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Financial risk management in the planning of refinery operations

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Abstract

Most models for refinery planning are deterministic, that is, they use nominal parameter values without considering the uncertainty. This paper addresses the issue of uncertainty and studies the financial risk aspects. The problem addressed here is that of determining the crude to purchase and decide on the production level of different products given forecasts of demands. The profit is maximized taking into account revenues, crude oil costs, inventory costs, and cost of unsatisfied demand. The model developed in this paper was tested using data from the Refinery owned by the Bangchak Petroleum Public Company Limited, Thailand. The results show that the stochastic model can suggest a solution with higher expected profit and lower risk than the one suggested by the deterministic model.

Keywords: Refinery planning; Uncertainty; Financial risk management

1. Introduction

In the last 20 years, a number of models have been developed to perform short term scheduling and longer term planning of batch plant production to maximize economic objectives (Shah, 1998). In particular, the application of formal mathematical programming techniques to the problem of scheduling the crude oil supply to a refinery was considered by Shah (1996). The consideration includes the allocation of crude oils to refinery and harbour tanks, the connection of refinery tanks to crude distillation units (CDUs), the sequence and amount of crude pumped from the tanks to the refineries, and the details related to discharging of tankers at the harbour.

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Nomenclature

Indices

c	for the set of commodities
q	for the set of properties
s	for the set of scenarios
t	for the set of time periods
u,u'	for the set of production units

Sets

C	set of commodities
U	set of units
U_c	set of units that produce commodity c
T	set of time periods
$\mathrm{QO}_{u,c}$	set of properties of commodities c leaving unit u
C_{P}	set of commercial products
C_{O}	set of crude oils
C_{IA}	set of purchased intermediate
UC_u	set of ordered pairs of unit and commodity (u',c) that feeds unit u
$\mathrm{UO}_{u,c}$	set of units that are fed by commodity c of unit u
CO_u	set of commodities leaving unit u
ctank	set of crude oil storage tanks
CDU	set of crude distillation units
CRU	set of catalytic reforming units
NPU	set of naphtha pretreating units
HDS	set of hydrodesulphurization units
GSP	set of gasoline pool units
INT	set of gasoline intermediate tanks
AV_q	set of properties on volume basis
AW_q	set of properties on weight basis

Parameters

$\mathrm{pro}_{u,c,q}$	property q of commodity c from unit u
$\mathrm{px}_{c,q}$	maximum property q of product c
$\mathrm{pn}_{c,q}$	minimum property q of product p
$\mathrm{cyield}_{c',c}$	percent of component c in crude oil c' (%)
$\mathrm{yield}_{u,c}$	percent yield of commodity c from unit u (%)
$\mathrm{dem}_{c,t}$	demand of product c in time period t (m^3)
ux_u	maximum capacity of unit u (m^3)
un_u	minimum capacity of unit u (m^3)
ox_c	maximum monthly purchase of crude oil c (m^3)
on_c	minimum monthly purchase of crude oil c (m^3)
stox_c	maximum storage capacity of product c (m^3)
$\mathrm{cp}_{c,t}$	unit sale price of product c in time period t ($/$\mathrm{m}^3$)