Citation List

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Patent Document 6: JP-A 2012-000708 (US 20110312255)

DISCLOSURE OF INVENTION

The method of cutoff machining a sintered magnet block which is secured by a jig repeats the steps of mounting the jig having the magnet block secured thereto on a cutoff machining tool, cutoff machining the magnet block into pieces, taking the jig having the magnet pieces still secured thereto out of the tool, securing a new magnet block to the jig, and mounting the jig with the new magnet block on the tool again. After the jig is taken out of the machining tool, the divided (or sawed) magnet pieces are removed from the jig, and a magnet block to be sawed is newly secured to the jig. In the step of securing a magnet block to the jig, especially by adhesive bonding, the operation of manually bonding and confirming a secure attachment is necessary to avoid the risk that the magnet block is disengaged from the jig during the cutoff machining step, causing the magnet block, outer cutoff blade, and machining tool to be damaged. Since the procedure involving such operation is difficult to automate, there is a need for a labor- and energy-saving method of securing and cutoff machining sintered magnet.

Embodiments of the invention seek to provide an apparatus and method for cutoff machining a sintered magnet without a need for attachment and detachment of the magnet to a jig and a need for mounting and dismounting of the jig to a cutoff machining tool.

According to a first aspect, the invention provides a machining apparatus for the cutoff machining of sintered magnets, comprising the following components:

(1) a cylindrical or columnar work carrier mounted on a horizontal rotation axis such as a rotation spindle and having a generally regular polygonal shape in a cross section perpendicular to the rotation axis, with the proviso that the polygon has 3 to 180 sides;

(2) a plurality of endless elastic belts which are extended so as to come in proximity to a portion of the peripheral surface of the work carrier, adapted to urge a work of sintered magnet against the peripheral surface of the work carrier to secure the work, and adapted to travel synchronously with the rotation of the work carrier in a circulatory manner,

(3) a belt expanding mechanism for tensioning the belts,

(4) at least two belt supports for supporting the belts in tension and adapted to define the traveling direction of the belts during their circulatory travel, the at least two belt supports including a first belt support disposed above the rotation axis of the work carrier and in proximity to a portion of the peripheral surface of the work carrier which extends from the top of the work carrier to a forward position in the rotational direction of the work carrier, and a second belt support disposed below the rotation axis of the work carrier and in proximity to a portion of the peripheral surface of the work carrier which extends from the bottom of the work carrier to an aft position in the rotational direction of the work carrier,

(5) an outer cutoff blade mounted on a horizontal rotating shaft and adapted to be positioned such that a circumferential edge of the blade is close to the peripheral surface of the work carrier.

(6) work seats formed on the respective sides of the peripheral surface of the polygonal work carrier and arranged in the rotational direction of the work carrier, the plurality of elastic belts being extended such that the work resting on each work seat is secured thereto by at least two elastic belts which are juxtaposed at a spacing,

the apparatus being operable such that in use the work is delivered onto the peripheral surface of the work carrier before the first belt support, with reference to the rotational direction of the work carrier, and secured to the seat by the elastic belts between the first and second belt supports in accordance with rotation of the work carrier,

the work is advanced in accordance with rotation of the work carrier and cutoff machined by said outer cutoff blade inserted between the at least two elastic belts,

the resulting divided work is further advanced in accordance with rotation of the work carrier, released from the seat, and discharged from the work carrier at a position after the second belt support, with reference to the rotational direction of the work carrier.

The cutoff machining apparatus of the invention operates as follows. As the work carrier rotates, the work is delivered to the peripheral surface of the work carrier from an

aft position in the rotational direction of the work carrier with respect to the first belt support, and secured to the work seat by the elastic belts between the first and second belt supports. In accordance with rotation of the work carrier, the work is moved forward and cutoff machined into pieces by the outer cutoff blade which is inserted through the spacing between the at least two elastic belts (securing the work) toward the peripheral surface of the work carrier. In accordance with rotation of the work carrier, the divided (or sawed) work is moved further forward, released from the seat, and discharged from the work carrier at a forward position in the rotational direction of the work carrier with respect to the second belt support.

According to a second aspect, the invention provides a method for machining sintered magnet workpieces by cutoff machining the workpieces into divided pieces, comprising: (a) providing machining apparatus comprising a rotating work carrier having work seats distributed around its peripheral surface to receive respective workpieces; a blade assembly comprising a rotatable cutoff blade having a circumferential edge and positioned adjacent the peripheral surface of the work carrier for cutting workpieces thereon at a cutting position, and means for holding the workpieces against the peripheral surface of the work carrier for said cutting, comprising elastic belts adapted to circulate synchronously with the rotation of the work carrier, at least two belt supports for supporting the belts in tension and defining their circulatory path of the belts, and a belt tensioning mechanism for tensioning the belts, said belt supports including a first belt support and a second belt support disposed in proximity to the peripheral surface of the work carrier so as to urge the circulating tensioned belts running between them against a corresponding region of the peripheral surface of the rotating work carrier which includes the cutting position; (b) supplying the workpieces into respective said work seats on the peripheral surface of the rotating work carrier, before said region where the belts are urged against the work carrier; securing the workpieces in their seats by the belts being urged against the workpieces as they advance to said region where the belts are urged against the work carrier; cutting through the workpieces to form divided pieces by means of the rotating cutoff blade as the workpieces advance past the cutting position, with the blade inserted between adjacent belts, whereby the divided pieces are held in place by the belts after the cutting, and discharging the divided pieces from the work carrier after they advance past the region where the belts are urged against the work carrier.

With the cutoff machining apparatus and method of the invention, a series of steps of fixedly attaching a work of sintered magnet to a carrier, cutoff machining the work by an outer cutoff blade, detaching the divided work and discharging from the carrier can be automatically performed. Accordingly, the steps of continuously delivering works onto the peripheral surface of a work carrier, clamping each work between the carrier and elastic belts and securing it to a seat on the carrier, moving the work forward in accordance with rotation of the carrier, cutoff machining the secured work by an outer cutoff blade which is disposed forward in the moving direction, and detaching and discharging the divided work are carried out in a serial flow with rotation of the carrier. The cutoff machining apparatus and method eliminate a need for attachment and detachment of sintered magnet to and from a jig and a need for mounting and dismounting of the jig to and from a sawing machine, as required in the prior art, and are successful in continuously securing and cutoff machining sintered magnet works at a high productivity and high accuracy while reducing the standby time of the apparatus.

The cutoff machining apparatus may further include a nozzle for supplying a coolant to the site where the work is cutoff machined by the outer cutoff blade. The provision of the nozzle enables positive cooling of the cutoff site.

A plurality of work seats are formed on the respective sides of the peripheral surface of the polygonal carrier and arranged in the rotating spindle direction of the carrier. Then a plurality of works may be arranged at a time in the rotating spindle direction of the work carrier. Further, the outer cutoff blade takes the form of a multiple blade assembly having a plurality of outer cutoff blades mounted on the rotating shaft with spacers interposed between the blades. Using the multiple blade assembly, one work can be

their track or push the belts inside their track between the third and fourth belt supports for tensioning the belts more intensely. Then the tension state of the belts for imparting a pressing force to the work is consistently established.

While the work may be manually delivered onto the peripheral surface of the carrier, the cutoff machining apparatus preferably further includes an inlet conveyor disposed near the area where the work is delivered onto the peripheral surface of the carrier for conveying the work to the area. Also preferably a guide is disposed in the area where the work is delivered onto the peripheral surface of the work carrier for resting the work in place on the seat at the work delivery position, i.e., placing the work in alignment with the seat at the work delivery position. This ensures that the attitude and position of the work which is delivered to the seat are easily controlled as desired.

Also preferably, the cutoff machining apparatus further includes an outlet conveyor disposed near the area where the divided (or sawed) work is released from the seat and discharged from the work carrier, for conveying the divided work out of the area. Then the divided works may be continuously discharged.

ADVANTAGEOUS EFFECTS OF INVENTION

The cutoff machining apparatus and method of the invention can eliminate a need for attachment and detachment of sintered magnet to and from a jig and a need for mounting and dismounting of the jig to and from a cutoff machining machine, and can be successful in cutoff machining a sintered magnet at a high productivity and high accuracy.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a side elevational view of a cutoff machining apparatus in one embodiment of the invention.

FIG. 2 is a view of a portion of the work carrier in FIG. 1.

FIG. 3 is a view of the same portion as FIG. 2, showing that elastic belts are close to the work carrier.

FIG. 4 is a side view showing that the belts are supported by the first belt support in the apparatus of FIG. 1.

FIG. 5 is a side view showing a belt expanding mechanism and third and fourth belt supports in the apparatus of FIG. 1.

CLAIMS:

1. Machining apparatus for the cutoff machining of sintered magnets, comprising:

a cylindrical or columnar work carrier mounted on a horizontal rotation axis such as a rotation spindle and having a generally regular polygonal shape in a cross-section perpendicular to the rotation axis, with the proviso that the polygon has 3 to 180 sides,

a plurality of endless elastic belts which are extended so as to come close to a portion of a peripheral surface of the work carrier, adapted to urge a work of sintered magnet against the peripheral surface of the work carrier to secure the work, and adapted to travel synchronously with the rotation of the work carrier in a circulatory manner,

a belt expanding mechanism for tensioning the belts,

at least two belt supports for supporting the belts in tension and adapted to define the traveling direction of the belts during their circulatory travel,

an outer cutoff blade having a circumferential edge, mounted on a horizontal rotating shaft and adapted to be positioned such that the circumferential edge is close to the peripheral surface of the work carrier, and

work seats formed on the respective sides of the peripheral surface of the polygonal work carrier and arranged in the rotational direction of the work carrier, the plurality of elastic belts being extended such that the work resting on each work seat is secured thereto by at least two elastic belts which are juxtaposed at a spacing,

the at least two belt supports including a first belt support disposed above the rotation axis of the work carrier and in proximity to a portion of the peripheral surface of the work carrier which extends from the top of the work carrier to a forward position in the rotational direction of the work carrier, and a second belt support disposed below the rotation axis of the work carrier and in proximity to a portion of the peripheral surface of the work carrier which extends from the bottom of the work carrier to an aft position in the rotational direction of the work carrier,

the apparatus being operable such that in use the work is delivered onto the peripheral surface of the work carrier before the first belt support, with reference to the rotational direction of the work carrier, and secured to the seat by the elastic belts between the first and second belt supports in accordance with rotation of the work carrier,

the work is advanced in accordance with rotation of the work carrier and cutoff machined by said outer cutoff blade inserted between the at least two elastic belts,

the resulting divided work is further advanced in accordance with rotation of the work carrier, released from the seat, and discharged from the work carrier at a position after the second belt support, with reference to the rotational direction of the work carrier.

2. Machining apparatus of claim 1 comprising a nozzle for supplying a coolant to the site where the work is cutoff machined by the outer cutoff blade.

3. Machining apparatus of claim 1 or 2 wherein each of the work seats on the respective sides of the peripheral surface of the polygonal work carrier is divided into a plurality of seat segments in the rotation axis direction of the work carrier.

4. Machining apparatus of any one of claims 1 to 3 wherein the outer cutoff blade takes the form of a multiple blade assembly having a plurality of outer cutoff blades mounted on the rotating shaft with a spacer interposed between the blades.

5. Machining apparatus of any one of claims 1 to 4 wherein the peripheral surface of the work carrier is provided with a groove in the rotational direction of the work carrier, for receiving the circumferential edge of the outer cutoff blade.

6. Machining apparatus of any one of claims 1 to 5 wherein the work seats are provided with grooves extending between their opposite ends in the rotation axis direction of the work carrier.

7. Machining apparatus of any one of claims 1 to 6 wherein belt abutments are formed, in line with each belt, at the edges between said sides of the peripheral surface of the polygonal work carrier, to restrain the belt from shifting in the rotation axis direction of the work carrier.

8. Machining apparatus of claim 7 wherein the belt abutments project radially outward from said edges on the work carrier.

9. Machining apparatus of any one of claims 1 to 8 wherein the at least two belt supports further include third and fourth belt supports which are disposed outside the region where the belts come close to the peripheral surface of the work carrier, for keeping the belts in tension while defining the path of the belts for their circulatory travel.

10. Machining apparatus of any one of claims 1 to 9 wherein the belt expanding mechanism engages the belts and is operable so as to pull outwardly on the belts and adjust their path outward or inward, e.g. between the third and fourth belt supports defined in claim 9.

11. Machining apparatus of any one of claims 1 to 10, comprising an inlet conveyor disposed near a region where the work is delivered onto the peripheral surface of the work carrier, for conveying the work to said region.

12. Machining apparatus of any one of claims 1 to 11, comprising a guide disposed at the region where the work is delivered onto the peripheral surface of the work carrier, for guiding each work into place on a said work seat.

13. Machining apparatus of any one of claims 1 to 12, comprising an outlet conveyor disposed near the region where the divided work is discharged from the seat on the work carrier, for conveying the divided work out of the area.

14. A method for machining sintered magnet workpieces by cutoff machining the workpieces into divided pieces, comprising

(a) providing machining apparatus comprising:

a rotating work carrier having work seats distributed around its peripheral surface to receive respective workpieces;

a blade assembly comprising a rotatable cutoff blade having a circumferential edge and positioned adjacent the peripheral surface of the work carrier for cutting workpieces thereon at a cutting position, and

means for holding the workpieces against the peripheral surface of the work carrier for said cutting, comprising elastic belts adapted to circulate synchronously with the rotation of the work carrier, at least two belt supports for supporting the belts in tension and defining their circulatory path of the belts, and a belt tensioning mechanism for tensioning the belts, said belt supports including a first belt support and a second belt support disposed in proximity to the peripheral surface of the work carrier so as to urge the circulating tensioned belts running between them against a corresponding region of the peripheral surface of the rotating work carrier which includes the cutting position;

(b) supplying the workpieces into respective said work seats on the peripheral surface of the rotating work carrier, before said region where the belts are urged against the work carrier;

securing the workpieces in their seats by the belts being urged against the workpieces as they advance to said region where the belts are urged against the work carrier;

cutting through the workpieces to form divided pieces by means of the rotating cutoff blade as the workpieces advance past the cutting position, with the blade inserted between adjacent belts, whereby the divided pieces are held in place by the belts after the cutting, and

discharging the divided pieces from the work carrier after they advance past the region where the belts are urged against the work carrier.

15. Method of claim 14 carried out by an apparatus having the features as defined in any one of claims 1 to 13.