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Advances in Intelligent and Soft Computing

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Soft Computing in Industrial Applications

Algorithms, Integration, and Success Stories

Springer

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Preface

WSC 14 Honorary Chair's Welcome Message

It is my great pleasure to welcome you to participate in the 14th Online World Conference on Soft Computing in Industrial Applications (WSC14) to take place on the Internet. As a nonconventional conference, WSC14 provides a new type of platform for our participants to share and disseminate our new research findings. Although we could not meet or talk face to face at WSC14 as at conventional conferences, we could interact at our desktops/laptops in live sessions or discussion forums via the Internet during the conference period and beyond. WSC14 serves as a good complement of conventional conferences (such as WCCI) in the fields covering the whole spectrum of soft computing and its applications. In a sense, the online conference could be more efficient in terms of savings of traveling time and costs to get together at a venue.

I thank you for your active participation and wish you to enjoy the conference with fruitful results.

WSC14 Honorary Chair
Jun Wang
The Chinese University of Hong Kong

WSC 14 Chair's Welcome Message

Dear Colleague,

On behalf of the Organizing Committee, it is our honor to welcome you to the WSC14 (14th Online World Conference on Soft Computing in Industrial Applications).

A tradition started over a decade ago by the World Federation of Soft Computing (http://www.softcomputing.org) is continued to bring together researchers interested in advancing state of the art in the field. Continuous technological improvements since then continue to make this online forum a viable gathering format for a world class conference.

The program committee received a total of 62 submissions from more than 20 countries, covering all the continents. This reflects the worldwide nature of this event. Each paper was peer reviewed by referees, culminating in the acceptance of 33 papers for publication. Authors of all accepted papers were notified to prepare and submit their final manuscripts and conference presentations.

The organization of the WSC14 conference is completely voluntary. The review process required an enormous effort from the members of the International Program Committee. We would like to thank all the members of the International Program Committee for their contribution to the success of this conference. We would like to express our sincere thanks to the plenary presenter David Prokhorov for his excellent contribution on "Computational Intelligence in Automotive Applications," and to the special session organizers Muhammad Sarfraz for organizing "Special Session Soft Computing in Computer Graphics, Imaging, and Vision," Sudhirkumar Barai for organizing "Special Session Soft Computing in Civil Engineering," Oscar Castillo and Patricia Melin for organizing "Special Session Soft Computing for Intelligent Control," and Michele Ottomanelli and Mauro Dell'Orco for organizing "Special Session Traffic and Transportation Systems." Also our thanks to the publisher Springer for their hard work and support in organizing the conference. Finally, we would like to thank all the authors for their high quality contributions. Congratulations especially to Roberto Sepulveda, Oscar Montiel-Ross, Oscar Castillo, and Patricia Melin to the WSC14 Best Paper Award contribution "Embedding a KM Type Reducer for High Speed Fuzzy Controller Into an FPGA." It is all of you who make this event possible!

We hope you will enjoy the conference, and we are looking forward to meeting you virtually at the WSC14. We encourage you to take an active part in the WSC14 paper discussions - your feedback is very important to other authors!

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8th *February 2010*
http://wsc14.science-city.org

Welcome Note by the World Federation on Soft Computing (WFSC) Chairman

On behalf of the World Federation on Soft Computing (WFSC) I would like to thank you for your contribution to WSC14! The 14th online World Conference on Soft Computing in Industrial Applications provides a unique opportunity for soft computing researchers and practitioners to publish high quality papers and discuss research issues in detail without incurring a huge cost. The conference has established itself as a truly global event on the Internet. The quality of the conference has improved over the years. The WSC14 conference has covered new trends in soft computing to state of the art applications. The conference has also added new features such as community tools, syndication, and multimedia online presentations.

I would also like to take this opportunity to thank the organisers for a successful conference. The quality of the papers is high and the conference was very selective in accepting the papers. Also many thanks to the authors, reviewers, sponsors and publishers of WSC14! I believe your hard work has made the conference a true success.

Chairman of WFCS
Professor Rajkumar Roy
World Federation on Soft Computing (WFSC)
8th February 2010

WSC14 Plenary Presentation

Computational Intelligence in Automotive Applications

David Prokhorov
Toyota Research Institute NA, Ann Arbor, Michigan

Abstract. Computational intelligence is traditionally understood as encompassing artificial neural, fuzzy and evolutionary methods and associated computational techniques. Nowadays there is no sharp boundary between CI and other learning methods. Different CI methodologies often get combined with each other and with non-CI methods to achieve superior results in various applications. In this presentation I will discuss CI methodological issues and illustrate them with several applications from the areas of vehicle manufacturing, vehicle system monitoring and control, as well as active safety. These will be representative of CI applications in the industry and beyond. I will also discuss some lessons learned about successful and yet-to-be-successful industrial applications of CI.

Dr. Danil Prokhorov began his technical career in St. Petersburg, Russia, in 1992. He was a research engineer in St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences. He became involved in automotive research in 1995 when he was a Summer intern at Ford Scientific Research Lab in Dearborn, MI. In 1997 he became a Ford Research staff member involved in application-driven research on neural networks and other machine learning methods. While at Ford, he took active part in several production-bound projects including neural network based engine misfire detection. Since 2005 he is with Toyota Technical Center, Ann Arbor, MI, overseeing important mid- and long-term research projects in computational intelligence. He has more than 100 papers in various journals and conference proceedings, as well as several inventions, to his credit. His personal home page is http://home.comcast.net/d̃vp/

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Part I

Soft Computing for Modeling, Control, and Optimization

Optimization of Co-rotating Twin-Screw Extruders Using Pareto Local Search

Cristina Teixeira, José Covas, Thomas Stützle, and António Gaspar-Cunha

Abstract. A Pareto Local Search (PLS) algorithm was developed and applied to the screw configuration of co-rotating twin-screw extruders. This problem can be seen as a sequencing problem where a set of different screw elements are to be sequentially positioned along the screw in order to maximize the extruder performance. The results obtained were compared with previous results obtained with a Multi-Objective Evolutionary Algorithm (MOEA), which was previously developed by the authors. These results show that the PLS algorithm, despite its conceptual simplicity, is able to generate screws with good performance.

1 Introduction

Due to their geometrical flexibility and good mixing capacity, co-rotating twin screw extruders are widely used in the polymer compounding industry. This type of machines can easily be adapted to work with different polymeric systems, e.g., polymer blends, nanocomposites or highly filled polymers, taking into account its modular construction. However, this geometrical flexibility makes the performance of these machines strongly dependent on the screw configuration being used, i.e., defining the adequate screw geometry to use in a specific polymer system is an important process requirement. This can be seen as an optimization problem involving the selection of the location of a set of available screw elements along the screw axis.

In the case tackled in this paper, the optimization consists in permuting a specific number of different screw elements in order to maximize the global performance of

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the system. This problem was designated as Twin Screw Configuration Problem (TSCP); it is a sequencing problem with, the aim of determining the position of screw elements along the screw axis. Since it involves several conflicting objectives, it is actually a multi-objective combinatorial optimization problem (MCOP).

The TSCP was previously tackled using a Multi-Objective Evolutionary Algorithm (MOEA) [1]. One important limitation of using MOEAs is the high number of necessary evaluations of the objective functions, since this implies running a numerical modelling routine, which has significant computational costs. Therefore, in the present work a Stochastic Local Search (SLS) algorithm was applied as an alternative for tackling this problem. In particular, we adopted the Pareto Local Search (PLS) strategy [2,3]. For that purpose, a detailed comparison to the previously designed MOEA using different objectives was made. In particular, this work is a part of a more comprehensive study where different approaches will be tested, including MOEA, Multi-Objective Ant Colony Optimization (MO-ACO), simple SLS algorithms and hybrids of these three classes of algorithms. The main motivation for the study of PLS here is its conceptual simplicity and its known very good performance.

This paper is organized as follows. In section 2, the twin-screw extrusion configuration problem is described. In section 3, the details of the algorithms used are discussed. Then, in section 4 the results are presented and discussed and we conclude in section 5.

2 Twin-Screw Extruders

Intermeshing co-rotating twin-screw extruders have by two Archimede-type screws with the same geometry rotating in the same direction inside a heated barrel [4]. The screws are usually built up by coupling individual screw elements with different geometries. Conveying, mixing and kneading elements are available, with distinct geometries. The performance of this type of extruders depends on the use of the correct sequence of elements, so that the extruder be able to accomplish its main functions, namely, transporting and melting the solid polymer, mixing and devolatilizing and forcing the polymer to pass trough the die [4]. Polymer pellets or powder are usually fed inside the barrel at a pre-set feed rate. The rotation speed of the screws, together with the local temperatures and screw geometry subject the polymer to a variety of thermomechanical stresses along the screw axis.

Therefore, the co-rotating twin-screw configuration problem consists in defining the best location of a set of screw elements along the screw shaft as illustrated in figure 1. In this example the aim is to determine the position along the screw of 10 transport elements, 3 kneading blocks (with different staggering angles) and one reverse element.

The performance of each screw configuration is obtained by using an elaborated computer simulation of the polymer flow through the screw elements, taking into account the relevant thermal and rheological physical phenomena. The process comprises the following steps: (i) transport of solid material; (ii) melting; (iii) mixing and homogenisation; (iv) pressure generation and (v) flow through the die

[5, 6]. The flow characteristics are determined by the different geometries of the screw elements. Right handed elements have conveying properties while left handed and kneading blocks with a negative staggering angle create a flow restriction (generating pressure).

The computer simulation programme considers all above steps [6]. After the solid polymer is fed into the hopper, it will flow under starved conditions through transport elements. When a restrictive element is reached, the channel starts to fill up and the melting process is initiated. When the polymer is full melted, the flow develops with or without pressure in the remaining of the screw elements, depending on whether they are totally or partially filled; overall, the pressure is determined by the location of the restrictive elements. Each evaluation of a screw configuration takes about one to two minutes on current CPUs. Hence, the high computational effort required for these evaluations is an additional complicating factor and we require algorithms that use a low number of function evaluations.

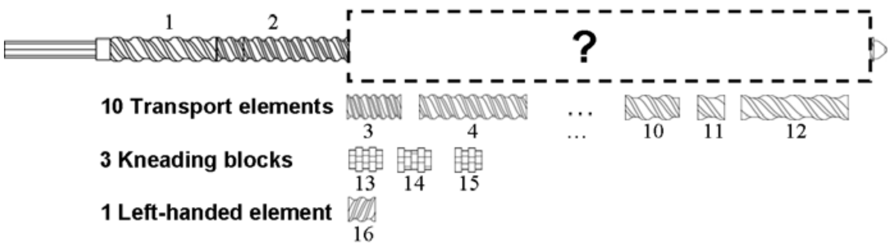

Fig. 1 Screw elements

3 Multi-objective Optimization

3.1 Multi-objective Evolutionary Algorithms

MOEAs have been recognized in the last decade as good methods to explore and find an approximation to the Pareto-optimal front for multi-objective optimization problems. This is due to the difficulty of traditional exact methods to solve this type of problems and by their capacity to explore and combine various solutions to find the Pareto front in a single run. A MOEA must provide a homogeneous distribution of the population along the Pareto frontier, together with an improvement of the solutions along successive generations [7, 8].

In this work, the Reduced Pareto Set Genetic Algorithm (RPSGA) is adopted [9, 10], where a clustering technique is applied to reduce the number of solutions on the efficient frontier. Initially, RPSGA sorts the individuals of the population in a number of pre-defined ranks using a clustering technique, in order to reduce the number of solutions on the efficient frontier, while maintaining its characteristics intact. Then, the individuals' fitness is calculated through a ranking function. To incorporate this technique, the traditional GA was modified [9, 10], following the steps of a traditional GA, except for the existence of an external (elitist) population and for a specific fitness evaluation. Initially, an internal population of size *N* is randomly defined and an empty external population formed. At each generation a fixed number of best individuals, obtained by reducing the internal population with the clustering algorithm [10], are copied to an external population. This process is repeated until the number of individuals of the external population becomes full. Then, the RPSGA is applied to sort the individuals of the external population, and a pre-defined number of the best individuals are incorporated in the internal population by replacing low fitness individuals. Detailed information about this algorithm can be found elsewhere [9, 10].

3.2 Pareto Local Search Algorithm

SLS algorithms [11] have been successfully applied to single objective problems and, more recently, also to Multi-Objective Optimization Problems (MOOP). Successful single-objective based SLS algorithms can be readily extended to MOOPs via two strategies. The one we study here is to adopt a component-wise acceptance model, where a new solution is accepted in the local search if it is non-dominated by any of the other previous. As an example of such a strategy, we use Pareto Local Search (PLS) [2,3]. A key component of any local search algorithm is the definition of which solutions are neighbouring. Some preliminary experiments showed that the most suitable neighbourhood relation to be used in the local search is based on the 2-swap operator: two solutions are considered to be neighbours, if one can be obtained from the other by swapping the position of two screw elements.

The main ideas of PLS are the use of an archive, where all non-dominated solutions found so far are kept, and the exploration of the neighbourhood of each of these solutions using non-dominance criteria to decide about the acceptance of solutions [2,3]. The algorithm starts with a random initial solution. This is added to the archive and its neighbourhood is explored using the 2-swap operator. All non-dominated solutions identified in the neighbourhood exploration are added to the archive, if they are not dominated by any of the solutions in the archive, otherwise it is eliminated. These solution selection and archive update steps are iterated until the neighbourhood of all solutions in the archive has been explored. In order to avoid a too strong increase of the number of solutions in the archive, an archive bounding technique is used [12]. This bounding technique divides the objective space by a grid into hypercubes and allows only one non-dominated solution to occupy a given hypercube.

4 Results and Discussion

4.1 Case Study

The RPSGA and the PLS algorithms presented above were tested using the individual screw elements presented in Table 1 for a Leistritz LSM 30.34 twin-screw extruder. In this example the objectives considered are the average strain, the specific mechanical energy (SME) and the viscous dissipation. Four instances and three different case studies were considered as presented, respectively, in Tables 1 and 2. Each optimization run was performed 10 times using different seed values. The comparison between the algorithms was made using the attainment functions methodology [13].

Table 1 Configuration of the individual screw elements for the 4 instances considered

Instance	Screw Element	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TSCP1	Length (mm)	97.5	120	45	60	30	30	30	60	30	120	30	120	37.5	60	60	30
	Pitch (mm)	45	30	45	30	20	60	30	20	KB -60º	30	30	60	20	45	30	20
TSCP2	Length (mm)	97.5	120	45	60	30	30	30	60	30	120	30	120	37.5	60	60	30
	Pitch (mm)	45	30	45	30	-20	60	30	20	KB -60º	30	30	60	20	45	30	20
TSCP3	Length (mm)	97.5	120	45	60	30	30	30	60	30	120	30	120	37.5	60	60	30
	Pitch (mm)	45	30	KB -45º	30	-20	60	30	20	KB -60º	30	30	60	20	45	30	20
TSCP4	Length (mm)	97.5	120	45	60	30	30	30	60	30	120	30	120	37.5	60	60	30
	Pitch (mm)	45	30	KB -45º	30	-20	60	30	20	KB -60º	30	30	60	KB -30º	45	30	20

Table 2 Optimization objectives, aim of optimization and prescribed range of variation used in each case

	Objectives	Aim	X_{min}	X_{max}
Case	Average Strain	Maximize	1000	15000
study 1	Specific mechanical energy	Minimize	0.1	2
Case	Average Strain	Maximize	1000	15000
study 2	Viscous dissipation	Minimize	0.9	1.5
Case	Specific mechanical energy	Minimize	0.1	2
study 3	Viscous dissipation	Minimize	0.9	1.5

4.2 Comparative Results

In order to demonstrate the capacity of the PLS algorithm to deal with the TSCP, figure 2 shows a Pareto front for case study two and instance 1, considering a single run. As expected, the viscous dissipation (to be minimized) increases with the average strain (to be maximized). The viscous dissipation (measured as the ratio between the average melt temperature and the set barrel temperature) is smaller