Journal of Ecology of Health & Environment
An International Journal

http://dx.doi.org/10.18576/jehe/050102

Research of Improved Case adaptation Technology for Steelmaking and Concasting Dynamic Scheduling

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Received: 11 Sep. 2016, Revised: 22 Nov. 2016, Accepted: 24 Nov. 2016.
Published online: 1 Jan. 2017.

Abstract: The purpose of this paper is to optimize dynamic scheduling in steel-making, the main case adaptation approaches and the case adaptation framework in case-based reasoning were summarized. Based on that, the Poliscastro reconstruction method was applied, the adaptation knowledge was obtained by using the target case and similar cases in the input and output, an improved portfolio adjustment algorithm was proposed for the complex case adaptation problems. Finally, using the improved adjustment technology, the dynamic scheduling of steel production is solved. The results show that the proposed technique is effective and accurate in solving the complex and changeable case adjustment problem.

Keywords: case adaptation; adaptation knowledge; case adaptation framework; improved portfolio adjustment; steel production dynamic scheduling.

1 Introduction

With the introduction and development of advanced technologies in steel production, especially the research on knowledge engineering and expert system [1,2,3,4,5,6]. Some domestic scholars and expert mostly design expert systems for iron and steel production. At this stage, the expert system for the steel production mainly in the following three areas: business planning system(BPS), manufacturing execution systems(MES), process control systems(PCS).This paper mainly research on steel production planning and scheduling system and its constraints based on the national Natural Science Foundation of China, Formulated production plan, and it can be adjusted automatically in the presence of disturbance of dynamic scheduling , not to consider the BPS and PCS [7,8,9,10,11].

Currently, Beijing University of Technology, Wuhan Iron and Steel Group, Northeastern University, Shanghai Jiaotong University, Baosteel, and other research units for the steel MES expert system research widely. Honghua Tang from Beijing Science and Technology University prepared some schedulers based on production rules, which combined with the specific circumstances of the first electric furnace steel plant Guangzhou Iron and Steel, It can be adjusted in real time production organization appearing prolonged smelting, prolonged casting and other situation [12]. When the integrated steel production management system was established by Qichun Peng from Wuhan Iron and Steel Group, they main use production rule representation for different types of disturbances, the production plan using real-time adjustment, this paper established the case-based reasoning dynamic scheduling system for the continuous casting process [13].

Northeastern University, Xiuying Wang etc. In order to control the steel production scheduling problem, scheduling method based on optimization, expert systems, case-based reasoning technology have been proposed which successfully developed a set of preparation, online tracking adjustment, a intelligent scheduling software based HCI [14].

Shanghai Jiaotong University, Xiaofeng Li in the steel-making continuous casting scheduling simulation system [15], dynamic scheduling model of the equipment was established by using timed colored Petri nets , so as to obtain the dynamic scheduling type, and according to this model, a heuristic scheduling algorithm was proposed to realize the steel-making continuous casting equipment failure, maintenance and other abnormal events process simulation; Petri network was a good description of the dynamic characteristics of the system, but it is limited to the model of the curse of dimensionality and randomness of expression.

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Tsinghua University,Zengji Han used colored Petri ,a electric furnace steel-making continuous casting process of real-time scheduling model was established,based on this model ,the entire production processcan was not only Simulated, synthesize real-time scheduling strategy was but also analyze. Baosteel Research Institute Chen Junpeng, Pang Xingfu [16] CBR technology applications was using in steelmaking

continuous casting dynamic scheduling, to solve the production of the disturbance of real-time transmission, real-time adjustment, to ensure the production of stable and smooth.Domestic planning and scheduling system of [17,18,19] improve the steel production management level in a certain extent , but the existing system in response to the production process disturbance when processing capacity is limited, mostly by way of human-computer interaction, relying on scene dispatcher's experience,coordination and control production process varies from person to person, volatility is relatively large;even with the technology of case based reasoning, its essence was to use artificial experience, and there will be the phenomenon of case and the reality does not match.

Steel production process is generally summarized as steel-making, refining, casting and rolling four main processes, and has product diversity, the complexity of the process, the process of piecewise continuous, centralized production capacity and flexible organization so on, therefore, An important factor in the production scheduling problem has been the impact steelmakers dynamic, timely, orderly and integrated production management level[20].Mang researchers steel production planning and scheduling, Yu Shengping, etc. for dynamic scheduling problem of continuous casting, a planning model based on variable constraints, the paper [21] designed self-identifying with the disturbance and disturbed independent setting mechanism.Then develop a iron and steel scheduling system.In order to optimize the production planning and scheduling strategy, the prototype system based on the actual model is improved [22].the paper [23] proposes a method to express the dynamic scheduling case by using the two levels of CBR combined with the decision tree.This method to solve the steelmaking-continuous casting dynamic scheduling

Case-Based Reasoning (case-based reasoning, CBR) is an important reasoning method in artificial intelligence[24,25,26,27,28,29,30,31,32], which overcomes the problem of rule-based reasoning approach of "knowledge acquisition bottleneck", solves new problem through use the existing cases and knowledge reuse and change . CBR completes the new design with existing cases and knowledge reuse and change, including two main aspects of matching case and case adaption. Case matching is the process of retrieving from the case base to meet the similarity case based on certain similarity algorithm, the difference between the search results and the target issues will be resolved by case adaptation. Recently, more and more attention has been paid on the application of CBR in steeling production and the case adaption is the core theme of CBR [33,34].

To obtain useful adjusting knowledge is the key to the case adapation.. but the adjustment knowledge is not easy to obtain,which needs mang experienced technical staff to select the appropriate adjustments in actual production process and measures the difference of case attributes to obtain. The literature [35] pointed out that the adjusting knowledge is limited by the difference of case attributes so the case attributes difference and gradient are combined together The literature [36] obtained adjusting knowledge through the input and output in the form of reconstruction of cases ,which takes into account the differences of case attributes and gradients, thus the adjusting knowledge is more comprehensive.

This paper attempts to put out case adaptation technologies of dynamic scheduling of steel production. The case adaptation technology includes three parts: First, the case adjusting knowledge generated based on Policastro; the second. It is design different algorithms by similarity of target different adjustment cases, highlighted an improved algorithm of combination adjustment ;the third ,it is a case adjustment framework of steel production dynamic scheduling is proposed,in order to improve reasoning performance.

The rest of the article is organized as follows. The first section is steel-making continuous casting case adjustment description,which describes in detail the case of steelmaking and continuous casting adjustments. The second section of dynamic scheduling model of steel-making and continuous casting gives specific case adaptation model. The third section is verification and analysis, which analyzes the proposed new adjustment technology in steel production dynamic scheduling application. Finally, the section of conclusion concludes the article.

2 Steelmaking And Continuous Casting Case Adjustment Description

The method of knowledge representation in rough set [37,38] is used to describe the dynamic scheduling system of steelmaking and continuous casting, which can be expressed as S= (U, CUD, F, V), in which U={a1, A2,..., an} is used to express the dynamic regulation of steelmaking and continuous casting case base, in which C = {CHN, SPAN, CSF, OB, OBV, OB1, OB1S, OB1S, OB1V, OB2, OB2S, OB2V, CCP, CCPS, CCPV, LTS, HIC, HICIV, HICIV1, OCC, OCC1, OCC1S, OCC1SV, OCC1SP, OCC1A, OCC1L, OCC2, OCC2S, OCC2SV, OCC2SP, OCC2A, OCC2L} is the condition attribute set, where the elements in the collection in turn represented as furnace number.

The processing cycle, the steel need to change, whether heated election refining equipment, refining equipment 1, state of refining equipment 1, state value refining equipment 1, refining equipment 2,state of refining equipment 2, state

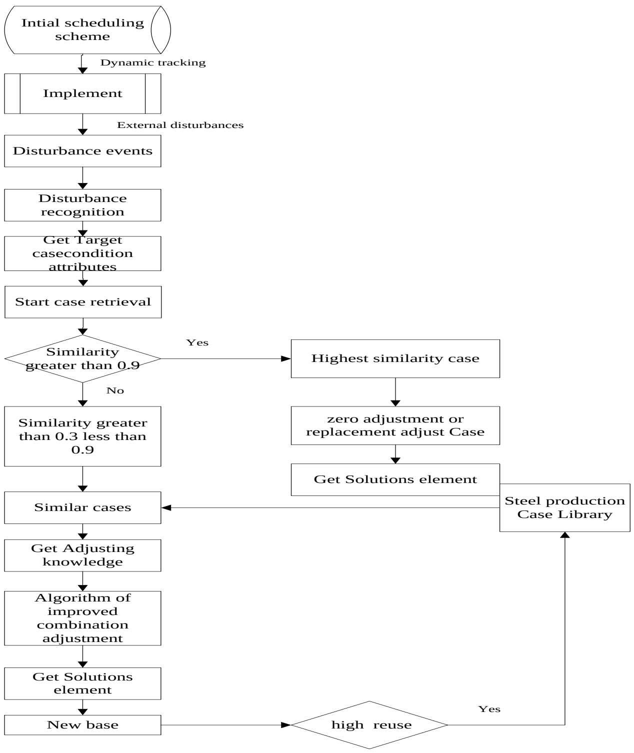

Fig. 1 Dynamic scheduling case adjustments flowchart.

value of refining equipment 2 , the current number of caster equipment, the state of the next heats, the state value of the next heats, whether continuous casting after adjustment, whether molding, The time to molding , whether molded component meeting the requirements, the number of caster equipment, the number of first caster (1CC) equipment other than the current, state of 1CC , state value of 1CC , steel of 1CC , whether adjustments being needed to 1CC , whether 1CC being the last heat, the number of the second caster (2CC) equipment other than the current,state of 2CC,state value of 2CC,steel of 2CC,whether adjustments being needed to 2CC,whether 2CC being the last heat. D = {AOCCSC, RCC1, RCC2, HUOB2, IOCC, CSP} is decision attribute set, which in turn represent elements of the collection as a follow-up to accelerate change in the original casting,changing the destination of casting to the CC1, changing the destination of casting to the CC2, raised to refining equipment 2, interrupting the original caster casting, change grades.C is called condition attribute set and D is called case decision attribute. there is a mapping relationship--f between C and D , f:U × {C∪D} → V is a mapping function, V is range of condition attributes and decision attribute .it is more complex case system that Steel production dynamic scheduling system .

Assuming that the target Case for a0 (a0 decisions unknown properties), using of the target problem and the conditions of similarity sim (a0, a) determination [39], if the similarity is greater than or equal to the threshold value (a = 0.9) , it directly matches the highest similarity case, then call its zero adjustment or replacement. When the similarity of the target problem and the source case is less than the preset threshold value, U '= {au0 | au0∈U, u = 1,2, .. ., k} can be obtained by using matching methed of the literature,which is similar cases of a0 , where au0 is similar case as a0, k is the number of cases in U'. Dynamic scheduling of steel production is a case study of the problem to be considered as a target case A0, a similar case set U' is matched based on the condition attributes and the target attribute similarity sim (A0. A)) and carry out a series of operations, non-redundant adjustment knowledge is received from which,then the target case is solved through the analysis of adjustment knowledge.Dynamic scheduling case adjustment is shown in Figure 1.

3 Dynamic Scheduling Model of Steelmaking and Continuous Casting

In order to obtain the practical knowledge, an improved technology of steelmaking continuous casting is elaborated in this paper. Similar cases of every case in similar cases U' is retrieved through literature [37] case matching, based on the Policastro method to produce dynamic scheduling of steel production adjustment knowledge. According to different problems, this paper proposes different adjustment algorithm including zero adjustment, alternative adjustment and improved combination adjustment design, and the framework of dynamic scheduling for steelmaking and continuous casting is put forward.

3.1 The generation of adjustment knowledge based on Policastro method

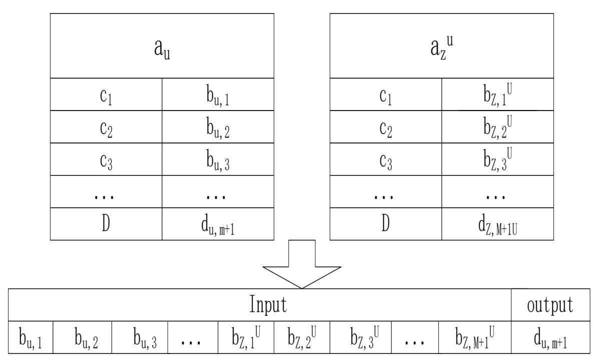

Fig. 2 Policastro proposed the input and output knowledge form.

For the target case au, it is assumed that the condition attribute {bu, 1, ..., bu, m}, decision attribute {du, m + 1}, is determined case by the condition attribute and target problem (target case) attribute similarity sim (au, a) (0.3 <sim (au, a) <0.9) to give a similar case set as U '= {azu | azu∈U, z = 1,2, ..., ku},and az is similar case of au, {bz, 1, ..., bz, m} is the condition attribute and{dz, m + 1} is decision attribute in az,and ku is the number of cases in U',and au is target case, the knowledge of the input and output in the form of Policastro presented in Figure2

Through the above input output in the form of reorganization, adjusting knowledge contains both all the attribute information of the similar case , but also contains the condition attribute information of the target case,because of the value of difference and gradient information for each target case and similar cases properties properties can be good reflects,adjusting knowledge is more comprehensive and provides good foundation for the following knowledge reasoning .

3.2 Case adjustment algorithm

Algorithm 1: alternative adjustment.

Step1: according DiffAttr (ao, a),the impact of the set of attributes of the element d as solution was determined , and its parameters property was adjusted;

Step2: Calling the function Para (d) = f (a1, a2 ... am),attribute set of target problem was inputed to calculate the target problem of Para (d) [14];

Step3:The newly calculated Para (d) instead of value of the original case is as a parameter value target element d of problem solutions.

Algorithm 2：improved combined adjustment.

Step1: adjustment knowledge of case is obtained by Policastro method;

Step2: C = C0∪C1∪C2 ... ∪Cn is divided according to attribute space;

Step3: the case attribute subset is matched, the most similar case is used as the reference object;

Step4: all the corresponding elements of the solution d in objects adjusted with referenced are removed, objects are adjusted with reference to, if necessary, algorithm 1 can be called to achieve the adjustment of each element d of solution.

Step5: After the solution adjusted each element d are combined to form a new complete solution set of elements.

3.3 Case adjustment framework

First, the closeness of the condition attributes and objective problem was measured by the introduction of concept similarity , sim (ao, a) is the similarity of the target case and the attribute in question ,where the value is [0,1], and defining the matching threshold for a (a=0.9).Small probability event that is set to less than 0.3 similarity is directly discarded this case.When the similarity between the target case and the similar case is 1, the solution of the similar case can be directly used,when the similarity is not 1,the solution of the target problem was obtained by calling the adjustment algorithm.

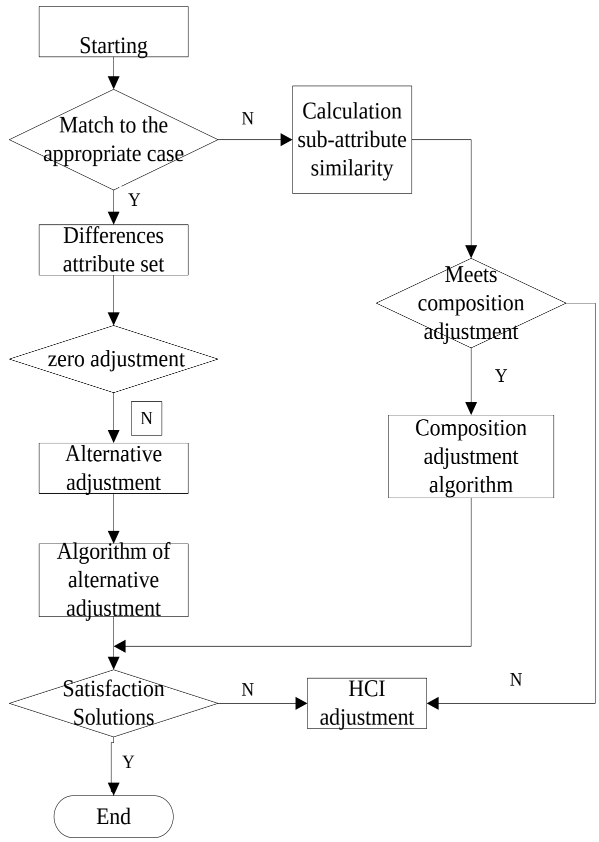

Fig. 3 The case adjust frame.

In this case, the adjustment model is a model with complex and tightly coupled constraints, in which the collective characteristics are:

(1) The redundant attributes of each solution element all include CHN, SPAN, CCP, OCC, OCC1, OCC2, and so on.

(2)The condition attribute C is divided, so that any intersection of C = C0∪C1∪C2 ... ∪Cn and C1, C2, C3 ... Cn are empty, where C0 is the redundant attributes space of all the solution, where C1, C2, ..., Cn is non-redundant attributes collection space of one element of the solution d at least.

(3)Multiple attributes of subspace constraints exist between the elements of the solution parameters.

By analyzing the above characteristics, principles and procedures is designed about dynamic scheduling adjustment technology:

1.First, the similarity ao is determined between the target problem attribute and the similar case condition attribute.

2.When the matching case and the actual problem is exactly the same, there is no need to adjust.

3.When the similarity of case matched and the practical problems within the threshold range (0.9≤sim (ao, a) <1),adjusting case is finished by direct calling to an alternative algorithm.

4. If the similar case with the corresponding to the practical problems were not finded within the range of threshold,then the case of similarity 0.3≤sim (ao, a) <0.9 was selected as a set of cases similar cases.These similar cases divided into C0, C1,..., N form Cn sub attribute space.then by using the method of Policastro,practical problems and inputting and outputting form of similar cases were reconstructed.Through the analysis of each sub-attribute space of similar cases and practical problems ,similarity was calculated,and the highest similarity child combination of attributes was selected,and finally solution of sub-properties was integrated to complete solution elements,completing the combination of adjustments to the practical problems,presented in Figure 3.

4 Example Verification And Analysis

Dynamic scheduling of steel production is a multi-variable, multi-constraint, and complex "ill-structured" problem.[40,41] If parameter perturbation range significantly in the scheduling plan ,the waiting time will increase by using of the original schedule plan or even cause the production sequence infeasibly, however, dynamic scheduling is needed to solve the problems, and the content of dynamic scheduling not only involves quantitative calculation but also a lot of qualitative decision making.In order to test the validity of the model, several typical cases of dynamic scheduling in iron and steel production are analyzed, the case condition attribute is shown in table 1and reconciliation set is shown in table 2.

When matching a similar case, if within a preset threshold don't range match to similar cases, the similarity is(0.3≤sim (ao, a) <0.9) matching similar cases matching set of C1, C2, C3.

Table 1 The atrributes and solutions of target problem and similar cases

Attributes	Note	problem	Case1	Case2	Case3	Attributes	Note	problem	Case1	Case2	Case3
CHN	furnace numbers	6	8	7	8	HICIV	The time to IC	100	100	100	98
SPAN	processing cycle	135	145	120	125	HICIV1	Whether IC meeting the requirements	2	2	2	1
CSF	the steel need to change	Ap1	Ck1	Ck1	Ju5	OCC	the number of CC	1	3	2	1
OB	whether heated	1	2	2	1	OCC1	the number of 1CC	1	2	2	1
OBV	Selective refining equipment	Rh2	0	0	Rh2	OCC1S	state of 1CC	on	on	on	on
OB1	refining equipment 1	Rh1	Cas2	Cas1	Rh1	OCC1SV	state value of 1CC	19	18	18	19
OB1S	state of refining equipment 1	on	on	on	on	OCC1SP	the steel of 1CC	Ju5	Ck1	Ck1	Ju5
OB1V	state value of refining1 equipment	16	16	16	11	OCC1A	whether adjustments to 1CC	2	2	2	2
OB2	refining equipment 2	Rh2	Cas1	Cas2	Rh2	OCC1L	whether 1CC being the last heat	1	1	1	1
OB2S	state of refining equipment 2	on	on	on	off	OCC2	the number of 2CC	3	3	3	3
OB2V	state value of refining2	8	8	8	20	OCC2S	state of 2CC	on	on	on	on
CCP	the current number of caster equipment	1	1	1	2	OCC2SV	state value of 2CC	26	9	34	26
CCPS	the state of the next heat	on	on	on	on	OOC2SP	the steel of 2CC	Ap1	Ck1	Ck1	Ap1
CCPV	the state value of the next heat	10	10	10	46	OCC2A	whether adjustments to 2CC	2	2	2	2
LTS	whether continuous casting after adjustment	1	1	1	2	OCC2L	whether 2CC being the last heat	2	1	2	2
HIC	whether molding	2	2	2	1	JTTZ	Solution element set		2	1	3

Note:1-T(ture),2-F(false) CC-caster equipment 1CC-the first caster equipment other than the current 2CC-the second caster equipment other than the current IC-molding

Table 2 Partial adjustment program table

Solution Element Set	meaning
1	Acceleration original CC subsequent charge; redirected to another CC1.
2	Acceleration original CC subsequent charge; redirected to other CC2.
3	Acceleration original CC subsequent charge; warmed to refine 2; redirected to other CC2.
4	Interrupt original CC casting; redirected to other CC2.
5	Redirected to another CC2.
6	IC molten supplement the original CC; warmed to refine 2; redirected to another CC1; trace element solution = {process Process1, algorithm Algorithm1, rules Rule2}.

The similar cases and goal cases attribute set were divided: g0 = {CHN, SPAN, CCP, OCC, OCC1, OCC2}, g1 = {OB, OBV, OB1, OB1S, OB1V, OB2, OB2S, OB2V}, g2 = {CCPS, CCPV, LTS, HIC, HIC1V, HIC1V1}, g3 = {CSF, OCC1S, OCC1SV, OCC1SP, OCC1A, OCC1L, OCC2S, OCC2SV, OCC2SP, OCC2A, OCC2L}. Among them,g0 redundancy attributes are not considered and g1, g2, g3 any two sets of the intersection is empty, then the actual problem (as case 4) and similar cases C1, C2, C3 input and output forms of reconstruction by Policastro methods.

In accordance with the target problems and similar cases set attribute set gn1, gn2, gn3 ,it get subset of attributes g11, g22, g33 through it calculates the similarity and selects the highest similarity .According to determine attribute set ,11 do not activate elements of the "warming to refining", g22 get available solution elements "accelerated after the original CC change", g33 can obtain solution elements "redirected to another CC1".the final, the three solution elements were integrated to target the problem, "the former CC accelerated change, redirected to another CC1".

This paper focuses on the target problem in the threshold range,the questions that case base does not match to similar cases were studied in detail, and get the following conclusions:

The use of Policastro for target case and similar cases input and output attributes reconstruction, making adjusting knowledge larger scale and the information more comprehensive , also it can reflect differences in the gradient and properties. Due to the comprehensive adjusting knowledge, the accuracy of case adaptation is greatly improved. This article propose an improved combined adjustment when the target case can not directly matche the similar case in the threshoid range. a combination of adjustment and adjusting knowledge makes steel production complex scheduling problems adjustment efficiently.

5 Conclusions

In this paper, a new dynamic scheduling method for steel production is proposed, and a corresponding case adjustment algorithm is not only designed, a general framework adjustment case is but also given.

Firstly, the input and output of Policastro is reconstructed, and the adjusting knowledge of dynamic scheduling case is obtained, and then the different cases are adjusted for different problems to ensure that the general framework of the case is adjusted. The results of the experiment show that the method is scientific and effective, and it improves the accuracy of the case.

In addition, the research technique of this paper is universal, and can be extended to other cases, which are not easy to match. The algorithm is time consuming, so we need to do further research in the optimization algorithm.

Acknowledgments

This research was supported by National Natural Science Foundation of China (72171160), Science Foundation of Hubei Province of China, This support is greatly acknowledged.

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