in order to improve the quality of the available scrap, it is possible to purchase pure metals, without any limit, although at a significantly higher price. The problem thus becomes that of establishing the quantities to buy for each scrap and pure metal to be used in a blend of minimum total cost which satisfies quality constraints.

The following table shows a data file prepared according to the syntax of AMPL, JuMP and Pyomo for a hypothetical problem of aluminum blending from scrap. The objective is to obtain a blend which satisfies a set of quality specifications, does not use more scrap than available, and produces the required quantity of finished product at minimum totla cost.

AMPL

Julia

Pyomo

Listing 1: Al6061.dat

```
# optimal blending of Al scrap

set MATERIALS := UBC MixedAuto Radiator WireScraps MixedTurnings␣
↪LithoSheets Si Mg;

set ELEMENTS := Si Mg Fe Cu Mn Zn;

param required := 1500;  # kg

param: minReq  maxReq :=
Si           0.4       0.8
Mg         0.8       1.2
Fe         0.        0.7
Cu         0.15      0.4
Mn         0.0       0.15
Zn         0.0       0.25
;

param compos:
        UBC    MixedAuto Radiator WireScraps MixedTurnings LithoSheets Si␣
↪Mg:=
Si      0.225  10.125     0.       0.1875    6.75         0.6     100. 0.
Mg      0.975  0.225      0.       0.45      0.225        0.          0. ␣
↪100.
Fe      0.375  0.825      0.525    0.3       0.75         0.6375         0.
↪ 0.
Cu      0.15   2.625     30.0      0.0375    2.625        0.125         0.␣
↪0.
Mn      0.825  0.375      0.       0.0375    0.375        0.6375         0.
↪ 0.
Zn      0.0375 0.9        0.       0.0525    1.125        0.075         0.␣
↪0.
;

# cost in Euro per kg
param:
              cost   avail :=
UBC           1.25   1000
MixedAuto     1.4    1000
Radiator      1.35   1500
WireScraps    0.8    1200
MixedTurnings 0.6    1000
LithoSheets   1.2    1600
Si           10.    2000
Mg           10.    2000
```

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```
;
```

Listing 2: Al6061.dat

```
# optimal blending of Al scrap

MATERIALS = ["UBC", "MixedAuto", "Radiator", "WireScraps", "MixedTurnings
↪", "LithoSheets", "Si", "Mg"]

ELEMENTS = ["Si", "Mg", "Fe", "Cu", "Mn", "Zn"]

required = 1500  # kg

bounds = JuMP.Containers.DenseAxisArray(
  [0.4       0.8;
  0.8        1.2;
  0.         0.8;
  0.15       0.4;
  0.0        0.15;
  0.0        0.25],
ELEMENTS, ["minReq", "maxReq"])

compos = JuMP.Containers.DenseAxisArray(
#        UBC      MixedAuto Radiator WireScraps MixedTurnings LithoSheets␣
↪Si Mg:=
     [0.225  10.125  0.       0.1875   6.75        0.6          100. 0.;
      0.975  0.225   0.       0.45     0.225       0.                 0.␣
↪100.;
      0.375  0.825   0.525    0.3      0.75        0.6375         0. 0.;
      0.15   2.625   30.      0.0375   2.625       0.125        0. 0.;
      0.825  0.375   0.       0.0375   0.375       0.6375         0. 0.;
      0.0375 0.9     0.       0.0525   1.125       0.075        0. 0.],
  ELEMENTS, MATERIALS)

scrapdata = JuMP.Containers.DenseAxisArray(
# cost in Euro per kg
[
1.25   1000;
1.4    1000;
1.35   1500;
0.8    1200;
0.6    1000;
1.2    1600;
10.    2000;
10.    2000
], MATERIALS, ["cost", "avail"])
```

Listing 3: Al6061.dat

```
# optimal blending of Al scrap

set MATERIALS := UBC MixedAuto Radiator WireScraps MixedTurnings␣
↪LithoSheets Si Mg;

set ELEMENTS := Si Mg Fe Cu Mn Zn;
```

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