z | h | f | o | z |
| 11 | 100 | 0.65 | m | a | m | e | a | z | a | b | a | b |
| 12 | 600 | 0.75 | m | c | m | e | x | h | a | b | n | a |
| 13 | 500 | 0.8 | b | a | n | y | c | g | m | b | m | b |
| 14 | 400 | 0.68 | m | c | m | y | x | g | m | b | n | b |
| 15 | 300 | 0.87 | b | x | n | i | c | l | b | c | m | p |
| 16 | 300 | 0.83 | c | c | a | f | x | h | b | c | m | j |

Table 2 he weight scope, ignition cost, and processing volume unit cost of each processing cellar

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Number of processing cellar | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Minimum processing weight (KG) | 300 | 300 | 300 | 600 | 600 | 600 | 900 | 900 | 900 |
| Maximum processing weight (KG) | 600 | 600 | 600 | 900 | 900 | 900 | 1200 | 1200 | 1200 |
| Ignition cost (Yuan) | 400 | 400 | 400 | 500 | 500 | 500 | 600 | 600 | 600 |
| Processing volume unit cost (Yuan/KG) | 2 | 2 | 2 | 1.8 | 1.8 | 1.8 | 1.6 | 1.6 | 1.6 |

Table 3 Results in Question 3 (Each processing raw materials weight of each processing cellar, KG)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cellar  Material | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 |  |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |  |  |
| 9 |  |  |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |  |  |
| 11 |  |  |  |  |  |  |  |  |  |
| 12 |  |  |  |  |  |  |  |  |  |
| 13 |  |  |  |  |  |  |  |  |  |
| 14 |  |  |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |  |  |
| 16 |  |  |  |  |  |  |  |  |  |
| Efficiency rate |  |  |  |  |  |  |  |  |  |