Air pollution control with semi-infinite programming

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Abstract

Imponer un límite al nivel de polución del aire en una zona determinada, al mismo tiempo que se optimiza un objetivo económico, resulta en un problema de programación semi-infinita (SIP). Se ilustran tres formas de resolución para problemas de control de polución del aire usando herramientas SIP. Se muestran los resultados numéricos para tres ejemplos.

Keywords: Air pollution control, semi-infinite programming

1. Introduction

In this paper we describe how air pollution control problem can be formulated as semi-infinite programming (SIP) problems. Three examples were coded in a modeling language (SIPAMPL [5]) and solved with a general SIP solver (NSIPS [6]), illustrating the potential of these formulations. SIP deals with optimization problems where a finite number of decision variables are optimized subject to an infinite number of constraints (see, for example, [3]).

Assuming that the plume spread has a Gaussian distribution, the concentration, $\mathcal{C}$, of gas or aerosols (particles less than about 20 microns diameter) at position x, y, and z from a continuous source with an effective emission height, $\mathcal{H}$, is given by $\mathcal{C}(x, y, z, \mathcal{H})$ (see, for example, [4]). The effective emission height, $\mathcal{H}$ (m), is the sum of the physical stack height, h (m), and the plume rise, $\Delta\mathcal{H}$ (m) given by the Holland equation (see [7]).

2. The formulations

Being the gas chemical inert, the minimization of the stacks height (stacks costs), while keeping the air pollution level below some given threshold at ground level, can be formulated as a SIP problem. Another formulation comes from the planning of the sampling stations position to monitoring the air pollution emissions. In this formulation the maximum attained pollution, at ground level, is computed, while the active points of the pollution concentration constraint are points where the maxima pollution is attained. The last formulation considered refers to an air pollution control problem, where pollution emission reduction is minimized while the ground air pollution level is limited to a given threshold.

3. Numerical results

In the minimum stack weight a scenario with ten stacks from [7] was considered with a limit on sulfur dioxide and with a lower bound on the stacks height imposed by the Portuguese law. The discretization method available in the NSIPS [6] solver was able to find the solution 196.9, 380.1, 403.1, 428.4, 344.8, 274.6, 402.8, 396.8, 415.6, 424.0 for the stacks height. In the sampling stations planning the maximum attained pollution was $1.81 \times 10^{-3} gm^{-3}$ for source data presented in [2] where 25 stacks are considered. The constraint maximum was attained at $(x, y) = (8500, 7000)$. For the air pollution abatement SIP problem we considered the source data from [1] with a Gaussian model. A reduction of 98.7%, 95.1% and 94.3% in the three sources considered is necessary to comply with the given threshold. The three test problems considered are coded and publicly available in the SIPAMPL database.

4. Bibliography

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