

**AN INTERMEDIATE MATERIAL FOR PRODUCING A DUAL GAUGE STRIP AND
METHOD FOR PRODUCING THE SAME AND METHOD FOR PRODUCING A DUAL
GAUGE STRIP**

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an intermediate material for producing a dual gauge strip and a method for producing the same, and a method for producing a dual gauge strip. More specifically, the present invention relates to a method for producing a dual gauge strip having one or plural thick parts on the surface along the longitudinal direction of the strip, starting from a flat strip and being used for electronic parts; and an intermediate material for producing a dual gauge strip at the process of producing the dual gauge strip and a method for producing the intermediate material. The present invention is applicable to materials comprising copper, copper alloy, aluminium, aluminium alloy, magnesium, magnesium alloy, iron, and steel; and complex materials thereof in combination.

Description of the Background Art

As conventional dual gauge strips made of copper and copper alloy for use in electronic parts, it has been known for example

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a dual gauge strip with one or two thick parts 22 at the center of strip 21 along the longitudinal direction, as shown in Fig.9. Herein in Fig.9, symbol 23 represents thin part. The method for producing such dual gauge strip includes those proposed in Japanese Patent Publication No. Sho 62-55462, Japanese Patent Laid-open No. Sho 59-42150, Japanese Patent Publication No. Hei 6-77764, Japanese Patent Publication No. Hei 8-32334 and the like.

According to the method for producing a dual gauge strip which is proposed in Japanese Patent Publication No. Sho 62-55462, use is made of a hammering tool (upper die) which has at least one protrusion part slanting toward the feeding direction of flat strip and with a flat hammering face whose width is smaller than longitudinal dimension of the upper die. And while making the upper die perform a series of unit strike compression motion, the flat strip is fed forward intermittently between the upper and lower die along the longitudinal direction at an interval of individual strikes of the upper die. The flat strip width component reduced via each strike compression being a part of the width of a part of which the thickness is reduced thereafter, sequentially enlarging the width of a part with the reduced thickness via each unit strike compression, while retaining the adjacent parts at the initial thickness, and gradually sifting

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the material along the cross direction of the flat strip, thereby sequentially modifying the cross section of the flat strip from the initial cross section to the final cross section, depending on the feeding process, to produce a dual gauge strip.

According to the method for producing a dual gauge strip as proposed in the Japanese Patent Laid-open No. Sho 59-42150, use is made of a rolling roller with a V-character type tableland part (protrusion part) formed toward the circumference, wherein the part is of the width sequentially changing toward the circumference direction on the surface of the roller and the tableland part is formed in a protruding fashion such that both the ends might be descending with a slope, together with a flat roller, and by feeding a flat strip gradually between these rollers while shortening the distance between these rollers on the outward way and enlarging the distance on the inward way to make the rollers perform reciprocal motion, a dual gauge strip is produced.

According to the method for producing a dual gauge strip as proposed in the Japanese Patent Publication No. Hei 6-77764, a dual gauge strip is produced by processes comprising a step of loading a rolling force on a material part to be thinned along the longitudinal direction of the material by means of a work roll with at least one groove roll, thereby pressing the material,



to deform the material part corresponding to the groove part of the groove roll into the groove via compression buckling, a step of pressing the buckled part of the deformed material as flat, a step of pressing the thin mold part including a part with difference in level between the thick mold part of the material with the buckled part pressed and flattened and the thin mold part at a low reduction ratio, and a step of pressing the material pressed at the low reduction ratio at the same reduction ratio, depending on the strip thickness along the longitudinal direction.

According to the method for producing a dual gauge strip as proposed in the Japanese Patent Publication No. Hei 8-32334, a dual gauge strip is produced by processes comprising a step of pressing a part of a fed material to be thinned along the longitudinal direction under a compressive force by means of a pair of upper and lower rollers having a groove of a given curvature at a predetermined position and a protrusion of a given curvature on the position corresponding to the groove while the part is curved inside the groove, a step of nearly flattening the pressed material, and a step of pressing the nearly flattened material at the same reduction ratio, depending on the thickness ratio along the longitudinal direction, by means of a pair of rollers with a mold equal to the cross section of a product, to



finish the product at a predetermined cross sectional dimension.

As the method for producing dual gauge strips, various processes with different fundamental compositions have been proposed as has been described above, such as forging process as proposed in Japanese Patent Publication No. Sho 62-55462, reciprocating roll process as proposed in Japanese Patent Laid-open No. Sho 59-42150, and tandem roll process as proposed in Japanese Patent Publication Nos. Hei 6-77764 and Hei 8-32334.

In the reciprocating roll process among the processes described above, the hammering tool (upper die) of the forging process serves as rolling roller while the support of flat strip works as flat roller, but flat strip is rolled between the rolling roller and the flat roller to form a thin part, remaining heavy distortion in the deformed strip which is modified with much difficulty. Although the tandem roll process is believed to be practical, a long time is possibly required for setting rolls and adjusting including centering. Alternatively, the forging process comprises striking and compressing a flat strip by means of a hammering tool (upper die), thereby elongating the flat strip under press to form a thin part, and the process is practical. However, rough surface may occur on the lower surface of boundary part 24 between thick part 22 and thin part 23 on dual gauge strip 21, as shown in Fig.9, possibly because of the crystal grain size



and the forging ratio of forging materials and the shape of dual gauge. If the rough surface, which exceeds $1.0 \mu m$ by R_{max} , is remained in the final product, the product may be disadvantageous for utilities essentially requiring smaller surface roughness, such as the use as lead frame.

SUMMARY OF THE INVENTION

In such technical background, the present invention has been achieved. It is an object of the present invention to improve the problems of the forging process as described above and to provide a method for producing a dual gauge strip with no occurrence of rough surface on the lower at the boundary between the thick part and the thin part of a dual gauge strip product. It is the other object of the present invention to provide an intermediate material for producing a dual gauge strip prior to final rolling, from which such dual gauge strip with excellent surface roughness can be produced, together with a method for producing such an intermediate material.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a cross sectional view, perpendicular to longitudinal direction of strip, of the intermediate material for producing a dual gauge strip in accordance with the present



invention;

Fig.2 is an explanatory view of a die for producing the intermediate material of the present invention by forging process, wherein "a" represents the bottom view of the upper die; and "b" represents the upper view of the lower die;

Fig.3 is a cross sectional view, perpendicular to feeding direction of the strip, at an intermediate process stage by means of the die shown in Fig.2;

Fig.4 is a cross sectional view of another embodiment at an intermediate process stage by means of the upper and lower dies;

Fig.5 is an explanatory view of the rolling process in accordance with the present invention;

Fig.6 is a cross sectional view of the dual gauge strip of the present invention;

Fig.7 is a cross sectional view of the dual gauge strip of another embodiment of the present invention;

Fig.8 is a cross sectional view of the dual gauge strip of another embodiment of the present invention; and

Fig.9 is an explanatory view of the dual gauge strip.

DETAILED DESCRIPTION OF THE INVENTION

So as to attain the objects described above, the intermediate material of the present invention is an intermediate material



for producing a dual gauge strip having one or plural thick parts on the surface along the longitudinal direction of the strip, wherein a protrusion part of a trapezoid cross section is formed on the other surface.

In the intermediate material for producing a dual gauge strip, the trapezoid cross section of the protrusion preferably has a bottom angle θ of 5 to 60 ° to the horizon, a height "h" of 0.03 to 0.50 times the thickness "T" of the thick parts, and a base line length "w" within a range of - 3 mm to + 3 mm against the base line length "W" of the thick parts, as shown in fig. 1.

The method for producing the intermediate material in accordance with the present invention comprises repeated compression on a flat strip between a lower die and an upper die equipped with protrusions of an inverse V character shape on the bottom, slightly progressing forward the flat strip after each load of repeated compression, wherein the lower die should have a groove of a trapezoid cross section at a slight depth on the surface corresponding to the groove positions of the upper die.

According to the method for producing the intermediate material, then, the groove of a trapezoid cross section at a slight depth on the surface of the lower die is preferably formed at a bottom angle θ of 5 to 60 ° to the horizon, a height "h" of 0.03 to 0.50 times the thickness "T" of the thick parts, and a



base line length "w" within a range of - 3 mm to + 3 mm against the base line length "W" of the thick parts.

The method for producing a dual gauge strip in accordance with the present invention comprises subjecting the above-mentioned intermediate material to rolling process, thereby forming the protrusion part of a trapezoid cross section on the lower surface into the flat surface.

The method for producing a dual gauge strip in accordance with the present invention comprises subjecting the dual gauge strip formed the protrusion of a trapezoid cross section into the flat surface to finish rolling process.

In accordance with the present invention, as described above, an intermediate material for producing a dual gauge strip having one or plural thick parts on the upper surface along the longitudinal direction of the strip, has one or plural protrusions of a trapezoid cross section on the lower surface. And the trapezoidal part flows into the thin part smoothly at the boundary between the thick part and the thin part by the subsequent rolling, leaving small surface roughness at the boundary area, compared with a dual gauge strip rolled from a forged intermediate material without a lower trapezoidal section. The protrusion on the lower surface is so slight that the intermediate material can be rolled to flat surface with no



occurrence of rough surface, even if the side of the other surface is rolled with a flat roll, and by subsequent annealing and finish rolling process, furthermore, a dual gauge strip with no rough surface on the lower surface can be recovered.

So as to sufficiently receive the operations and advantages described above, the trapezoid cross section of the protrusion on the other surface of the intermediate material for producing a dual gauge strip (see Fig.1) preferably has a bottom angle θ of 5 to 60 ° to the horizon, a height "h" of 0.03 to 0.50 times the thickness "T" of the thick parts, and a base line length "w" within a range of - 3 mm to + 3 mm against the base line length "W" of the thick parts. The reason will now be described below.

If the bottom angle θ exceeds 60 °, the trapezoidal part is enlarged transversely by the subsequent rolling, to make poor surface such as "wrinkles" or "fold" readily. Furthermore, efficiency is spoiled because increased metal flow is needed to make the lower surface flat. If the bottom angle θ is below 5 °, the lower surface is close to a flat shape, so that the favorable metal flow is not made, which readily generates rough surface at a corner part where the protrusion on the other surface crosses with the lower surface. Based on the grounds, the bottom angle θ is preferably 5 to 60 ° to the horizon.

If the height "h" on the side of the lower surface exceeds



0.50 times the thickness "T" of the thick parts, the trapezoidal part is enlarged transversely by the subsequent rolling, to make poor surface such as "wrinkles" or "fold" readily. Furthermore, efficiency is spoiled because increased metal flow is needed to make the lower surface flat. If the height "h" is less than 0.03 times the thickness T of the thick parts, the lower surface is close to a flat shape, so that the favorable metal flow is not made, which readily generates rough surface at a corner part where the protrusion on the other surface crosses with the lower surface. Based on the grounds, the height "h" is preferably 0.03 to 0.50 times the thickness "T" of the thick parts.

If the base line length "w" is larger by 3 mm or more than the base line length "W" of the thick parts on the upper surface, a larger reduction ratio is required to make the protruded part on the lower surface into flat at the subsequent rolling process for preparing a dual gauge strip, readily generating rough surface. Furthermore, the productivity of a dual gauge strip is lowered. If the base line length "w" is shorter by 3 mm or more than the base line length "W" of the thick parts on the upper surface, the favorable metal flow is not made, which readily generates rough surface at a corner part where the protrusion on the other surface crosses with the lower surface. Based on the grounds, the base line length "w" is preferably formed within



a range of -3 mm to +3 mm against the base line length "W" of the thick parts.

MODE OF CARRYING OUT THE INVENTION

The embodiments of the present invention will now be described hereinbelow with reference to drawings. Fig.1 is a cross sectional view, perpendicular to longitudinal direction of strip, of the intermediate material for producing a dual gauge strip in accordance with the present invention; Fig.2 is an explanatory view of a die for producing the intermediate material of the present invention by forging process, wherein "a" represents the bottom view of the upper die; and "b" represents the upper view of the lower die; and Fig.3 is a cross sectional view, perpendicular to feeding direction of the strip, at an intermediate process stage by means of the die shown in Fig.2.

As shown in Fig.1, in the intermediate material for producing a dual gauge strip 1 of the present invention, thick part 2 is formed at the center of the strip 1 on the surface along the longitudinal direction of the strip; and thin parts 3 are formed on both the sides thereof. On the surface side of the thick part 2 is formed trapezoid part 4 of almost the same height as that of a desirable dual gauge strip, while protrusion 5 at a slight height is formed on the other surface. The shape of the



protrusion 5 on the other surface is trapezoid in its cross section, preferably with a bottom angle θ of 5 to 60 ° to the horizon, a height "h" of 0.03 to 0.50 times the thickness "T" of the thick parts, and a base line length "w" within a range of - 3 mm to + 3 mm against the base line length "W" of the thick parts.

The upper and lower dies 6, 7 shown in Fig.2 are dies for producing the intermediate material for producing a dual gauge strip 1 by forging process, wherein hollow part 8 for forming the trapezoid part 4 of the intermediate material for producing a dual gauge strip 1 is formed at the center of the upper die 6, and protrusion parts 9 of an inverse V character shape formed toward the top (upstream side of feeding direction of flat strip M) are formed on both the sides. At the center of the lower die 7 is formed groove 10 of a trapezoid cross section at a slight depth, in a manner opposing to the hollow part 8 of the upper die 6. By making the upper die perform a series of unit strike compression motion and intermittently feeding flat strip M between the upper and lower dies 6,7 along the longitudinal direction, the flat strip M can be forged into the shape of the intermediate material for producing a dual gauge strip 1. Because the flat strip M is compressed under strike during the forging process, then, the thin part 3 formed in the flat strip M are elongated through the protrusion part 9 under press



primarily along the transverse direction, while metal flow progresses into the groove 10 of the lower die 7 on the other surface side of the flat strip M. Hence, protrusion part 5 of a slight height is simply formed on the other surface. And if the lower die is not equipped with a groove 10, a dual gauge strip forged by using such a lower die would show rough surface on the lower surface corresponding to a boundary area between a thick part 2 and a thin part 3.

In Fig.2 above, the lower die 7 is illustrated for example as a die with groove 10 of a trapezoid cross section formed on the center while the die is flat on both the sides, but as shown in Fig.4, the lower die 7 may take the form like the upper die 6, such that the groove 10 at the center is formed by protrusion part 11 at a slight height, as shaped in an inverse V character formed toward the top, on both the sides, and the thin parts 3 are elongated under press between the protrusion part 9 of the upper die 6 and the protrusion part 11 of the lower die 7 along the longitudinal direction.

The intermediate material mentioned above is rolled by a pair of rolls to make a dual gauge strip. The upper roll 15 has a groove 13 at the center whose cross section is almost same shape as the thick part 3 of a dual gauge strip. On the other hand, the lower roll 14 is flat to make the trapezoid part 5 of the



intermediate material on the lower surface flat. In the rolling process, the trapezoid part 5 on the lower surface flow into the thin part 3, so the smooth surface Rmax of $1.0 \mu\text{m}$ or less can be easily attained compared with a dual gauge strip manufactured by conventional forging process.

Continuously thereafter or by manufacturers of dual gauge strips, the intermediate material for producing a dual gauge strip 1 after rolling with the mold roll 15 is annealed and rinsed in acids or/and polished in a routine fashion, and is then subjected to finish roll (roll to refine the cross sectional shape of the intermediate material for producing a dual gauge strip 1) to produce a product dual gauge strip.

In the above example, the shape with one thick part 2 at the center along the longitudinal direction is illustrated, but the present invention is not limited to the example. Strips with plural thick parts may also be produced satisfactorily, which can exhibit the same operation and advantages.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Example 1

At routine processes of melting, casting, hot rolling and cold rolling, a phosphorus deoxygen copper (JIS-C1220) roll material



of a thickness of 2 mm was prepared, and slit to make a strip of 42mm in width. The raw strip was forged by means of the upper and lower dies shown in Fig.2, to prepare an intermediate material for producing a dual gauge strip shown in Fig.1. At the forging process, for comparison, 5 lower dies, the dimensions of a groove differ each other, are prepared. The dimensions of the cross sectional shapes of the intermediate material for producing dual gauge strips thus covered at the forging process are shown in Table 1.

Table 1

No.	W (mm)	T (mm)	t (mm)	α	w (mm)	h (mm)	θ	Rmax. (μ m)	Note
A1	25.70	2.0	0.7	80°	28.0	0.35	15°	0.5	Inventive Example
A2	25.70	2.0	0.7	80°	-	0	-	3.7	Comparative Example
A3	25.70	2.0	0.7	80°	21.5	0.35	15°	2.7	Comparative Example
A4	25.70	2.0	0.7	80°	28.0	0.03	15°	3.1	Comparative Example
A5	25.70	2.0	0.7	80°	28.0	0.55	3°	2.0	Comparative Example

By subsequently rolling the intermediate material for producing dual gauge strips covered at the forging process, intermediate materials (W = 25.25 mm; T = 1.70 mm; and t = 0.6 mm) of a trapezoid cross section with no protrusion on the other surface were prepared. After annealing the intermediate materials in a continuous anneal furnace in a non-oxidative atmosphere at 650 °C and rinsing the annealed products in acid, they are finally rolled to produce dual gauge strip A shown in Fig.6. The surface roughness (Rmax) of the lower surface of the



dual gauge strip A, specifically the part shown by symbol B, was measured. The results of the measurement are collectively shown in Table 1.

As apparently shown from the surface roughness in Table 1, the dual gauge strip A1 of the Inventive Example has an excellent surface roughness of $0.5 \mu\text{m}$ at the part B. However, the surface roughness exceeds $2 \mu\text{m}$ in all of the Comparative Examples, because dual gauge strip A2 has no protrusion part ($h = 0 \text{ mm}$) on the lower surface; dual gauge strip A3 has a larger (W-w) value of 4.2 mm at the protrusion part on the lower surface; dual gauge strip A4 is small with the depth "h" of the protrusion part being less than 0.03 times of T; and dual gauge strip A5 has a small bottom angle θ less than 5° . These strips could not satisfy the surface roughness ($R_{\text{max}} \leq 1 \mu\text{m}$) which is required for dual gauge lead flame such as power transistor.

Example 2

At routine processes of melting, casting, hot rolling and cold rolling, a phosphorus deoxygen copper (JIS-C1220) roll material of a thickness of 2 mm was prepared, and slitted to make a strip of 42 mm in width. The raw strip was forged in the same manner as in the Example 1, to prepare an intermediate material for producing a dual gauge strip shown in Fig.7. At the forging



process, for comparison, 2 lower dies are prepared. One is equipped with two grooves of trapezoid shape, the other has no grooves. The dimensions of the cross sectional shapes of the intermediate material for producing dual gauge strips thus covered at the forging process are shown in Table 2.

Table 2

No.	W1 (mm)	W2 (mm)	T (mm)	t (mm)	$\alpha 1$	$\alpha 2$	
C1	25.70	32.44	2.0	0.7	81°	75.5°	
C2	25.70	32.44	2.0	0.7	81°	75.5°	
No.	w1 (mm)	w2 (mm)	h (mm)	$\theta 1$	$\theta 2$	Rmax. (μ m)	Note
C1	13.1	36.1	0.5	10°	25°	0.5	Inventive Example
C2	-	-	-	-	-	3.2	Comparative Example

By subsequently rolling the intermediate material for producing dual gauge strips covered at the forging process, intermediate materials (W1 = 10.485 mm; W2 = 32.47 mm; T = 1.70 mm; and t = 0.6 mm) of a trapezoid cross section with no protrusion on the lower surface were prepared. After annealing the intermediate materials in a continuous anneal furnace in a non-oxidative atmosphere at 650 °C and rinsing the annealed products in acid, and they are finally rolled to dual gauge strip C shown in Fig.8. The surface roughness (Rmax) of the lower surface of the dual gauge strip C, specifically the part shown by symbol D, was measured. The results of the measurement are collectively shown in Table 1.

As apparently shown from the surface roughness in Table 1,



the dual gauge strip C1 of the Inventive Example has an excellent surface roughness of $0.5 \mu\text{m}$ at the part D, but the surface roughness is as large as $3.2 \mu\text{m}$ in the Comparative Example dual gauge strip C2 because of the absence of protrusion part ($h = 0 \text{ mm}$) on the lower surface. The strip could not satisfy the surface roughness ($R_{\text{max}} \leq 1 \mu\text{m}$) which is required for dual gauge lead frame such as power transistor.

As has been described above, the intermediate material for producing a dual gauge strip of the present invention has a formed protrusion part of a trapezoid cross section on the lower surface of the thick part, and even if the material is processed by forging process, the metal flow on the lower surface can be promoted at the boundary between the thick part and thin parts in a smooth manner, compared with a forged dual gauge strip using a flat lower die, though the former has a ledge on the lower surface.

The protrusion part on the lower surface of the intermediate material for producing a dual gauge strip is so slight that the protrusion part can be rolled into flat surface with no occurrence of rough surface by using a flat roll as a lower one. And furthermore, the rolled dual gauge strip can be finally rolled to the one with fine surface roughness on the lower surface, subsequent to annealing.





WHAT IS CLAIMED IS;

1. An intermediate material for producing a dual gauge strip having one or plural thick parts on the surface along the longitudinal direction of the strip , wherein one or plural protrusion parts of a trapezoid cross section is formed on the other surface.

2. An intermediate material for producing a dual gauge strip according to claim 1, wherein the trapezoid cross section of the protrusion has a bottom angle θ of 5 to 60 ° to the horizon, a height "h" of 0.03 to 0.50 times the thickness "T" of the thick parts, and a base line length "w" within a range of - 3 mm to + 3 mm against the base line length "W" of the thick parts.

3. A method for producing an intermediate material for a dual gauge strip having one or plural thick parts on the surface along the longitudinal direction of the strip, starting from a flat strip, comprising

repeated compression on a flat strip between a lower die and an upper die and slightly progressing forward the flat strip after each load of repeated compression, wherein the upper die equipped with protrusions of an inverse V character shape on the bottom, wherein the lower die should have one or plural grooves of a



trapezoid cross section with a slight depth on the surface corresponding to the groove positions of the upper die.

4. A method for producing an intermediate material for producing a dual gauge strip according to claim 3, wherein the groove of a trapezoid cross section with a slight depth on the surface of the lower die is formed at a bottom angle θ of 5 to 60° to the horizon, a height "h" of 0.03 to 0.50 times the thickness "T" of the thick parts, and a base line length "w" within a range of - 3 mm to + 3 mm against the base line length "W" of the thick parts.

5. A method for producing a dual gauge strip, comprising subjecting the intermediate material of claim 1 or 2 to rolling process, thereby forming the protrusion part of a trapezoid cross section into the flat surface.

6. A method for producing a dual gauge strip, comprising continuously subjecting the intermediate material manufactured by a method of claim 3 or 4 to rolling process, thereby forming the protrusion part of a trapezoid cross section into the flat surface.



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7. A method for producing a dual gauge strip, comprising
subjecting the dual gauge strip manufactured by a method
according to claim 5 or 6 to finish rolling process.



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