Crude Oil Pooling Problem

Problem Statement

In the crude oil pooling problem, there is need to schedule the unloading of incoming marine vessels to the refinery and the transfer of different crudes from storage to charging tanks to the crude oil distillation units (CDUs). Logistic constraints are very important and it is assumed that: (i) marine vessels carry a single crude and unload sequentially, following their order of arrival; (ii) tanks handling different crudes must be in standing-gage operation (Kelly and Mann, 2003) that prevents flow in and out to occur simultaneously; (iii) charging tanks may be connected to multiple CDUs but may feed a single CDU at a time; (iv) all CDUs are being fed continuously but their source charging tank, selected from exactly two alternatives, can vary throughout the time horizon. Such crude changeovers are either limited to a maximum number \( nd \), when maximizing the gross margin, or are penalized individually in the objective function, \( c^{chg} ($) \), when minimizing operating cost.

Let \( mv \in MV \) be a crude marine vessel, characterized by arrival time \( at_{mv} \), which is assumed to discharge to a given storage tank \( st \in ST \). Let \( ct \in CT \) be a charging tank, \( cd \in CD \) a crude oil distillation column, \( cr \in CR \) a crude oil and \( pr \in PR \) a crude oil property (e.g. density). To facilitate model formulation, we will also refer to a storage or charging tank with index \( tk \in TK = ST \cup CT \), while an equipment unit \( u \in U = MV \cup ST \cup CT \cup CD \) is either a vessel, a tank, or a distillation column. Units besides columns have known initial inventory \( v_u^{0,cr} \), while
for tanks there are lower $v_{tk}^{\text{min}}$ and upper $v_{tk}^{\text{max}}$ bounds on storage capacity. Tanks receiving different crudes are called blending tanks, the elements of set $B \subseteq TK$. The properties of the mix inside blending tanks will be computed assuming linear blending and using the given values $c_{cr,pr}$ for the individual crude sources, so as to respect limits $c_{tk,pr}^{\text{min}}$ and $c_{tk,pr}^{\text{max}}$. Flowrates between units are also subject to upper bounds $\rho_{u,u'}^{\text{max}}$ with transfers to columns being strictly positive, $\rho_{ct,cd}^{\text{min}} > 0$. Finally, we have minimum and maximum demands for crudes originating in the charging tanks, $d_{ct}^{\text{min}}$ and $d_{ct}^{\text{max}}$.

Subsets $U_u'$ and $CR_u$ identify respectively the units that feed unit $u'$ and the crudes that can appear inside unit $u$.

The network topology (shown in Figure 1 for EX2) allows to predict the worst case scenario in terms of the different types of crude inside a tank. These are considered individually in a source-based model.

Two alternative objectives will be handled. The first is the maximization of the total gross margin of distilled crude blends given the individual margins $p_{cr}$. The second deals with the minimization of total operating cost, given: sea waiting costs for marine vessels $c_{mv}^{\text{wsea}}$, harboring costs for unloading the crude $c_{mv}^{\text{harb}}$, inventory costs for storage and charging tanks $c_{tk}^{\text{inv}}$, and changeover costs for distillation columns, as mentioned above.