

Modellbasierte prädiktive Regelung in der industriellen Praxis

Industrial Application of Model Predictive Control

Rainer Dittmar und Bernd-Markus Pfeiffer

Modellbasierte prädiktive Regelungen (MPC) haben sich in der Prozessindustrie zur Standard-Technologie für die Lösung anspruchsvoller Mehrgrößen-Regelungsaufgaben entwickelt. Der vorliegende Beitrag erläutert Grundlagen, Anwendungseigenschaften und Ursachen für den industriellen Erfolg von MPC, gibt eine Übersicht über Aufbau und Funktionen kommerziell verfügbarer MPC-Programmsysteme und zeigt aktuelle Entwicklungstrends auf.

Model Predictive Control (MPC) is widely used in the process industries to solve challenging multivariable constrained control problems. The paper explains reasons for the industrial success of MPC and describes the structure and functionalities of commercially available MPC packages. Finally, current trends of the industrial application of MPC are discussed.

Schlagwörter: Prädiktive Regelung, gehobene Methoden der Prozessführung, Mehrgrößenregelung

Keywords: Model predictive control, advanced process control, multivariable control

1 Einführung

Mit dem Begriff „modellbasierte prädiktive Regelungen“¹ (Model Predictive Control, kurz MPC) wird eine ganze Klasse von Regelalgorithmen bezeichnet, die sich dadurch auszeichnen, dass ein Modell für das dynamische Verhalten des Prozesses nicht nur in der Entwurfsphase, sondern explizit auch im laufenden Betrieb der Regelung benutzt wird. In der Praxis werden überwiegend lineare Prozessmodelle verwendet, die durch aktive Anlagentests und anschließende Systemidentifikation gewonnen werden. MPC-Regler mit linearen Prozessmodellen werden auch mit dem Kürzel LMPC bezeichnet. Für MPC-Regler mit nichtlinearen Modellen wird die Bezeichnung NMPC verwendet.

Von frühen Vorläufern abgesehen, wurden MPC-Regelungen zuerst Mitte der 70er Jahre im Raffineriesektor und in der Petrochemie im großindustriellen Maßstab eingesetzt. Hervorzuhelien sind die Entwicklungen des IDCOM- (Identification/Command)-Algorithmus durch die Fa. Adersa in Frankreich [1] und des DMIC- (Dynamic Matrix Control)-Algorithmus bei Shell in den USA [2]. Diese Entwicklungen wurden in den ersten Jahren vor allem durch

in der Industrie tätige Regelungs- und Verfahrenstechniker vorangetrieben, bevor sie auch größere Aufmerksamkeit im akademischen Bereich erregten. Inzwischen hat sich die Situation gewandelt: die Zahl der Veröffentlichungen zu MPC ist stark angestiegen, und für LMPC gibt es eine ausgereifte Theorie (siehe z. B. [3] bis [5]). In deutscher Sprache liegt eine einführende Darstellung vor, die sich in erster Linie an Anwender in der Praxis wendet [6]. Zur industriellen Anwendung von MPC sind zwei ausführliche Übersichten [7] und [8] verfügbar, aus denen auch Einzelheiten zu einigen marktgängigen MPC-Programmsystemen entnommen werden können.

Tabelle 1 zeigt die Entwicklung der Gesamtzahl der industriellen MPC-Anwendungen in der Prozessindustrie und deren Verteilung auf unterschiedliche Branchen. Die Zahlen wurden durch Befragung der Anbieter von MPC-Programmsystemen ermittelt. In Wirklichkeit ist die Zahl der Anwendungen noch deutlich höher, weil In-House-Entwicklungen mancher Firmen (u. a. Statoil, Borealis, RWE npower) ebenso wenig erfasst worden sind wie Speziallösungen (z. B. Profiregelungen bei Papiermaschinen oder Walzprozessen). Nicht berücksichtigt wurden auch eingebettete Lösungen, d. h. MPC-Algorithmen, die in speicherprogrammierbare Steuerungen oder prozessnahe Kom-

¹ In der deutschen Fachliteratur wird oft auf den Zusatz „modellbasiert“ verzichtet und einfach von „prädiktiven Regelungen“ gesprochen.

Modellbasierte Regelung Von Industriellen W Rme Bertragern

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