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The Super-hard Cutting Tools' Thermal-cracks Monitoring System Based on Multi-agent Technologies

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Abstract. A thermal crack monitoring system of super-hard cutting tools was set up based on agent technologies. The system structure was designed, together with each agent'**s** workflow, inter-relationship among agents, and their communication mechanisms. If working properly, the system would realize the following functions, data collecting and retrieving, crack conditions monitoring, and resources state inspection and management.

1. Introduction

The working conditions of super-hard cutting tools are very hard, like undergoing loop-impacting loads and elevated temperatures, which would give rise to fluctuating stresses and strains and could eventually result in emergence of tools' thermal fatigue and fractures.

Although researches on thermal fatigue of metal-works have been done thoroughly [1-4], results are all about experiment and qualitive rules, being in short of their mechanism, like the inter-relationship of short cracks, models describing cracks population criterion, especially little about super-hard cutting tools losing effectiveness resulting from thermal fatigue.

Agent is a kind of highly self-government reality, with autonomy, reactivity and initiative. Each agent could perform its work independently, at the same time the whole system objectives would also be carried out through inter-communication and cooperation among agents. Agent can also have perceptual skills to apperceive outside environment changing and infer by the help of knowledge storied in the knowledge system to adjust properties dynamically, so as to make production more practical. Therefore, agent is suitable to be applied to the behavior research of crack individuality and mutual influences among cracks population.

2. System Structure

Agent is used to stand for various physical and logic resources or functional realities in the system. They are organized in mixing hierarchical distribution structures to form a multi-agent system through networks and agent communication protocols. The dispatching agent (Dis-agent for short), administration agent (Adm-agent for short), service agent (Ser-agent for short), cracks agent and resource agent (Res-agent for short) are used to realize monitoring and diagnosing of thermal cracks' conditions in the process of super-hard tools cutting process. The system structure of the cracks monitoring system is shown in Figure 1.

3. System Functions

3.1. Data Acquisition and Retrieving

The data acquisition system is deployed near the cutting tool and acoustic emission signals are collected and kept steady by the BR-ZS1 type of acoustic sensors in the cutting process, which are then transformed into numerical signals by the A/D converter and finally delivered to the FIFO(first in first out, FIFO for short) module. Once accumulated to some kind of amount, data would be carried to the processor and the Res-agent through RS232 bus, like displayed in Figure 2.

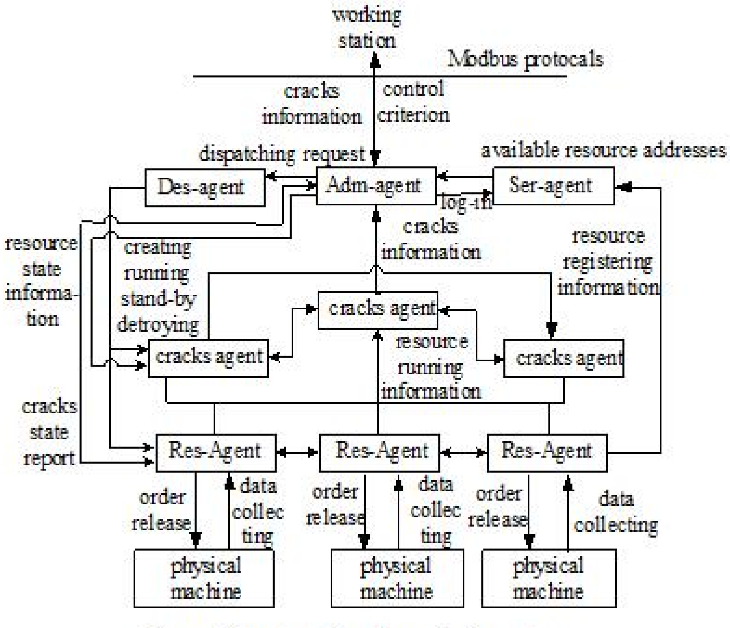

Figure 1. Structure of cracks monitoring system

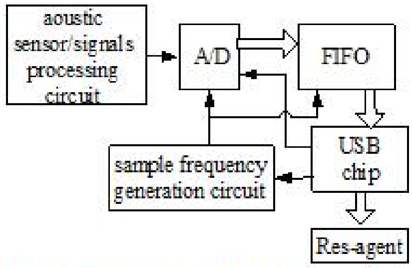

Figure 2. Principle of data aquisition module

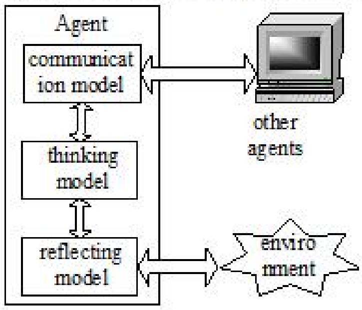

Figure 3. System structure of Agent

3.2. Cracks Monitoring and Tracking

Agent structure is formed by two kinds of modules, one is the thinking module, and the other is the reflecting module, as depicted in Figure 3. Symbol indication and reasoning methods are used to achieve the working goal of the thinking module, while the operation mode is responding directly to the changing of environment in the reflecting module. Once the input is received by agent, the reflecting module starts to work, and then the thinking module begins traditional inferring if no fast reaction or complex inferring is needed.

The Adm-agent receives administration tasks from the cracks monitoring system, then get them analyzed to create the cracks agent. It also interacts with the cracks agent and the Res-agent to grasp the dynamic developing information of cracks. If tools are in good conditions, the Adm-agent would examine whether all production tasks are done, and then finish its working if that is true, otherwise it would check whether tools condition would ensure parts being produced on time, then carry through the production scheme. When tools fail to act actively after taken all the above measures, the cracks monitoring system would dynamically reorganized to respond quickly to the environment and minimize the harmful effects through fast generation and extinction of cracks agent under intervention of Adm-agent. Its workflow is pictured in Figure 4.

Resources allocation optimization is performed by the Dis-agent. After building-up of cracks agent, the Adm-agent requests the Dis-agent to carry out the monitoring process using the enclosed dispatching algorithm, by which the shop production scheme is executed depending upon monitoring task assigned by Adm-agent, some dynamic and static information, such as resource states and abilities. It could interact with other agents to obtain various spots feedback information, through which the monitoring is adjusted. At the same time, the dispatching results are also delivered to the

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cracks agent and Res-agent. The Dis-agent may operate periodically, or driven by events. Its workflow is shown in Figure 5.

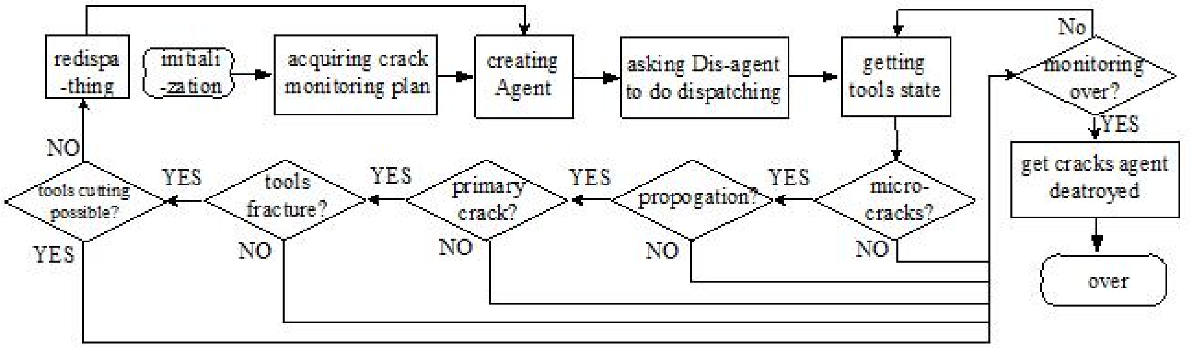

Figure 4. Workflow of Adm-agent

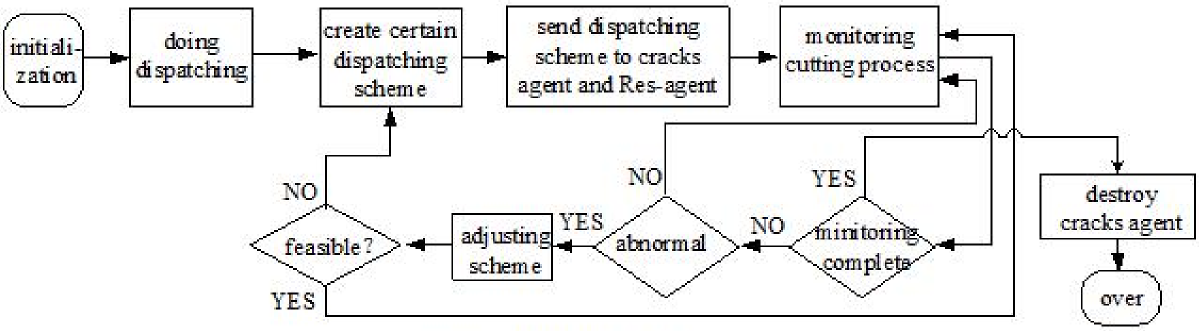

Figure 5. Workflow of Dis-agent

By the task decomposed by Adm-agent the cracks agent is generated. It attaches to the Adm-agent and its lifelong condition is also controlled by it. The cracks agent receives the monitoring sequence generated by the Adm-agent, and by which inquires about the available address information from the Ser-agent, also interacting with it to accomplish tools crack monitoring. The workflow is demonstrated in Figure 6.

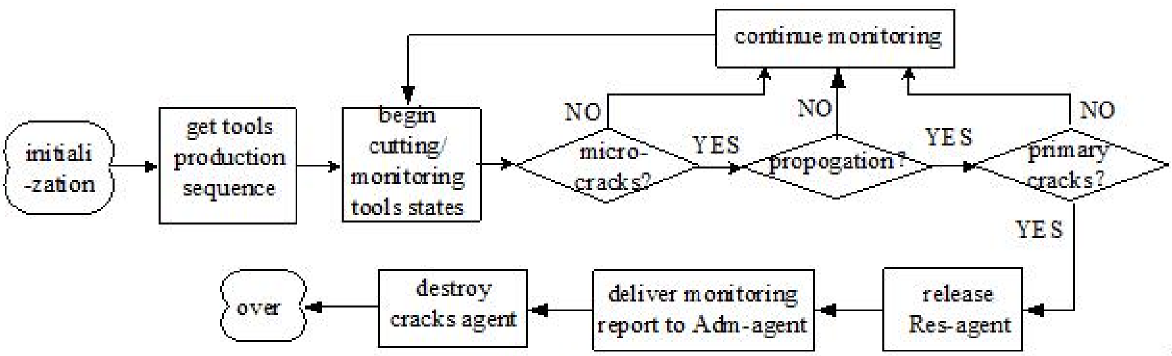

Figure 6. Workflow of cracks agent

3.3. *Resources Monitoring and Management*

As mapping of physical units in the cracks monitoring system, the Res-agent firstly registers its information to the Ser-agent, like name, address, interest, ability, objective and services provided by its corresponding physical machines. It also can be updated on-line when conditions and functions of physical units changed. The Ser-agent would obtain monitoring tasks by interacting with other agents and drive machines to execute the monitoring tasks. At the same time, the Ser-agent could acquire production data and states of shop-floor machines and deliver them to the cracks agent and the Adm-agent, in order to master monitoring development and resources transformation in time. In case some kind of broken-down happens, the Ser-agent could report it to the Adm-agent and cracks agent without delay and get it maintained on line. Its workflow is shown in Figure 7.

3.4. Communication Mechanism between Multi-agent

The cracks monitoring system is proposed to perform 8 functions, these are, 1) data collecting and acquiring, 2) cracks states monitoring, 3) cracks states tracking, 4) resources condition monitoring, 5) process management, 6) maintenance management, 7) task dispatching, 8) resource management.

From Figure 1 it is known that the cracks monitoring system realize the above functions through mutual coordination, cooperation and negotiation among multi-agent. Essential communication actions and relationships between indicator and receiver of each action are described in Figure 8, in which the figure above each arrow-line is in a consistent one-to-one match with the corresponding function.

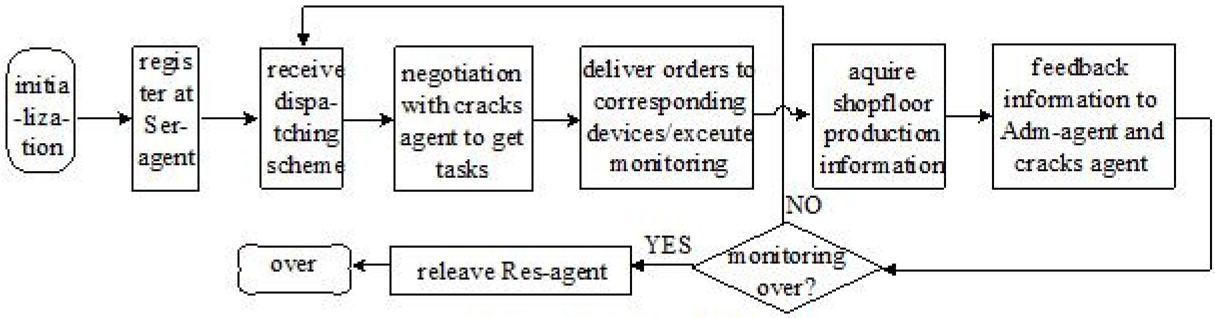

Figure 7. Workflow of Res-agent

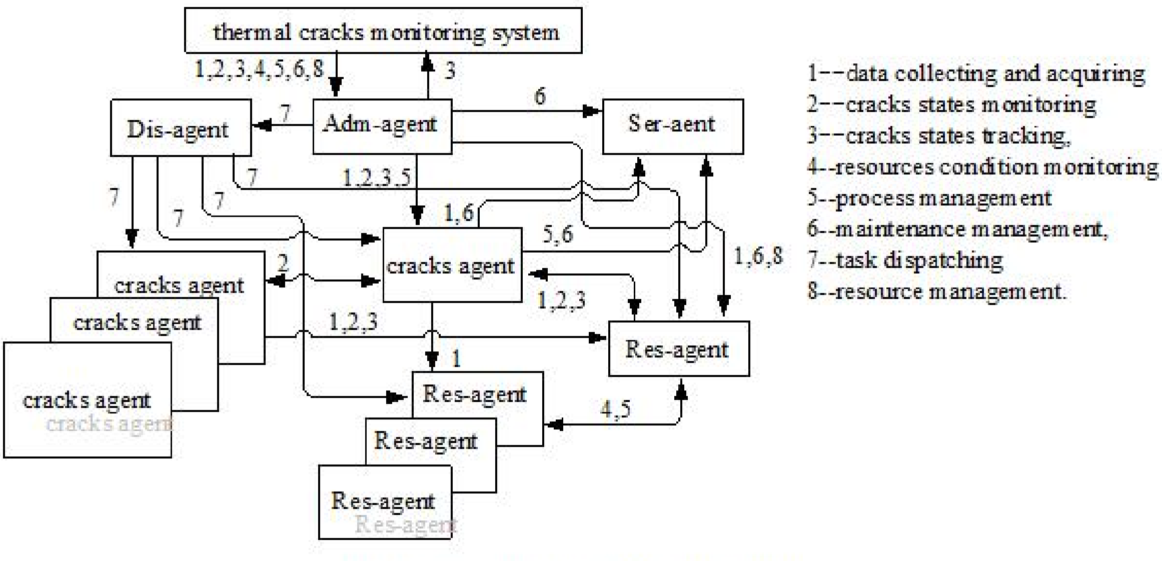

Figure 8. Communication among multi-agent

4. **System Software Realization**

The following crucial problems must be solved during the software actualization process

4.1. Thermal Cracks Typical Behavior Description

Setup cracks condition extension evaluation rules using the extension theory. On the basis of building up cracks evaluation matter-element [5, 6], cracks conditions are identified by calculating matter-element correlation [6, 7].

4.2. Description and Inferring of Thermal Cracks Evolution Rules

Using case-based reasoning methods, combining thermal fatigue tests and experiences [8], cases would be obtained quickly, exactly and practically.

4.3. Designing Agent Thinking-structure and Driven Mechanism

Ensure the agent controlling cracks behavior to be certainly as well as occasionally, the agent thinking structure would adopt the mixing structure combining responding and prudently thinking mode [9].

5. Conclusion

Agent technology is applied to the research of super-hard cutting tools thermal cracks in this paper. The system structure is offered. Such functions like data acquiring and thermal cracks monitoring and tracking, as well as resources real-time monitoring, are realized, by appropriately designing of each agent workflow and their communication relations. The realization of the above research would help to lengthen the tool life, decrease its cost and boost it wider application in various industry fields.

6. Acknowledgement

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7. References

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