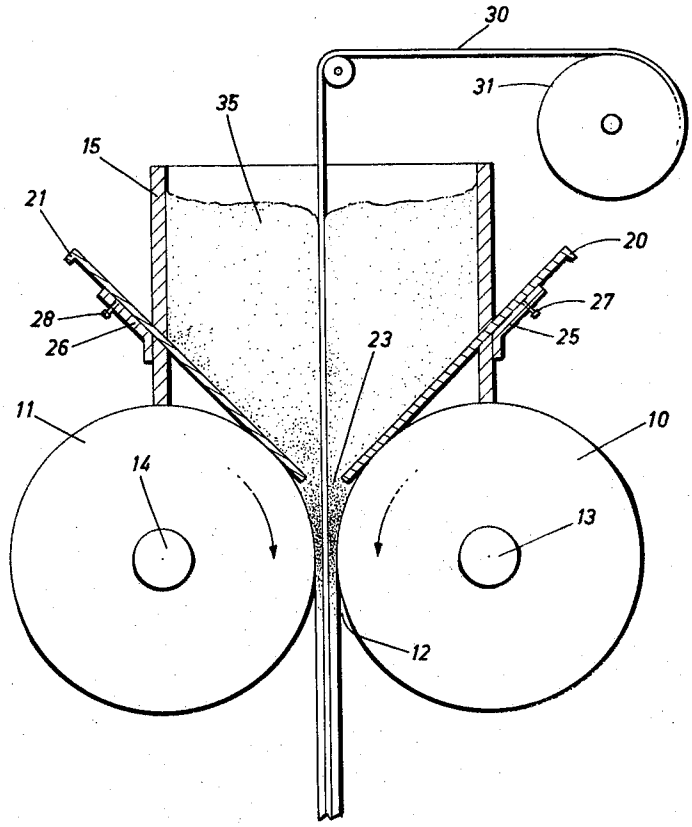
Sept. 29, 1964 J. A. H. LUND ETAL 3,150,974

PROCESS FOR ROLL COMPACTING FINELY DIVIDED METAL AND METAL COATED PARTICLES

Filed June 21, 1961



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United States Patent Office 3,150,974 Patented Sept. 29, 1964

3,150,974

PROCESS FOR ROLL COMPACTING FINELY DIVIDED METAL AND METAL COATED PARTICLES

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Filed June 21, 1961, Ser. No. 118,733
6 Claims. (Cl. 75—208)

This invention relates to a process for producing useful compacted products from compactible, finely divided particles of metal, including metal alloys and composite, metal coated, metal and non-metal compounds and mixtures thereof. It is particularly directed to providing a process for producing thick metal sheets and strips which can be hot and/or cold worked to produce useful commercial shapes.

Processes are known in the powder metallurgy art by means of which particles of metal and metal coated, metal and non-metal compounds and mixtures thereof can be compacted to form strips and sheets. These known processes have the important disadvantage, however, of being restricted to the production of relatively thin sheets and strips. It has not been possible, heretofore, to roll compact the particles into strips and sheets thicker than about one one-hundredth (0.01) of the diameter of the compacting rolls. For example, in using six inch diameter rolls, the maximum thickness of strip or sheet which can be rolled is about 0.060 inch. Thus, in order to make products comparable to the types of products which can be produced from cast ingots, bars, billets and the like, from metal and metal coated composite particles, it has been necessary to compress the particles in a static die followed by sintering to obtain a porous sintered billet of limited size, or to melt the powders and cast them into a conventional shape and follow conventional hot and/or cold working procedures to produce a desired useful shape such as, but not limited to, rods, wires, bars, plates, flanges, angles and the like. These procedures add materially to the cost of forming the desired products; they limit the lengths of products which can be produced from particulate material; they increase the danger of contamination when high purity is desired or required; they may destroy desired physical properties in the finished products, particularly those made from metal coated particles; and they conventionally involve a multiplicity of rolling, swaging, and other working stages which must be applied to permit adequate size reduction.

We have found that difficulties in forming thick sheets and strips of finely divided metal and metal coated particles for subsequent hot and/or cold working into desired, useful shapes can be overcome by feeding a coherent web, which may be a porous or non-porous sheet or strip of the same or different material, into and through the roll gap formed between a pair of oppositely positioned, horizontally disposed, powder metal compacting rolls and simultaneously feeding a layer of metal or metal coated composite particles on each side of the solid web as it enters the roll gap. It is found that the layers of metal or metal coated particles on each side of the centre web bonds firmly to that web as it passes through the roll gap to the extent that the compacted sheet or strip which emerges from the roll gap is a substantially unitary structure and is in a suitable condition for subsequent sintering and hot and/or cold working operations for the production of desired useful shapes. Alternatively, of course, the emerging sheet or

strip can be used as a solid centre web in a further roll compacting operation, as described in detail hereinafter, for producing a still thicker strip or sheet.

We have found, also, that the layers added to the web may be, individually, much thicker than an original "green" strip which can be produced by roll-compacting the same powders in the absence of the central web. That is, the product obtained with a central web can be substantially more than three times as thick as a single sheet or strip produced by roll-compacting the same powders.

An understanding of the process of this invention can be obtained from the following description, reference being made to the accompanying drawing which illustrates an end elevation, partly in section and partly schematic, of an embodiment of the invention.

Like reference characters refer to like parts throughout the description and drawing.

Referring to the drawing, the numerals 10–11 indicate rolls of a conventional type used for compacting metal particles. In the modification illustrated, they are plain, or unprofiled, rolls adapted to compact metal particles into sheet or strip of a desired width. The rolls are horizontally positioned and oppositely disposed, as illustrated, and are spaced apart a predetermined distance to form a roll gap 12 of predetermined width. The rolls are mounted on rotatable shafts 13–14 which are driven according to conventional practice, such as by an electric motor through a train of speed reducing gears, not shown. The rolls are formed of conventional material, such as steel with hard, ground, smooth surfaces. Conventionally, they are slightly resiliently mounted, according to conventional practice, to apply a predetermined pressure on the particulate material fed into the roll gap 12 with provision to increase or reduce the roll gap thus to increase or reduce the thickness of a compacted sheet or strip.

In the modification illustrated, the rolls are smooth, hard, ground steel rolls 6 inches in diameter with provision, not shown, for applying pressure on the sheet or strip passing through the roll gap of up to about 100 tons per square inch or more.

Metal or metal coated particles 35 are fed from a source of supply into a hopper 15 which is positioned above the rolls and, preferably, is about centrally disposed in respect of the roll gap.

Methods and apparatus are known for feeding metal powder, at a predetermined, uniform rate, to the roll gap. In the assembly illustrated in the drawing, the bottom of the hopper 15 is in the form of spaced, adjustable, oppositely disposed, angularly positioned baffle members 20–21 which are slidably mounted on supporting members 25–26. Set screws 27–28 extend through the supporting members and are adapted to be tightened against the baffles 20–21 to secure them firmly in their adjusted positions. The baffle members extend through opposing walls of the hopper to the entrance of the roll gap, stopping short of each other with their lowermost ends leaving a space 23 for the flow of particles from the hopper to the roll gap on each side of the strip 30 as described in detail hereinafter. This space 23 can be increased or decreased to increase or decrease the rate of flow of particles to the roll gap by linear adjustment of the baffles on the supports 25–26. The baffles can then be secured firmly in their adjusted positions by tightening the set screws 27–28.

A web in the form of a strip or sheet 30 is fed from a coil 31 to the centre of the roll gap 12. This web 30 can be of any desired porous or non-porous, coherent mate-

rial of the same width as the sheet or strip to be formed. For example, the web 30 can be a previously roll compacted and sintered sheet or strip of the same or different metal or metal coated particles or it can be formed of paper or other material which is self-disposable in the sintering step which conventionally follows the roll compacting operation.

Metal or metal coated particles flow into the roll gap on each side of the web **30** at predetermined and substantially uniform rates and are simultaneously compacted into a "green" sheet or strip and bonded to the centre web **30** as the lamination of the web and particulate material is advanced through the roll gap.

It will be understood that the utility of this process is limited only by the characteristics of the compacted sheet or strip desired, the infinite number of the types of webs of solid material which are available as core material and the types of metal and metal coated particles which are available. For example, the same metal or metal coated particles can be used in the web and the particulate material to form a uniform structure of the same material throughout. As a further modification, the same or different material can be bonded to a web formed of paper or other material which is self-disposable in the sintering step of the overall process. As a still further modification, a tri- or bi-metallic strip can be formed by applying different metal or metal coated particles to each side of a centre strip which is of the same material as one of the added layers to form a bi-metallic strip or sheet, or which is different from the two added layers to form a tri-metallic strip or sheet. Also, by regulating the flow of particles to the roll gap on each side of the centre strip, layers of different metal or metal coated particles of different thicknesses can be applied to the respective sides of the solid centre strip. As a further modification, the web can be perforated along its length to permit particles on one side to diffuse into particles on the other side during roll compacting and subsequent hot and/or cold working operations.

In the event that the sheet or strip emerging from the roll gap is to be used as a core sheet or strip for building a thicker sheet or strip, it is necessary to pass it through a sintering step before returning it to the roll gap to ensure that it is of sufficient density and coherence to resist breakage. The sintering of "green" shapes formed of metal particles is known. It involves heating the shape in an inert or reducing atmosphere at a temperature above the recrystallization temperature of the particulate material but below the melting temperature of the shape as a whole. This sintering step ensures, particularly in the case of relatively thick sheet or strip used as the core sheet or strip, that is of sufficient density and tenacity to resist breakage and disintegration in handling, coiling and rolling through the roll compacting unit.

As a specific example of the operation of the process, a "green" strip 0.04 inch thick was produced by roll compacting nickel powder of a particle size within the range of from about 50 to about 150 microns. The strip, after sintering, was returned to the roll compacting unit as the centre strip **30** after sintering at 2200° F. Nickel powder was fed into the roll gap on each side of the centre strip. The strip emerging from the compacting rolls was 0.20 inch thick, that is five times the thickness in one pass through the roll compacting unit, as the centre strip. It is found that the thickness of a sheet or strip which can be formed by this process is limited only by the capability of the roll compacting unit.

The following examples further illustrate results obtained in the operation of this process. The rolls employed were smooth, hard, ground steel rolls, 6 inches in diameter and rotated at a speed of 10 revolutions per minute. The roll gap was adjusted to various settings as required for various thicknesses of the roll compacted strip.

The results obtained in these tests are set out in Table 1.

Table 1

Centre Strip		Strip Produced	
Thickness, ins.	Material	Thickness, ins.	Densit , percent of theoretical
.035	Ni strip.	.148	56
.035	Ni strip.	.175	60
.048	Ni strip roughened.	.173	58
	Paper.	.070	75

The process of this invention possesses the important advantage of producing thick sheets or strips by roll compacting metal or metal coated particles from which conventional, useful shapes can be produced by hot and/or cold working.

It will be understood, of course, that modifications can be made in the preferred embodiment of the invention described and illustrated herein without departing from the scope of the invention defined by the appended claims.

What we claim as new and desire to protect by Letters Patent of the United States is:

1. In a process for forming compactible, finely divided metal and metal coated particles into strips and sheets in which said particles are fed, in a vertical plane, into the roll gap between oppositely positioned compacting rolls of a roll compacting unit, the improvement in combination therewith whereby thick strip and sheet is produced which comprises feeding a web of strong, coherent material vertically through the roll gap and concurrently feeding said particles into the roll gap on each side of the web of coherent material, said web of coherent material having sufficient strength to resist, without breakage, the forces imposed on it as it passes through the point of maximum pressure in the roll gap.

2. The process according to claim 1 in which the web of coherent material is self-disposable at a temperature above the recrystallization temperature of the roll compacted shape.

3. The process according to claim 1 in which the web of coherent material is formed of the same material as the particles fed into the roll gap.

4. The process according to claim 1 in which the web of coherent material is formed of material which is different from the particles fed into the roll gap.

5. The process according to claim 1 in which the particles fed into the roll gap on one side of the web of coherent material are different from the particles fed into the roll gap on the other side of the web of solid, coherent material.

6. In a process for forming finely divided metal and metal coated particles into strips and sheets in which said particles are fed, in a vertical plane, into the roll gap between two oppositely positioned compacting rolls of a roll compacting unit, the improvement in combination therewith whereby thick strip and sheet is produced which comprises vertically feeding a web of strong, coherent material through the roll gap and concurrently feeding said particles into the roll gap on each side of said web of coherent material, said web of coherent material having sufficient strength to resist, without breakage, the forces imposed on it as it passes through the point of maximum pressure in the roll gap; sintering the compacted composite strip discharged from the roll compacting unit, and returning the said sintered strip to the roll gap for use as the web of a strong coherent material in a succeeding compacting operation.

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