Ai-Knowledge based systems at BHP CPD

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Abstract

A surface level expert system has been developed to judge the feasibility of automating the design of new non-standard product routings. The main goal in this domain is to design or plan an appropriate sequence of processing units to be used in the manufacture of non-standard products. Each product order has associated with it a description of the desired steel product based on a range of mechanical and metallurgical features such as width, thickness, surface finish, hardness, coating type, and so on.

Keywords

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AI - KNOWLEDGE BASED SYSTEMS AT BHP CPD

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1 PROCESS ROUTINGS IN BHP SHEET AND COIL

A surface level expert system has been developed to judge the feasibility of automating the design of new *non-standard* product routings. The main goal in this domain is to design or plan an appropriate sequence of processing units to be used in the manufacture of *non-standard* products. Each product order has associated with it a description of the desired steel product based on a range of mechanical and metallurgical features such as width, thickness, surface finish, hardness, coating type, and so on.

The combination of an available data source and an articulate expert facilitated the use of Interactive Induction [Buntine and Stirling, 1988]. Some 800–1000 routings were analysed for patterns and other properties that could be exploited, resulting in a routing grammar which describes the legal combinations of processing units. Further induction on the product data conditioned at each diverging node in the grammar yielded a set of decision trees, and eventually rules. These indicated a unique path, that a production route should take based on the attributes or features of the product concerned. The resulting rule sets critiqued by the expert at each stage lead to a more focused input configuration of attributes for the next induction run. This quickly led to the distillation of an accurate knowledge in the form of a provisional rule base. A prototype using these rules was capable of correctly deducing the appropriate routing for existing products as well as producing plausible ones for new *non-standard* products.

2 ADAPTIVE SCHEDULING OF STAINLESS STEEL ROLLING

A deep level knowledge based system [Steels, 1990] is used here to provide consistent reduction schedules for the cold rolling of stainless steel strip. This system combines heuristic knowledge and qualitative mental models of the expert operators as well as deeper physical models from both rolling theory and the metallurgical domains. The system is being designed to provide the initial mill set-up schedule, reactive reschedules and assistance in the subsequent on-line control.

The cold rolling of stainless steel strip is subject to several extra processing constraints compared to those of low carbon steels. The major difference is the work hardening characteristics of the material requiring much higher deformation energies (roll forces). A second set of constraints arising from market pressures requires very high quality strip shape (flatness) and surface finish. Sendzimir reversing mills are usually used to process stainless steel strip subject to such constraints. These mills have multiple control parameters to effect the strip gauge and shape which makes the initial set-up (schedule) and subsequent operation/control of the mill complex and highly interactive.

A number of quantitative physically based models have been well established and used on other steel rolling applications within BHP. Some of these are currently being adapted for operation within this development. However, other processes and features of the Sendzimir mills are unique and/or too complex to be efficiently modelled by traditional quantitative means. On the other hand, expert rollers have skilfully operated the mill over many years having accrued a set of highly efficient loosely coupled heuristics and qualitative models. These are selectively activated and used in order to observe trends, reason about process behaviour, and predict and effect control so as to maintain the desired product quality. It is desirable to formalise and exploit such knowledge forms as they not only encompass highly effective control schemes but can also diagnose problems in the current rolling mill as well as with preceding process lines based on the response of the material being processed.

The prototype, the second of two so far [Stirling, 1989], can be viewed as several distinct sections each having its own set of rules or knowledge base and/or links to the quantitative models. The normal production of a pre-rolling schedule is accomplished through the successive satisfaction of several goal states in the system. Typically a heuristic schedule generator attempts to generate a monotonically decreasing reduction schedule, modelled on the best schedules the experts can produce - this often involves the relaxation of various soft constraints. After the gauge schedule has been generated, additional process set-up information is deduced from the yield stress and tension policy knowledge bases prior to being submitted to the quantitative rolling models [Stirling and Yuen, 1990]. These, amongst other features, predict for each pass, the required roll force to overcome the material's increasing yield stress pass by pass.

During a rolling pass, the process is monitored via a real-time data base. Various mill signals are combined with schedule information in a forward chaining knowledge base to trap several process conditions requiring action at the end of the current rolling pass. One such condition being rescheduling evokes a similar generation path to the initial schedule except that the yield stress would be significantly altered, its new value now being inferred from the roll force history and cold reduction up to that point. Depending on these yield stress predictions the reschedule generator might alter the number of passes and reductions between each.

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