Data description - A matheuristic solution approach for the milk and yoghurt production planning problem

May 7, 2018

The following is a description for the test instances presented in the article "Schneeberger, K., Schilde, M., Doerner, K.F. (2018): A matheuristic solution approach for the milk and yoghurt production planning problem, working paper".

In total 32 test instances are provided. The test instances are based on real-world data and guarantee a realistic setting. The data is provided as XML, to ensure an easy usage of the data.

Tables 1, 2, 3, and 4 show the relevant data needed to solve the model described in the paper. We show a detailed matching of the test instance data with this notation.

Each test instance file is separated into four parts: "General information", "Resources", "Products", and "Pipes".

The group "General information" provides the information for the small batch size (SBS, in kilograms), the small batch penalty (SBP, in minutes), and in addition the total makespan lower bound (in minutes) and the filler lower bound (in minutes).

The part "Resources" handles the following data:

- ID (part of the set A)
- Resource (the name of the resource, e.g., AG0)
- Plant (the plant the resource is situated, it is generally set to GeneratedInput)
- Resource_Category and Resource_Level (LEV_a, and in addition it is needed for the set of mixers (MI), heaters (HE), fermentation tanks (FE), and fillers (F), it can also be used for the set of all tank resources (TA) and machines (MA))

- Degree_Of_Utilization and the Rate_Of_Production are used to calculate the production speed (CC_{ai}) of each resource. Its calculation is: 60.0 / (Rate_Of_Production of a product multiplied by Degree_Of_Utilization of the resource). As a small example we use test instance "D-10-1.xml" with resource ID 1000. The Degree_Of_Utilization is 0.86 and the Rate_Of_Production of Prod_ID 12 is 68.058. Therefore the production speed of resource 1000 and product 12 is: 60.0 / (68,058 * 0.86) = 0.001025117. This value represents the minutes it takes to produce one unit of product 12 on resource 1000.
- Duration_Pre_Post_Processing_CIP (CPP_a, in minutes)
- Duration_CIP (CT_a, in minutes)
- CIP_ID (CIP_a, and part of $ACIP$)
- Duration_SIP (STT_a, in minutes)
- Duration_Cooldown (CDT_a, in minutes)
- SIP_ID (SIP_a, and part of $ASIP$)
- Interval_CIP_SIP (CI_a, in minutes)
- Max_Capacity (MAC_a, in kilograms)
- Product_Min_Needed_Capacities (MIC_{ai}, in kilograms)
- Product_Loss_Cleaning (CL_a, in kilograms)
- Rate_Of_Production (additionally show what product is able to be produced on that resource PP_a, also for tanks)
- Setup_Times ($ST_{ai'i}$, in minutes)
- CIP_Indictors ($CSI_{ai'i}$)

The part "Products" handles the following data:

- ID (corresponding product number)
- Label (name of the product)
- Type (Dummy, final product, or base product)
- Demand (D_i)

- Components
  - ID (the ID of the the component)
  - Type (e.g., base product if the prior product is a final product)
  - Factor ($R_{i'i}$, e.g., for test instance "D-10-1.xml" product ID 1 (FE1, final product) is filled out of one base product (product ID 11), and its factor to produce is 0.895, which is dependent on the bin of the final product or other measuring units)
  - Quantity_Unit (the unit used)
  - Plant (same as for resources, the plant is called GeneratedInput)
- Tolerance_Time (TT_i, in minutes)
- Fermentation_Time (FT_{ai}, if its null there is no fermentation time, in minutes)
- Max_Survival_Time (MST_i, in minutes)
- Soaking_Time (ST_{ai}, if its null there is no soaking time, in minutes)
- Density (additional information towards the used type of product)

The part "Pipes" handles the following data:

- ID (part of the set $APIP$)
- ID_Origin (PO_a)
- Resource_Origin (the name of the origin resource)
- ID_Destination (PI_a)
- Resource_Destination (the name of the destination resource)
- Pipe_Loss (PL_p, in kilograms)

Input	Description
A	Set of all resources
TA	Set of all resources which are tanks (mixing tanks, fermentation tanks, and filling tanks)
MA	Set of all resources which are machines (mixers, heaters, coolers, and fillers)
MI	Set of all resources which are mixers
HE	Set of all resources which are heaters
FE	Set of all resources which are fermentation tanks
F	Set of all resources which are filling machines

Table 1: Description of miscellaneous input data of the model.

Input	Description
PI_a	Set of product pipes inbound to resource a
PO_a	Set of product pipes outbound from resource a
$APIP$	Set of all unique product pipes
CIP_a	Set containing all CIP pipes connected to resource a
$ACIP$	Set of all unique CIP pipes
SIP_a	Set containing all SIP pipes connected to resource a
$ASIP$	Set of all unique SIP pipes
PL_p	Product loss in liters if pipe p is used to transfer a product

Table 2: Description of pipe specific input data of the model.

Input	Description
PP_a	Set of products that can be produced on resource a
CC_{ai}	Time required to process one unit of product i on resource a; for tanks and for dummy product $i = 0$
CT_a	Time required for cleaning resource a
CPP_a	Cleaning pre/post processing time on resource a
$CSI_{ai'i}$	Binary indicator if CIP/SIP is required when changing from product i' to product i on resource a
CL_a	Product volume lost when changing from one product to another or during CIP/SIP (independent of the production sequence; zero if not applicable)
$ST_{ai'i}$	Time required for setting up resource a when changing from product i' to product i
CI_a	Time after which a cleaning has to be performed for resource a (e.g. after CI_a hours without any kind of cleaning, resource a has to be cleaned and sterilized anyway)
STT_a	Time required for sterilizing resource a
CDT_a	Time required for cool down resource a after sterilization
MAC_a	Maximum lot size in liters for resource a (tank capacity or "big M" for machines)
MIC_{ai}	Minimum lot size in liters for product i on resource a
LEV_a	Resource level of resource a (level one for mixers, level two for mixing tanks, etc.)

Table 3: Description of input data with resource specific properties of the model.

Input	Description
D_i	Primary gross demand for product i
MST_i	Maximum amount of time product i may spend inside any resource (maximum survival time)
FT_{ai}	Time needed for fermentation of product i on resource a (fermentation time; zero if resource is no fermentation tank)
TT_i	Maximum amount of time before product i needs to be cooled after fermentation is complete (tolerance time)
ST_{ai}	Time needed for product i in order to soak after mixing is complete on resource a (soaking time; zero if resource is no mixing tank)
SBS	Constant defining a small batch (e.g., 25,000 liters; small batch size)
SBP	Time penalty in minutes for small batches at mixing (e.g., add 30 minutes for lab tests if a batch is less than SBS liters; small batch penalty)
$R_{i'i}$	Amount of product i' needed to produce one unit of product i

Table 4: Description of input data with product specific properties of the model.