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(54) **ROBOT SYSTEM AND METHOD FOR FIRE REFINED BUNDLING PROCEDURE IN METAL SMELTING PROCESSES**

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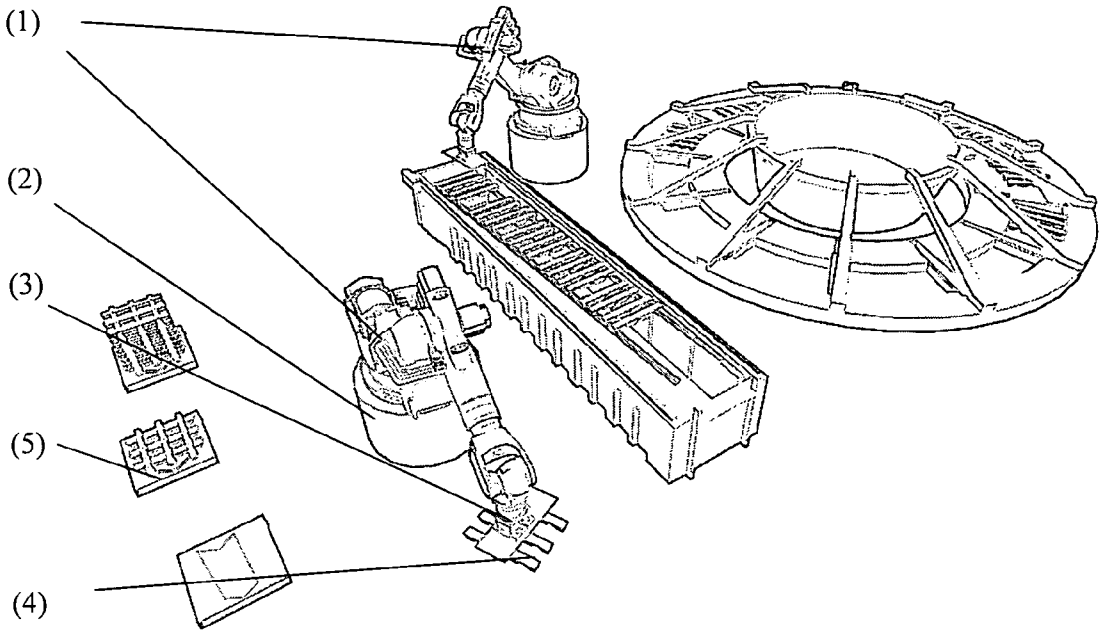
(57) **ABSTRACT**

At present, the ingots from the fire refined mold casting wheel are taken and arranged manually to make the fire refined bundles. The tasks associated to this procedure are characterized by the exposure to the personnel to harsh environmental conditions. In the medium and long term, this could generate serious occupational diseases to the operators in charge of developing this task. Due to the above, a robot system and method have been developed to automate fire refined bundling.

The robotic system is composed mainly of a robotic manipulator of at least 5 degrees of freedom (**1**) which is mounted on a fixed and/or mobile system (**2**) and provided with a gripping mechanism (**3**) to take, manipulate and release an ingot (**4**) for fire refined bundling (**5**). In this regard, most of the problems associated to the safety of the people and to the productivity of the current manual process are eliminated.



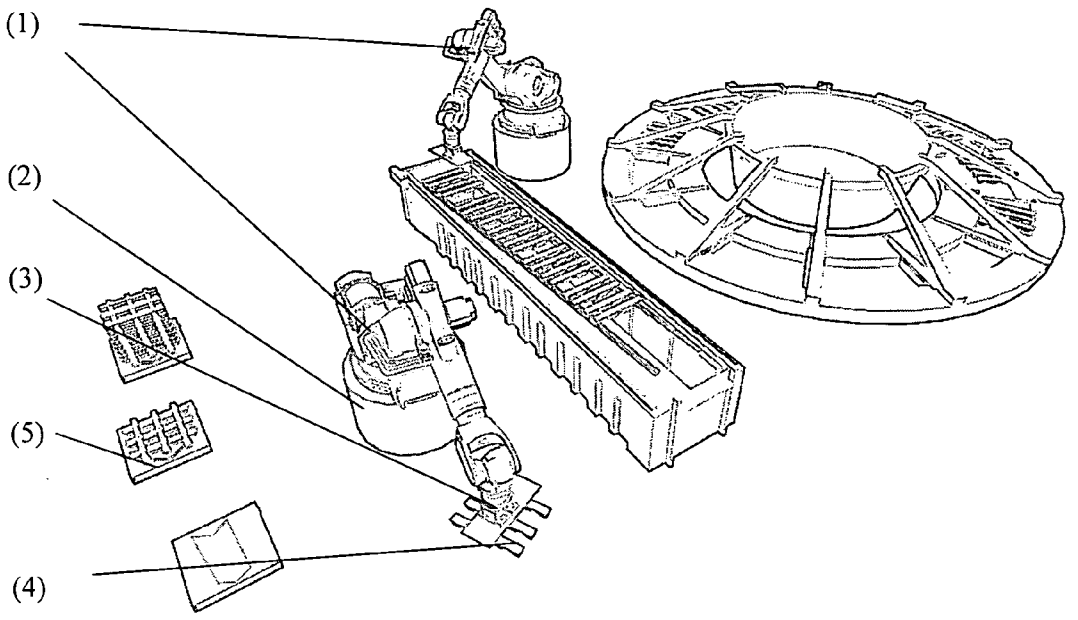


FIG. 1

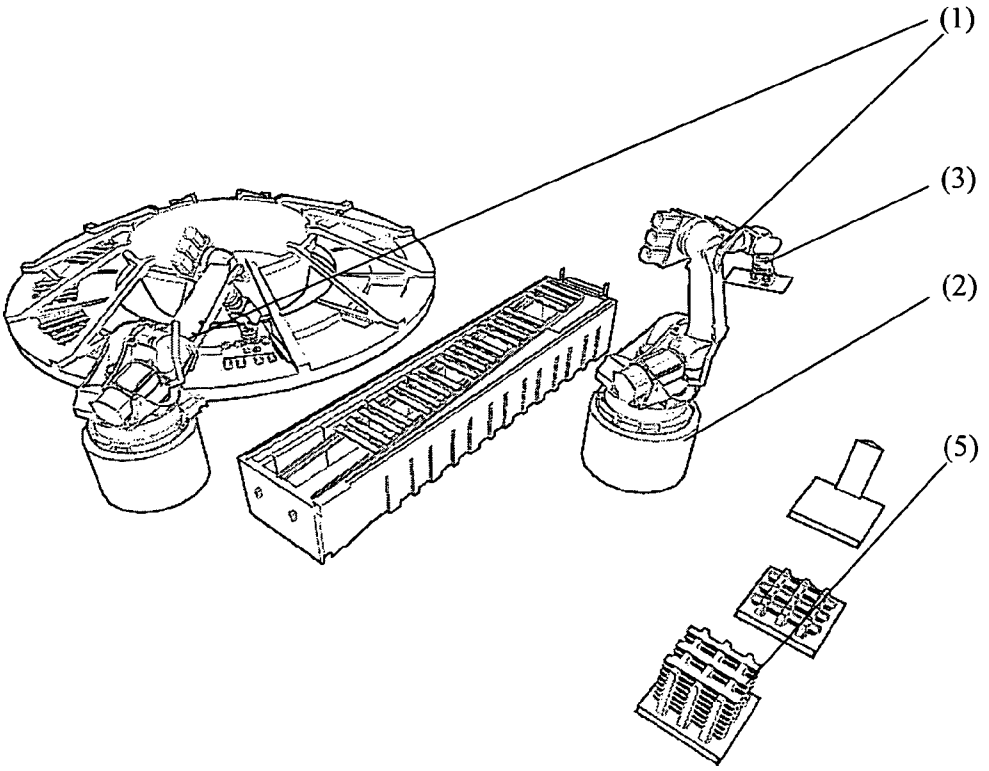


FIG. 2

ROBOT SYSTEM AND METHOD FOR FIRE REFINED BUNDLING PROCEDURE IN METAL SMELTING PROCESSES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of provisional patent application Ser. No. 60/734,988 filed 2005 Nov. 10 by the present inventor

FEDERAL SPONSORED RESEARCH

[0002] Not Applicable

SEQUENCE LISTING OR PROGRAM

[0003] Not Applicable

BACKGROUND

[0004] 1. Field of The Invention

[0005] This invention relates to the use of robotic technology in mining industry, specifically in the recovery of scrap material.

[0006] 2. Prior Art

[0007] During metal obtaining and refining processes, smelting furnaces are used to cast metal concentrates for purifying and extracting them. The first stage of the productive process is to move the dry concentrate to one of these furnaces, which could be a flash furnace and/or a Teniente converter, where casting is at temperatures over 1.200° C. In this way, while the concentrate becomes a molten liquid mass, its components are being separated and combined then to form a two layer bath. The heaviest layer is called matte and it is a metal enriched component. Over this layer, the slag is floating, which is a coat of impurities of the metal of interest. In this way and during successive stages, the stage rich in the metal of interest is sequentially cast and refined through several furnaces which allows to obtain a high purity metal.

[0008] In the last stage of the smelting process, the fire refining stage is carried out in which the metal is processed in rotary furnaces, by adding special purifying agents which are called fluidizing agents to oxide and eliminate all the impurities with the resulting effect of very few non desired elements contained in the molten bath. Then, the oxygen is extracted with steam or oil injections with the final result of a high purity level. Thus, when a metal load reaches the required purity level, the furnace is inclined and in exact quantities the metal is poured in one of the ingot molds of the fire refined mold casting wheel. Once the metal is poured into the mold, the wheel rotates to advance the following mold to the position and other ingot is molded. This way, the wheel speed is adjusted in an accurate way to the optimum speed profile, ensuring a smooth positive and negative acceleration level of the molds. This is intended to produce high quality ingots with a minimum burr formation grade.

[0009] To finish the smelting process, the dislodging process (stripping and/or extraction) proceeds in which the molded ingots are lifted and sent to a cooling tank to avoid the excessive oxidation and to obtain a deep scrubbing.

[0010] Finally, the molded ingots are counted and arranged in predetermined bundles.

[0011] One of the major disadvantages of the tasks associated to the ingots bundling process from the mold casting wheels is the exposure of the personnel to harsh environmental conditions. This, in the medium and long term, could generate serious occupational diseases to the operators in charge of carrying out such task.

[0012] Due to the above, a robot system and method have been developed to automate the procedure of fire refined bundling.

SUMMARY

[0013] A robot system comprised of two manipulators to handle ingots, while one robot takes the ingot from the casting wheel to the water bath to cool off, the second manipulator takes the cooled off ingot to the bundling area.

DRAWINGS—FIGURES

[0014] In the drawings, closely related figures share the same numbers, with different alphabetic suffixes.

[0015] FIG. **1** shows a general view of the robot system for fire refined bundling procedure.

[0016] FIG. **2** shows a general view of the robot system for fire refined bundling procedure.

DRAWINGS—REFERENCE NUMERALS

[0017] **1** Robotic manipulator of at least 5 degrees of freedom

[0018] **2** Fixed and/or mobile mounting system

[0019] **3** Gripping mechanism

[0020] **4** Ingot

[0021] **5** Bundling area

DETAILED DESCRIPTION

[0022] This invention relates to a new robot system as well as a robotic method for fire refined bundling procedures, which are mainly composed of an anthropomorphous robotic manipulator of at least 5 degrees of freedom, with a gripping mechanism, so the robotic system itself is designed to take, manipulate and release ingots.

[0023] With reference to FIG. **1** and FIG. **2**, the system is mainly composed of two anthropomorphous robotic manipulators of at least 5 degrees of freedom (**1**), provided with a communication, acquisition and control system, so as the robotic manipulators are mounted on a fixed and/or mobile system (**2**), and also provided with a gripping mechanism (**3**) to take, manipulate and release an ingot (**4**) to arrange fire refined bundles (**5**).

I claim:

1. A robot system for fire refined bundling in metal smelting processes, comprising two anthropomorphous robotic arms of at least 5 degrees of freedom, with their corresponding control, communication and programming units, gripper adapters, gripper mechanisms, gripper mechanism driving systems and electric supply systems wherein the first anthropomorphous robotic manipulator of at least 5 degrees of freedom is provided with a gripping mechanism which allows in a sequential and programmed way to take, manipulate and release metal ingots from the mold casting

wheel to the water bath to cool it, so once the ingot cools off, it is taken, manipulated and released from the water bath to the fire refined bundling area, in a sequential and programmed way, by the second anthropomorphous robotic manipulator of at least 5 degrees of freedom provided with a gripping mechanism, so the ingot is deposited on a mobile drawer rack containing them, located near the robotic manipulator.

2. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the first robotic manipulator could be mounted on a fixed and/or mobile system located between the mold casting wheel and the water bath, so it allows to approach and/or move away between the mold casting wheel and the cooling water bath according to the task to be performed.

3. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the second robotic manipulator could be mounted on a fixed and/or mobile system located between the fire refined bundling area and the water bath, so it may move to approach or move away between the fire refined bundling area and the cooling water bath according to the task to be performed.

4. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the anthropomorphous robotic manipulator could communicate by itself or through a PLC interface with the control system.

5. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the anthropomorphous robotic manipulator has the capacity to obtain and interpret the information from installed analogue and/or digital sensors.

6. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the anthropomorphous robotic manipulator has the capacity to generate analogue and/or digital signals to control analogue and/or digital input devices.

7. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the system has the capacity to move and manipulate the ingots, in a sequential and programmed way, in different paths within the work volume of the robotic manipulator.

8. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the anthropomorphous robotic manipulator has an electrical system driven by three-stage induction motors, with vectorial and/or scalar control.

9. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the system uses a gripping mechanism to take, manipulate and release the fire refined ingots.

10. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the system uses a gripping mechanism comprising at least 4 fingers, which allows to grasp and release the fire refined ingots.

11. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the anthropomorphous robotic manipulator has an electrical system driven by cage induction motors (with no slip rings), with vectorial control.

12. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein productivity and efficiency in the fire refined bundling procedure in the smelting process of different metals such as copper, iron, zinc, lead etc increases.

13. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the system could be integrated to fire refined bundling procedures of different metals of interest such as copper, iron, zinc, lead etc.

14. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the system could be integrated to bundling processes in any type of mold casting wheels of smelting furnace, whether copper smelting processes and of other metals (iron, zinc, nickel, lead, gold, tin, lead, etc.).

15. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein the system may operate automatically, or semiautomatically, and also allows solutions scalability.

16. A robot system for fire refined bundling in metal smelting processes, according to claim 1, wherein it prevents the plant personnel from being subjected to a high physical demand and harsh environmental conditions.

17. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the first the anthropomorphous robotic arm of at least 5 degrees of freedom is provided with a pneumatic gripping mechanism which allows in a sequential and programmed way to take, manipulate and release the metal ingots from the mold casting wheel to a water bath to cool it down and later taken, manipulated and released from the water bath to the fire refined bundling area in a sequential and programmed way by the anthropomorphous robotic arm of at least 5 degrees of freedom provided with a pneumatic gripping mechanism which allows in a sequential and programmed way to take, manipulate and release the ingot which is deposited in a mobile drawer rack containing them, located near the robotic manipulator.

18. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the first robotic manipulator could be mounted on a fixed and/or mobile system located between the mold casting wheel and the water bath so as it allows to approach and/or move away between the mold casting wheel and the cooling area according to the task to be carried out.

19. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the second robotic manipulator could be mounted on a fixed and/or mobile system located between the fire refined bundling area and the water bath so as it may move to approach or move away between the fire refined bundling area and the cooling water bath according to the task to be performed.

20. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the anthropomorphous robotic manipulator could communicate by itself or through a PLC interface with the control system.

21. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the anthropomorphous robotic manipulator has the capacity to obtain and interpret the information from installed analogue and/or digital sensors.

22. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the anthropomorphous robotic manipulator has the capacity to generate analogue and/or digital signals to control the analogue and/or digital inputs devices.

23. A robotic method for fire refined bundling in metal smelting processes using the robot system of claim 1 to **16**, wherein the system has the capacity to move and manipulate the ingots in a sequential and programmed way in different paths within the work volume of the robotic manipulator.

24. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the anthropomorphous robotic manipulator has an electrical and/or hydraulic system driven by electric motors with vectorial control.

25. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the system uses a gripping mechanism to take, manipulate and release the fire refined ingots.

26. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the system uses a gripping mechanism comprising at least 4 fingers which allows to tight and release the fire refined ingots.

27. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the anthropomorphous robotic manipulator has an electrical system driven by three-stage induction motors with vectorial and/or scalar control

28. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein productivity and efficiency in fire refined bundling processes in smelting processes of different metals such as copper, iron, zinc, lead, etc increases.

29. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the system could be integrated to fire refined bundling procedures of different metals of interest such as copper, iron, zinc, lead etc.

30. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein it could be integrated to fire refined bundling procedures in any type of mold casting wheel of the smelting furnace, whether in copper smelting processes or of other metals (iron, zinc, nickel, silver, golden, tin, lead, etc.).

31. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein the system may operate automatically or semi-automatically, and also allows solution scalability.

32. A robotic method for fire refined bundling in metal smelting processes using the robot System of claim 1 to **16**, wherein it prevents the plant personnel from being subjected to a high physical demand and harsh environmental conditions.

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