PRECISION SHOT PEENING

WPC TREATMENT

W wide	P peening	C cleaning
W wonder	P process	C craft

Keiji Mase — Fuji Seisakusho Co.Ltd.

Yoshio Miyasaka — Fuji Kihan Co., Ltd.

PRECISION SHOT PEENING

WPC TREATMENT

Yoshio Miyasaka Fuji Kihan Co., Ltd.

1. INTRODUCTION

In these days, due to appreciation of a high yen rate, the Japanese industries, particularly export industries encounter severe conditions such as downsizing in plant and equipment investment, thus, low cost and high efficiency are further required.

Since there is few natural resources in Japan, it is necessary to develop products each of which is produced from a cheap material, can be useful for long period, has small size and weight, and has high quality and additive value. This necessity is related to the proposition for conservation of natural resources.

The WPC Treatment is one of the working methods meeting with the necessity. The WPC Treatment is heat treatment for surface of a metal product characterized in that shot of 40 to 200μ having the hardness being equal to or higher than that of the product is injected against the surface of the metal product at the injection rate of 100 m/sec or faster so that the temperature near the surface is increased to A3 transformation point or higher. (See Japanese Patent No. 1594395 owned by Fuji Kihan Co., Ltd. and Fuji Seisakusyo Co., Ltd.)

2. WPC Treatment

In the WPC Treatment, is achieved the technique where desired quality of the product can be obtained on the basis of conditions such as shot's injection rate, hardness, particle size, specific gravity, archeight, coverage and the like being set optionally for each purpose.

In air type shot peening of the WPC Treatment, the shot is injected together with compressed air from a nozzle. In this case, by decreasing the shot's size, the shot is allowed to be placed easily on the compressed air so that the injection rate arrives the order of 200 m/sec. (in the steal shot of 50 μ, air pressure is 5kg/㎠ and injection rate is 210 m/sec; in the steal shot of 300μ, air pressure is 5kg/㎠ and injection rate is 153 m/sec).

When shot is injected to a work piece, the increasing of temperature of work piece is enhanced (because, in the case of $0 < e < 1$ where e is coefficient of restitution, the injection causes incomplete elastic collision, thus, heat is generated from the part of mechanical energy according to principle of conservation of mechanical energy).

As the shot's injection rate is increased, since the metal surface structure of the work piece is moved, the increasing of surface temperature is enhanced so that the temperature exceeds the A3 transformation point of the metal. (Then, since the metal has small specific heat, the area of temperature-increasing is small, thereby, the both of temperature increasing and decreasing are occurred quickly.)

Accordingly, in the temperature area beyond the A3 transformation point, overheat and quenching are repeated instantly so that the hardening by a heat treatment, effects of a forging, and a peening are improved in this working.

Therefore, the structure of surface layer of ferrous metal is fulmartensitic transformation so that the resultant structure which is refined precisely and has a large hardness and toughness can be obtained and in such shot peening, the hardness of the metal can be increased while its brittleness is depressed.

Even if the material metal is non-ferrous, for example, for cobalt used for binder of tungsten carbide in cemented carbide, and for nickel used for binder in cermet, the WPC Treatment is useful. In these cases, binding forces which would be insufficient only by sintering treatment are enlarged due to the refined binders.

Further, also for work piece treated with ceramic coating, if its coatir layer has the thickness of 10μ or smaller, the WPC Treatment carried out over the surface of the work piece effects sufficiently to the metal base.

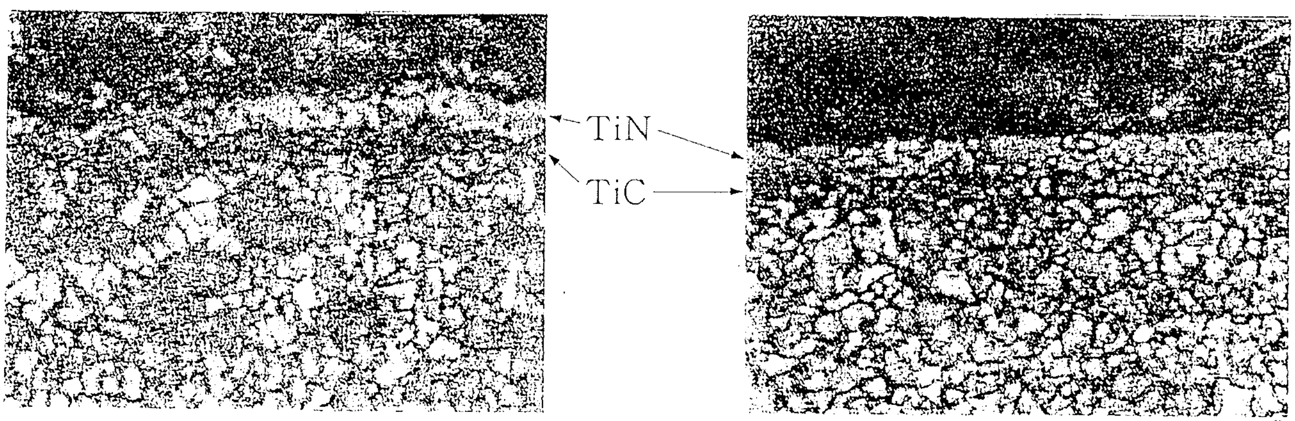
For the non-ferrous metal, in its A3 transformation point area, solutior treatment, recrystallization, and refining can be performed with the WPC Treatment so that structural deficits can be prevented on the resultant castinc product. (See Japanese Patent No. 1885376 owned by Fuji Kihan Co., Ltd. and Fuji Seisakusyo Co., Ltd. This patent discloses manufacturing method.)

Additionally, small spheres are formed on the surface so that the surface is irregular finely, thereby lubricating oil can be kept well on it. Accordingly, the workability of the lubricating oil is stable, thus refraction resistance and noise can be decreased.

3. Deformation of Structure of Metallic Product

3-1 Deformation of Structure of Cemented Carbide CVD Coated Product

When the WPC Treatment is carried out for a cemented carbide CVD coated (TiC + TiN) product ; Picture ①, cobalt, which has been deposited on the cemented carbide surface of the product, is put into its internal structure so as to be refined, at the same time, the internal residual compressive stress is increased, resulting in a smooth plane of the treated product; Picture ② comparing the untreated product.

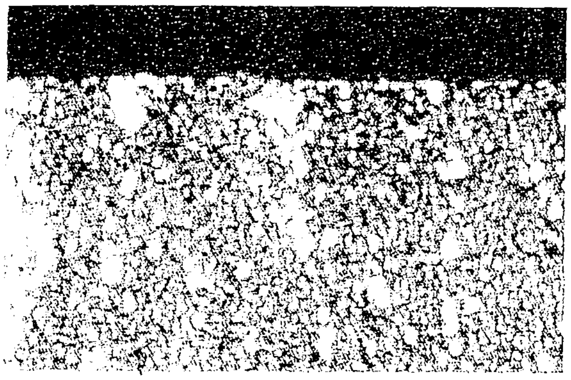


①未処理品組織　×2000　　②ＷＰＣ処理品組織　×2000

① Structure of untreated products ② Structure of WPC treated products

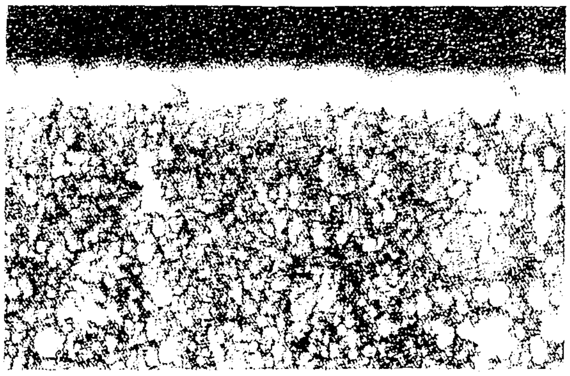
3-2 Deformation of Structure of SKH

When the WPC Treatment is carried out for a SKH 51 hardened and tempered product; Picture③, a structure having the thickness of about 10μ under the surface of the treated product; Picture④ is refined so as to prevent intergranular corrosion. Then, the surface hardness is increased from 850 (HV) to 1200 (HV). The internal residual compressive stress of the surface is 1550 MPa.



③未処理品　×1000

③Untreated products



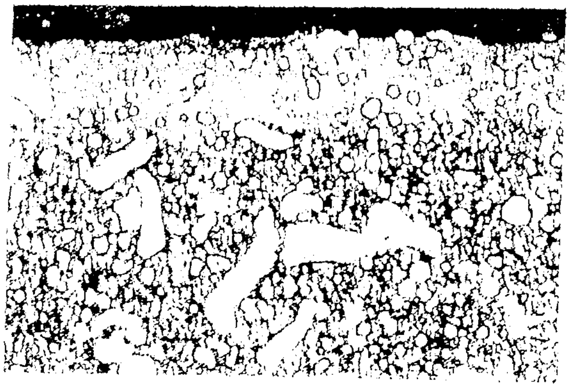
④WPC処理品　×1000

④ WPC treated products

3-3 Deformation of Structure of SKD

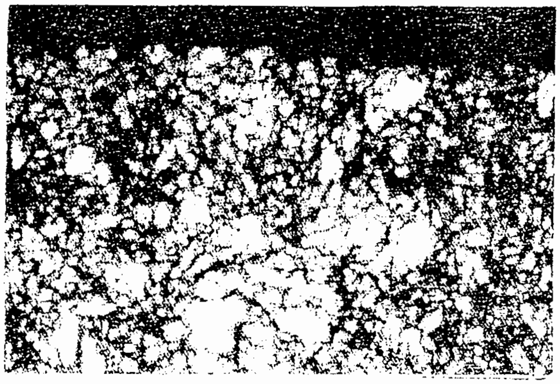
When the WPC Treatment is carried out for a SKD 11 hardened and tempered product; Picture⑤, a structure having the thickness of about 15μ under the surface of the treated product; Picture⑥ is refined so as to prevent intergranular corrosion. Then, the surface hardness is increased from 700 (HV) to 1000 (HV). The internal residual compressive stress of the surface is 1100 MPa.

⑤ Untreated products ×1000

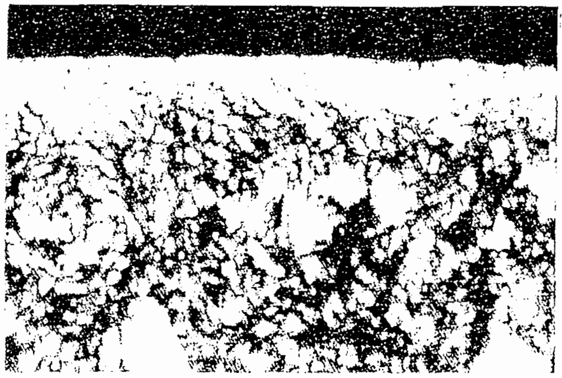


⑥ WPC treated products ×1000

When the WPC Treatment is carried out for a SKD 61 hardened and tempered product; Picture⑦, a structure having the thickness of about 30μ under the surface of the treated product; Picture ⑧ is refined so as to prevent intergranular corrosion. Then, the surface hardness is increased from 560 (HV) to 700 (HV). The internal residual compressive stress of the surface is 1400 MPa.

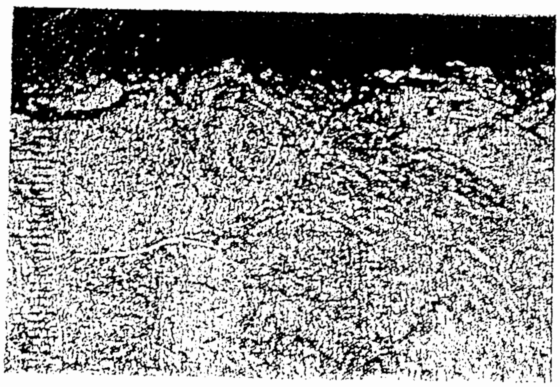


⑦ Untreated products ×1000

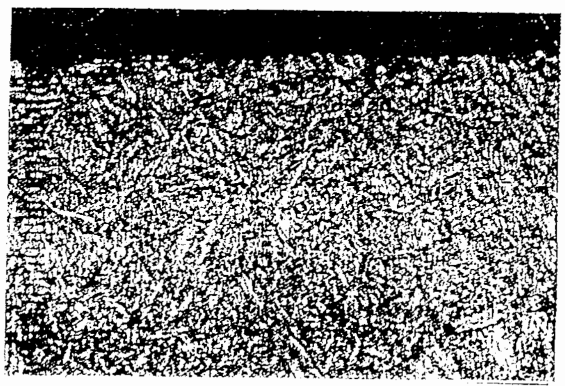


⑧ WPC treated products ×1000

When the WPC Treatment is carried out for a SKD 61 ionitride product; Picture⑨, a structure of the treated product; Picture ⑩ is refined and a separating layer between a base material and a nitride layer becomes a diffusion layer so as to suppress peeling. Then, the surface hardness is increased from 900 (HV) to 1300 (HV). The internal residual compressive stress of the surface is 1400 MPa.



⑨ Ionitride Product ×400

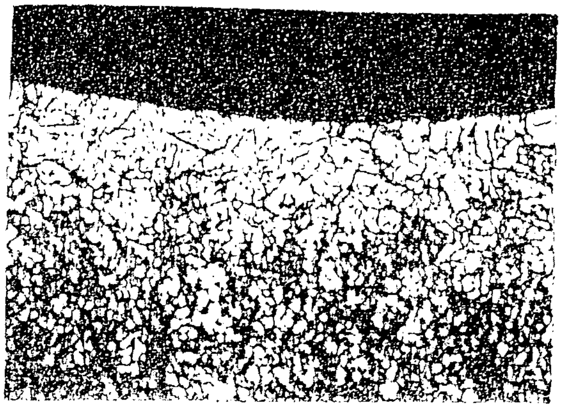


⑩ Ionitride WPC treated product ×400

3-4 Deformation of Structure of SCr 420

When the WPC Treatment is carried out for a SCr 420 carburized, hardened and tempered product; Picture⑪, a structure having the thickness of about 20 to 30μ under the surface of the treated product; Picture⑫ is made fulmartensitic transformation. A residual austeneite abnormal layer of the surface is deformed so as to be eliminated. Then, the structure is refined and the internal residual compressive stress of the surface is around 1400 MPa.

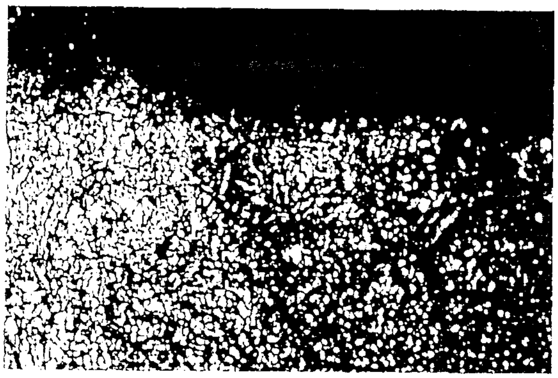
⑪ Untreated products ×400



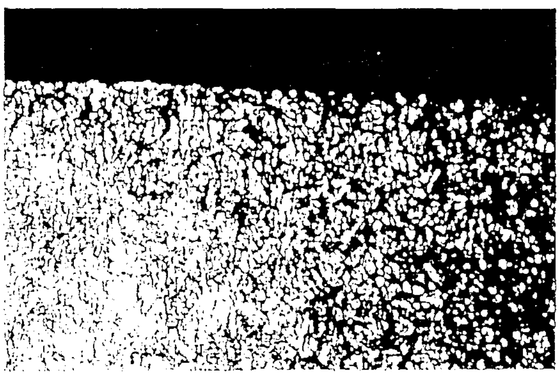
⑫ WPC treated products ×400

3-5 Deformation of Structure of SCM 420

When the WPC Treatment is carried out for a SCM 420 carburized, hardened, and tempered product; Picture⑬, structure having the thickness of about 20 to 30μ under the surface of the treated product; Picture⑭ is fulmartenized. A residual austeneite abnormal layer of the surface is deformed so as to be eliminated. Then, the structure is refined and the internal residual compressive stress of the surface is around 1500 MPa.



断面

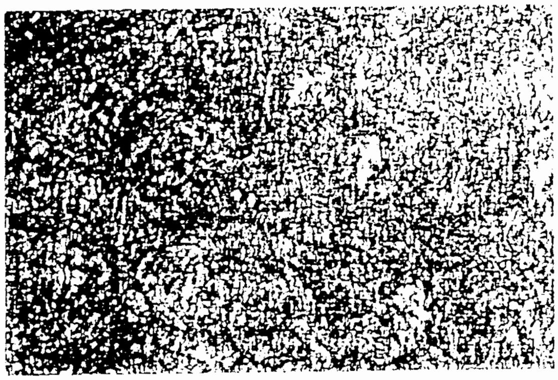


Cross

Section

surface

表
面



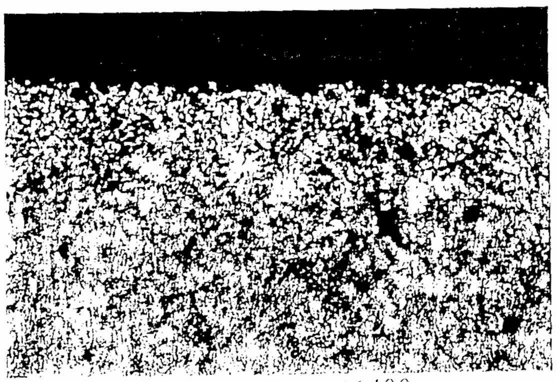
⑬ Untreated products ×400

⑭ WPC treated products ×400

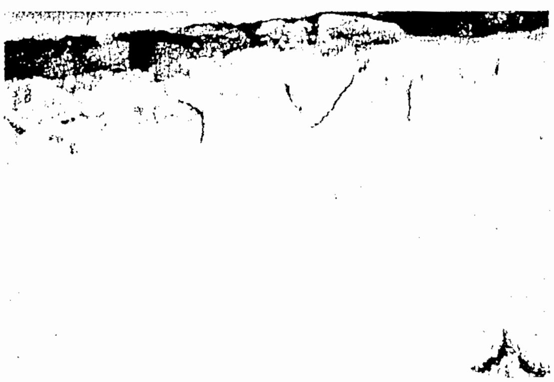
3-6 Deformation of Structure of SNCM 420

When the WPC Treatment is carried out for a SNCM 420 carburized and nitride product; Picture⑮, a structure having the thickness of about 20 to 30 ｵ under the surface of the treated product; Picture⑯ is fulmartenized. A residual austeneite abnormal layer of the surface is deformed so as to be eliminated. Then, the structure is refined and the internal residual compressive stress of the surface is around 1600 MPa.

⑮ Untreated products



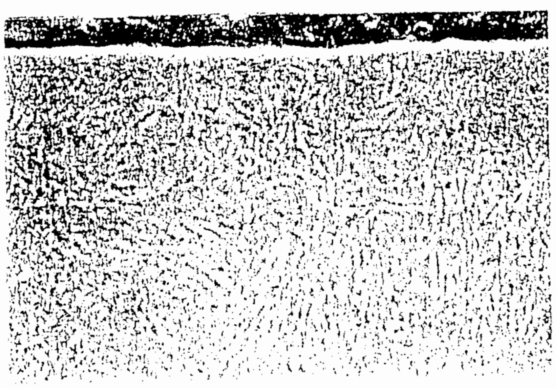
×400



×1000

⑯ WPC treated products

×400



×1000

3-7 Deformation of Structure of SUS 304

When the WPC Treatment is carried out for a SUS 304 austeneite stainless steel product; Picture⑰, the structure of the treated product; Picture ⑱ is fulmartenized. When the treated product is brought close to a magnet, it touches the magnet easily. Then, the surface hardness is increased from 300 (HV) to 600 (HV).

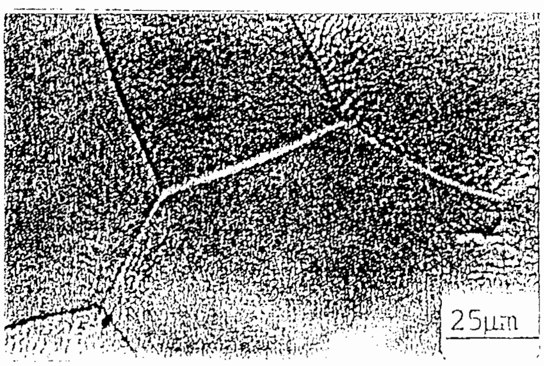
⑰ Untreated products ×400

⑱ WPC treated products ×400

3-8 Deformation of Structure of Titanium Alloy (Ti-8.6 Al)

When the WPC Treatment is carried out for a titanium alloy product; Picture⑲, the structure of the treated product; Picture ⑳ is refined. This kind of alloy is particularly suitable to accept the effect of WPC Treatment.

⑲ Untreated products

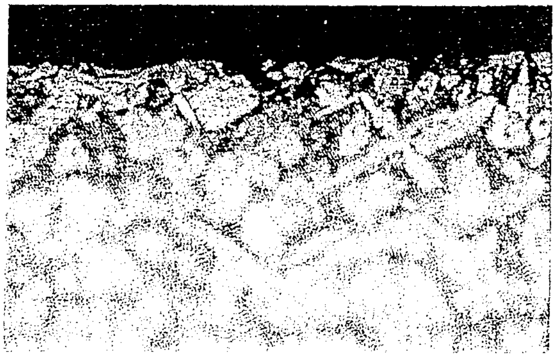


⑳ WPC treated products

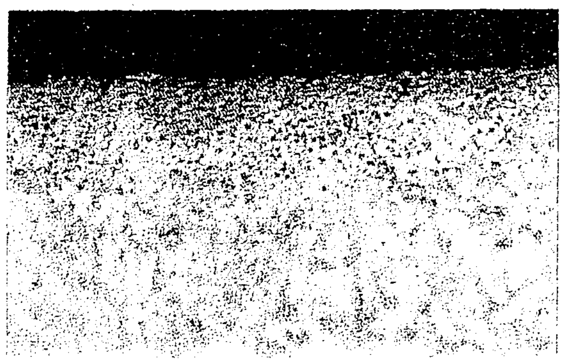
3-9 Deformation of Structure of Copper Alloy (Cu 72 %, Al 11 %, Mn 8.6 %, Co 0.61 %)

When the WPC Treatment is carried out for a copper alloy product; Picture ㉑, the structure of the treated product; Picture ㉒ is refined so as to be an amolphous-state.

㉑ Untreated products ×1000



㉒ WPC treated products ×1000

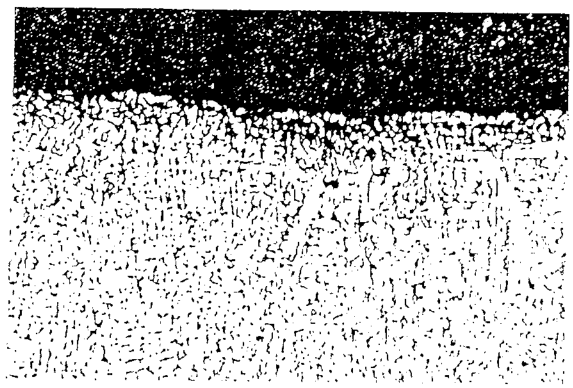


3-10 Deformation of Structure of BC 6 Copper Alloy

When the WPC Treatment is carried out for the pin-hole section of a BC 6 product; Picture㉓, solution treatment is performed at the pin-hole section in the treated product; Picture ㉔ so as to repair this section.

㉓ Untreated products ×50

㉔ WPC treated products ×50



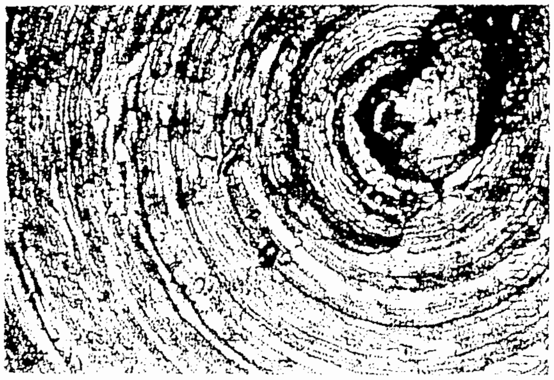
3-11 Deformation of Structure of Copper Electric Pole

When the WPC Treatment is carried out for a copper electric pole; Picture ㉕, the surface hardness is increased and the structure of the treated pole; Picture ㉖ is refined so that its electrical resistance is decreased.

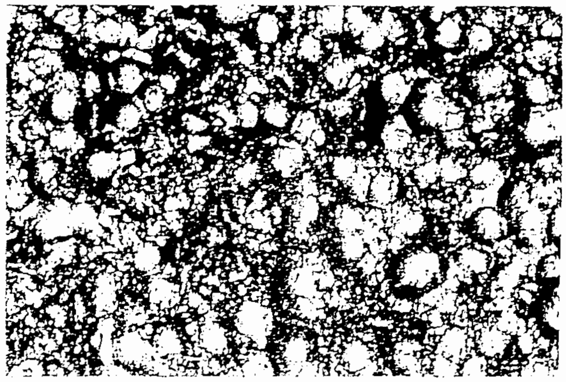
㉕ Untreated products ×50　　　㉖ WPC treated products ×50

surface

表面

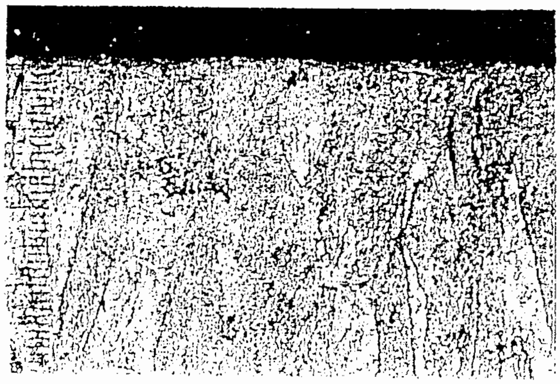


×100



×100

断面



㉕未処理品 ×400

㉖WPC処理品 ×400

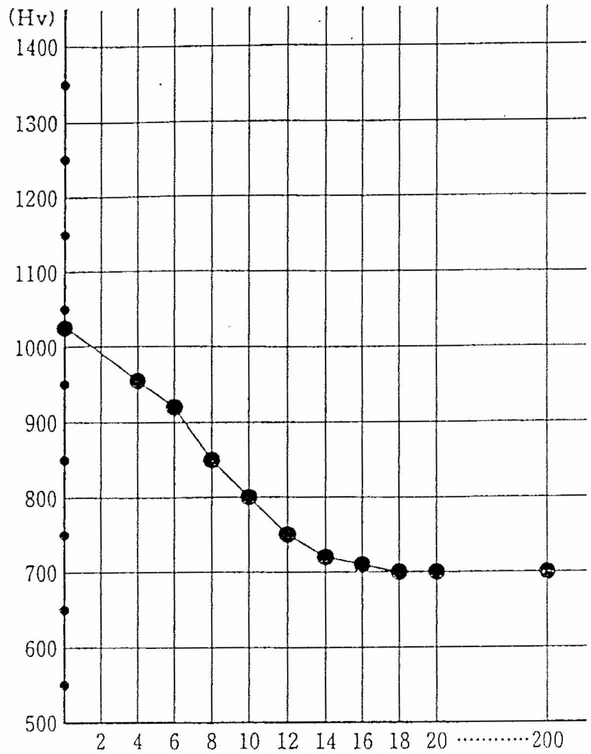
cross section

5-14 T / P Hardness Distribution Diagram in WPC Treatment

data (Hv 5 g. 10 g)

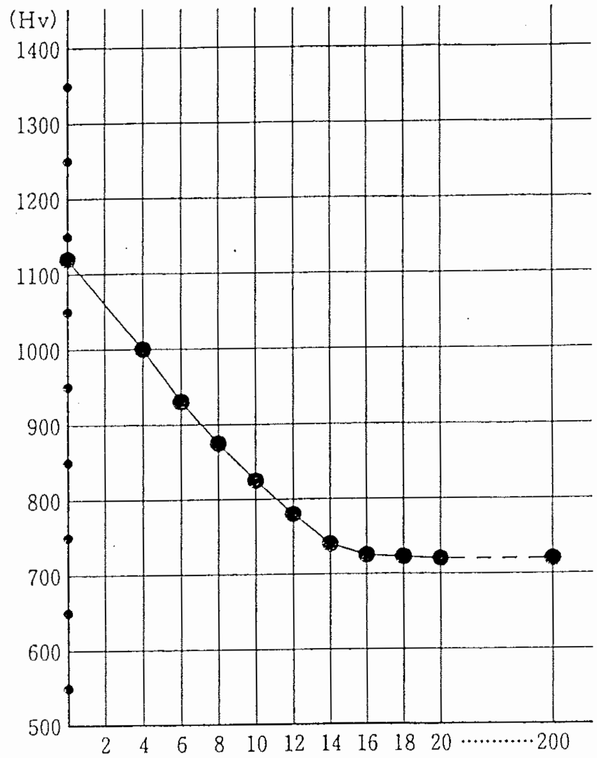
T/P Material SKD11

T/P Hardness (HRC)=60.3



T/P Material SKD11 (equivalent)

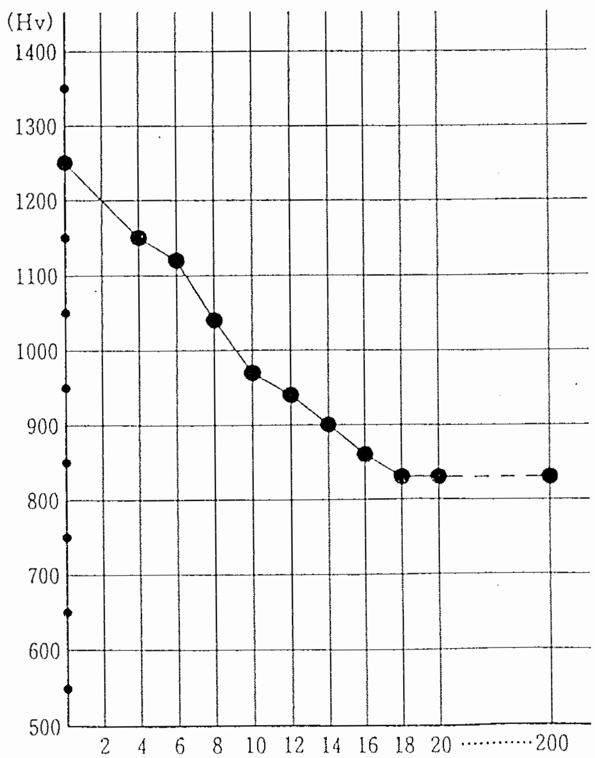
T/P Hardness (HRC)=60.4



Thickness of hardened structure (μ m)

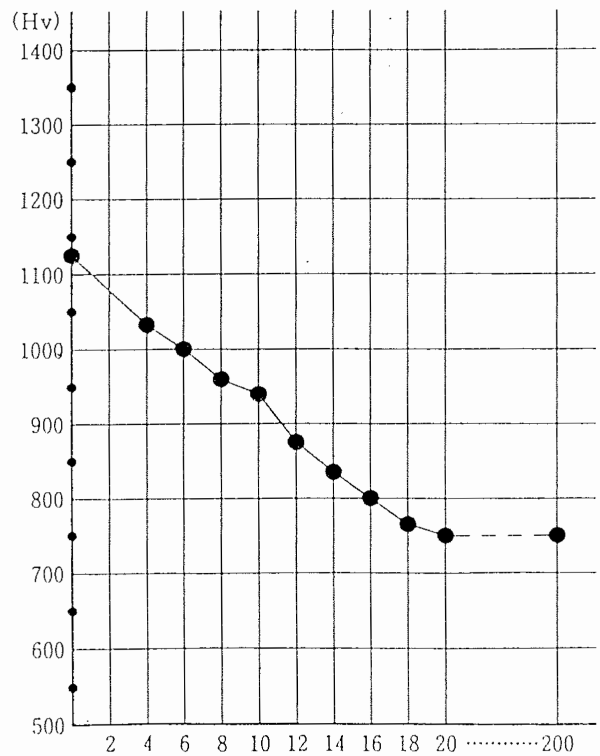
T/P Material SKH51(equivalent)

T/P Hardness (HRC)=62.3

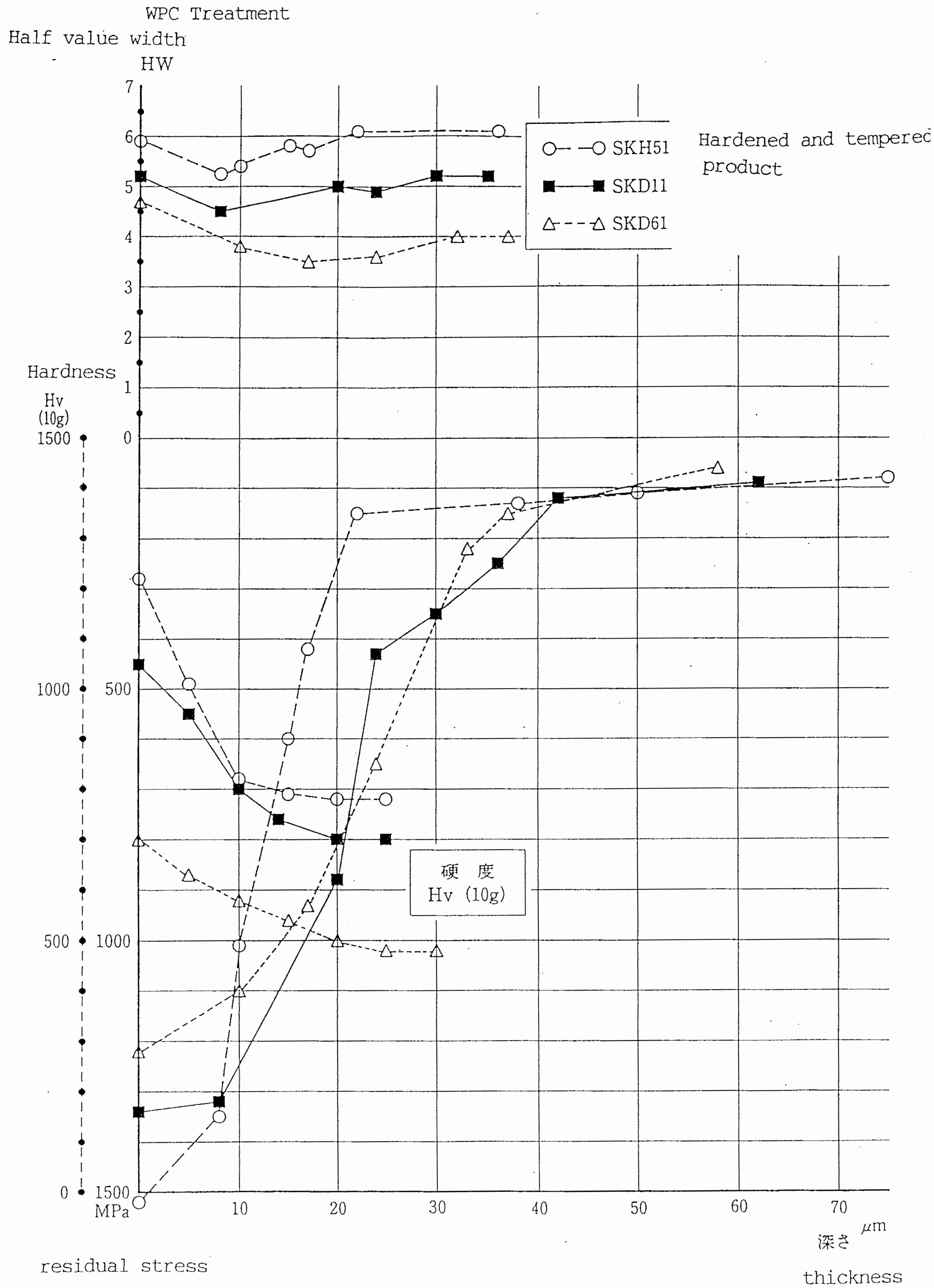


T/P Material SKH59(equivalent)

T/P Hardness (HRC)=64.9

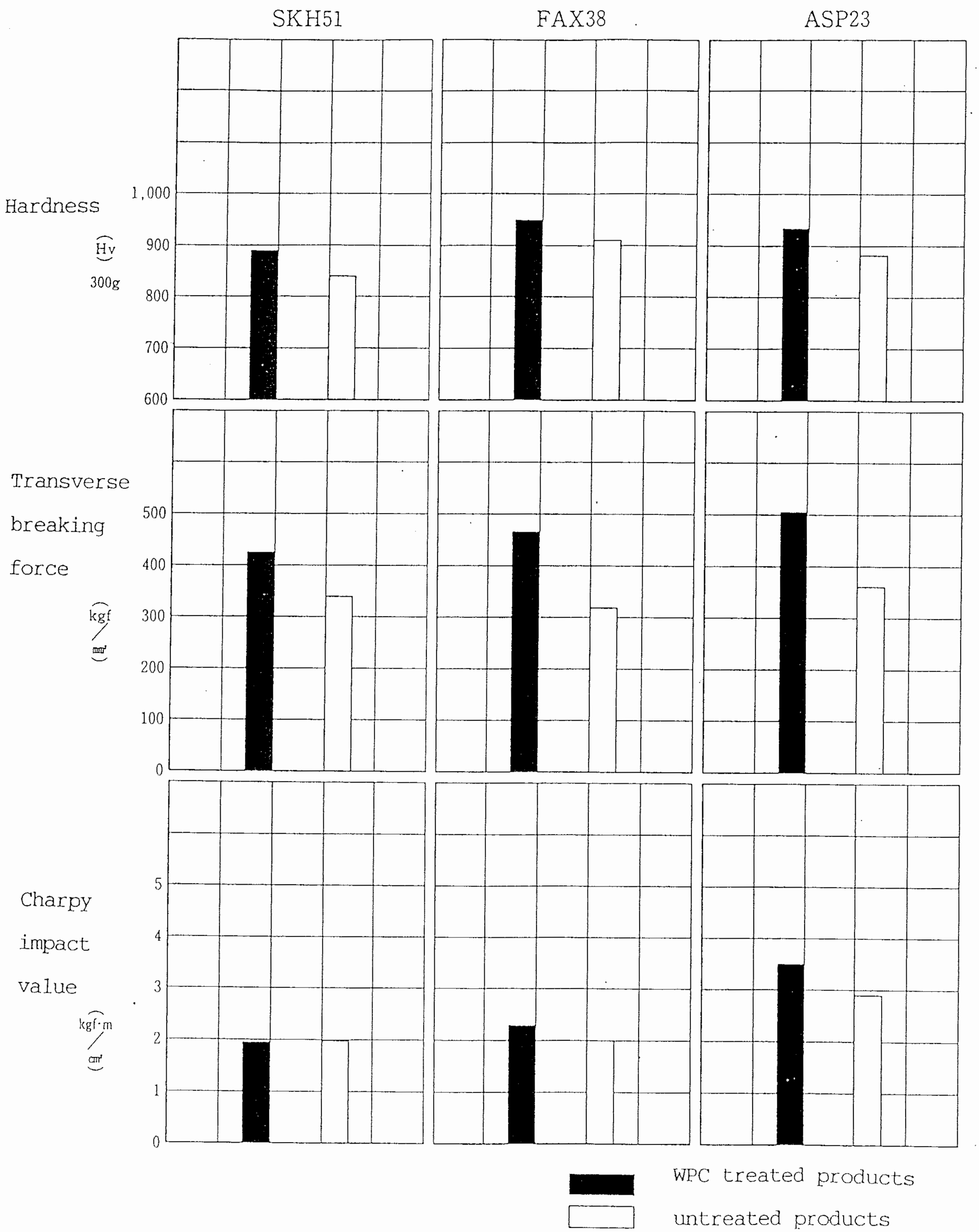


Thickness of hardened structure (μ m)



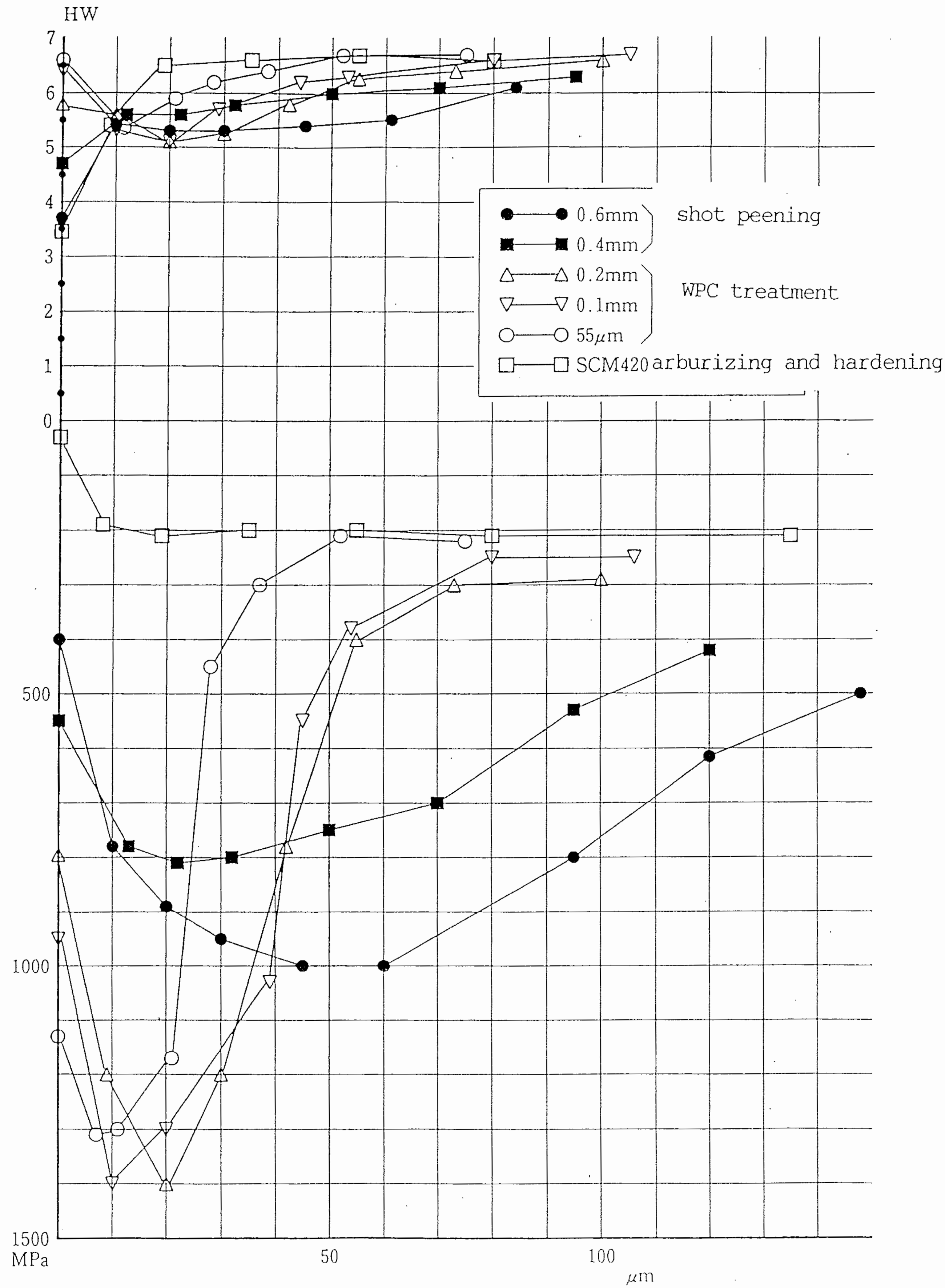
WPC Treatment
Half value width
HW
7
6
5
4
3
2
1
0
Hardness
Hv
(10g)
1500
1000
500
0
500
1000
1500
MPa
SKH51
SKD11
SKD61
Hardened and tempered
product
硬　度
Hv (10g)
10
20
30
40
50
60
70
μm
深さ
residual stress
thickness

3-16 Mechanical Properties of High Speed Tool Steel in WPC Treatment



... and Residual Stress in WPC Shot Peening Treatment

Half-Value Width



Residual Stress

4. Extending Life of Metallic Product by WPC Treatment

4-1 Examples of WPC Treatment for Cutter

1) HSSCO Drill F Company 10 times

2) HSSE Homo Treatment Tap K Company 4 times

3) Burnising Reamer with Cemented Carbide Step

- K Company 3 times

4) HSSCO End Mill Pretreated TiCN Coating

   T Company 10 times

5) Cemented Carbide End Mill Pretreated TiCN Coating

   M Company 10 times

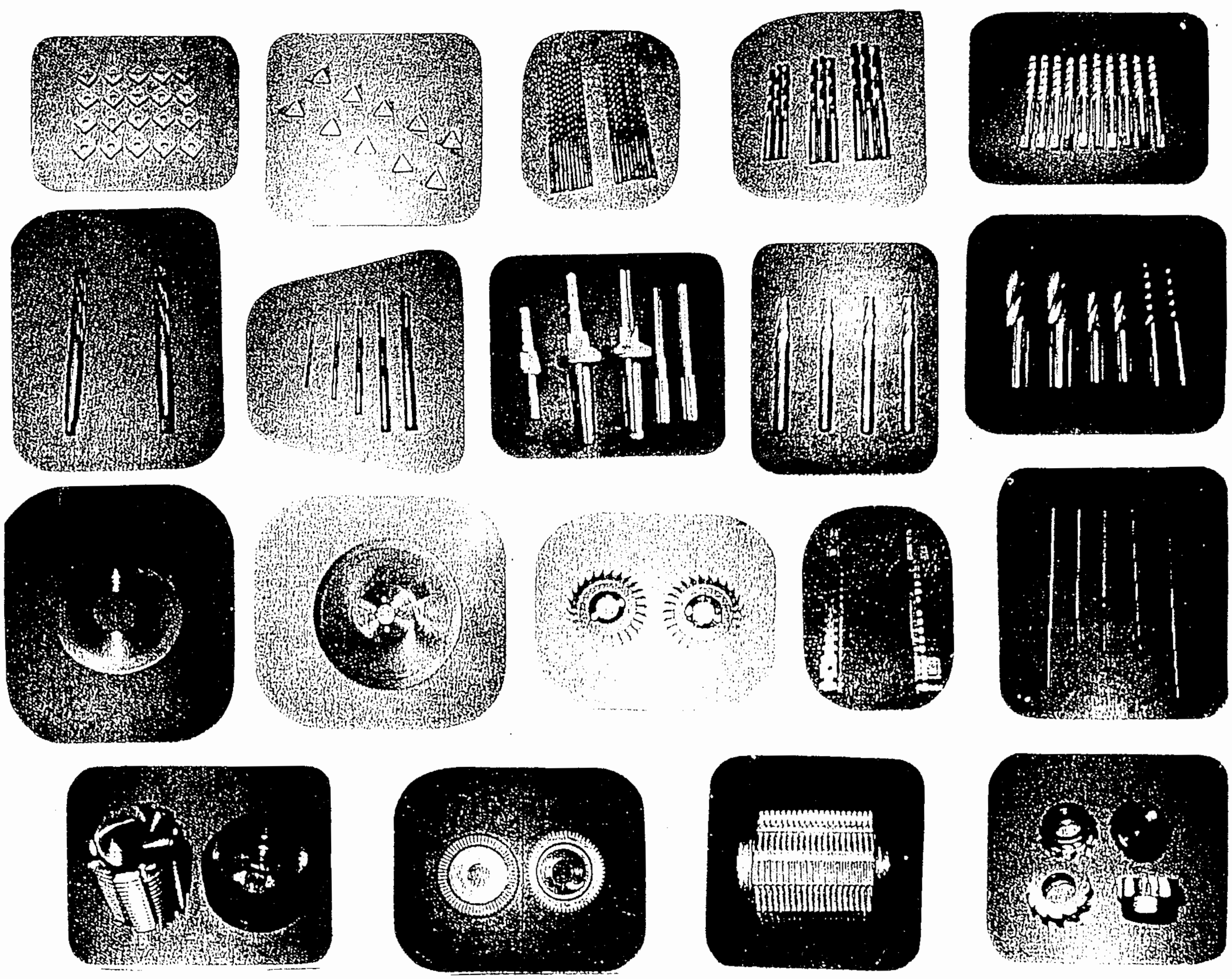
6) SKH 51 Broach A Company 4 times

7) Cemented Carbide Tip CVD Coating A Company 2 times or more

8) Cermet Tip K Company 2 times or more

9) SKH Builtup Gear Hob TiN Coating T Company 2 times or more

10) HSSE Rolled Tap G Company 8 times or more



4-2 Examples of WPC Treatment for Die

1) SKD 11 Press Punch   S Company   3 times

2) SKH 51 Press Punch   A Company   5 times

3) SKH 51 CVD Coating Punch   S Company   10 times

4) Cemented Carbide Press Die   M Company   5 times

5) Cemented Carbide Torque Punch   N Company   5 times

6) SKH 51 Cold Forging Die   O Company   5 times

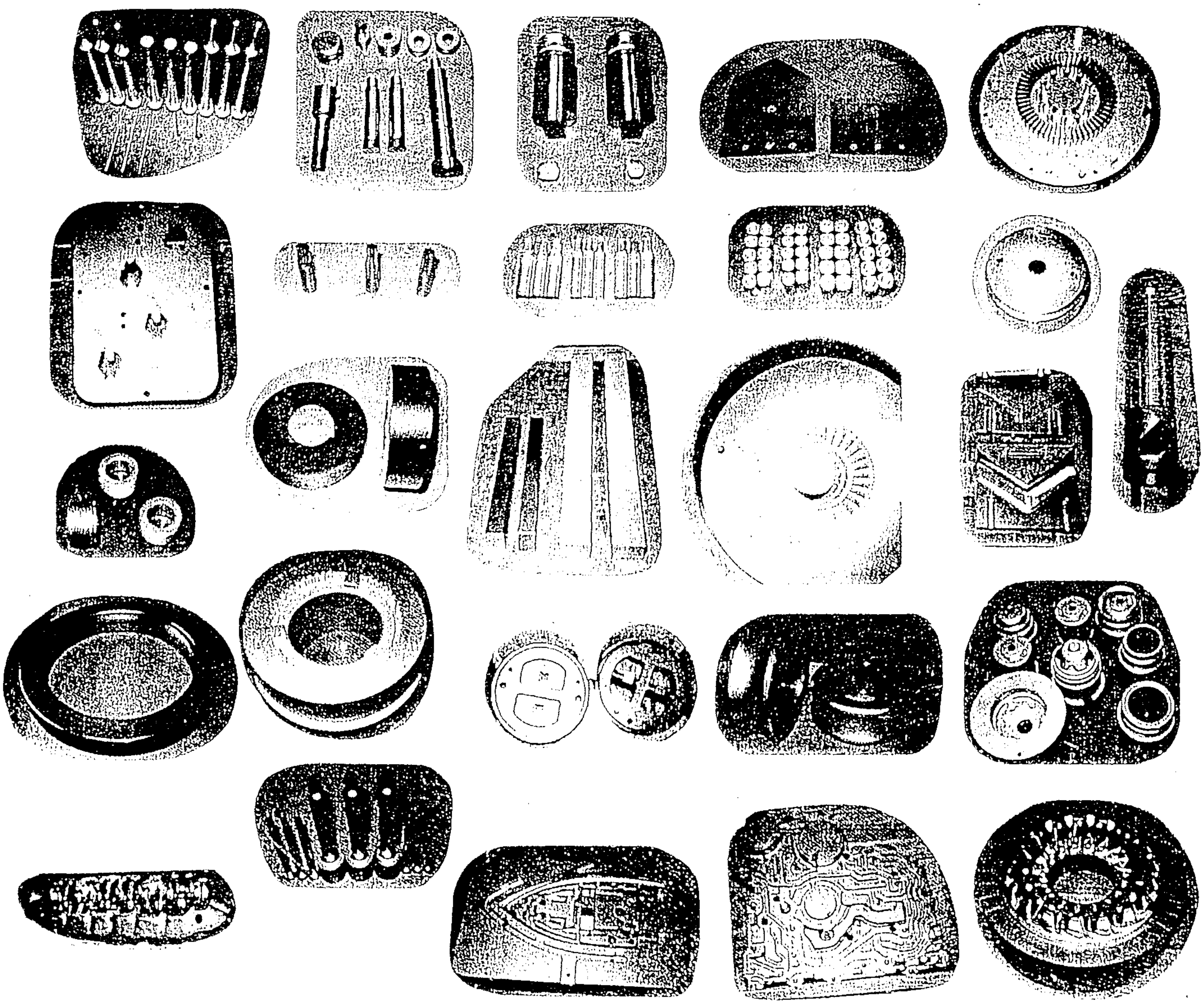
7) SKD 61 Heat Forging Die   A Company   2 times or more

8) SKD 61 Heat Forging Die   M Company   4 times

9) SKD 61 Die Casting Die   H Company   3 times or more

10) SKD 61 Die Casting Pin Pretreated TiCN Coating

S Company   5 times or more



4-3 Examples of WPC Treatment for Part

1) SCM Shaft   Y Company   5 times

2) SCM Gear   D Company   14 times

3) SCM Torsion Bar   T Company   10 times or more

4) SUJ Needle Roller   S Company   10 times or more

5) SK Pump Part N Company   10 times

6) Inconel (against stress corrosion cracking due to heat)

N Company   Not occurred

7) SUS 304 High Pressure Container (against stress corrosion cracking)

K Company   Not occurred

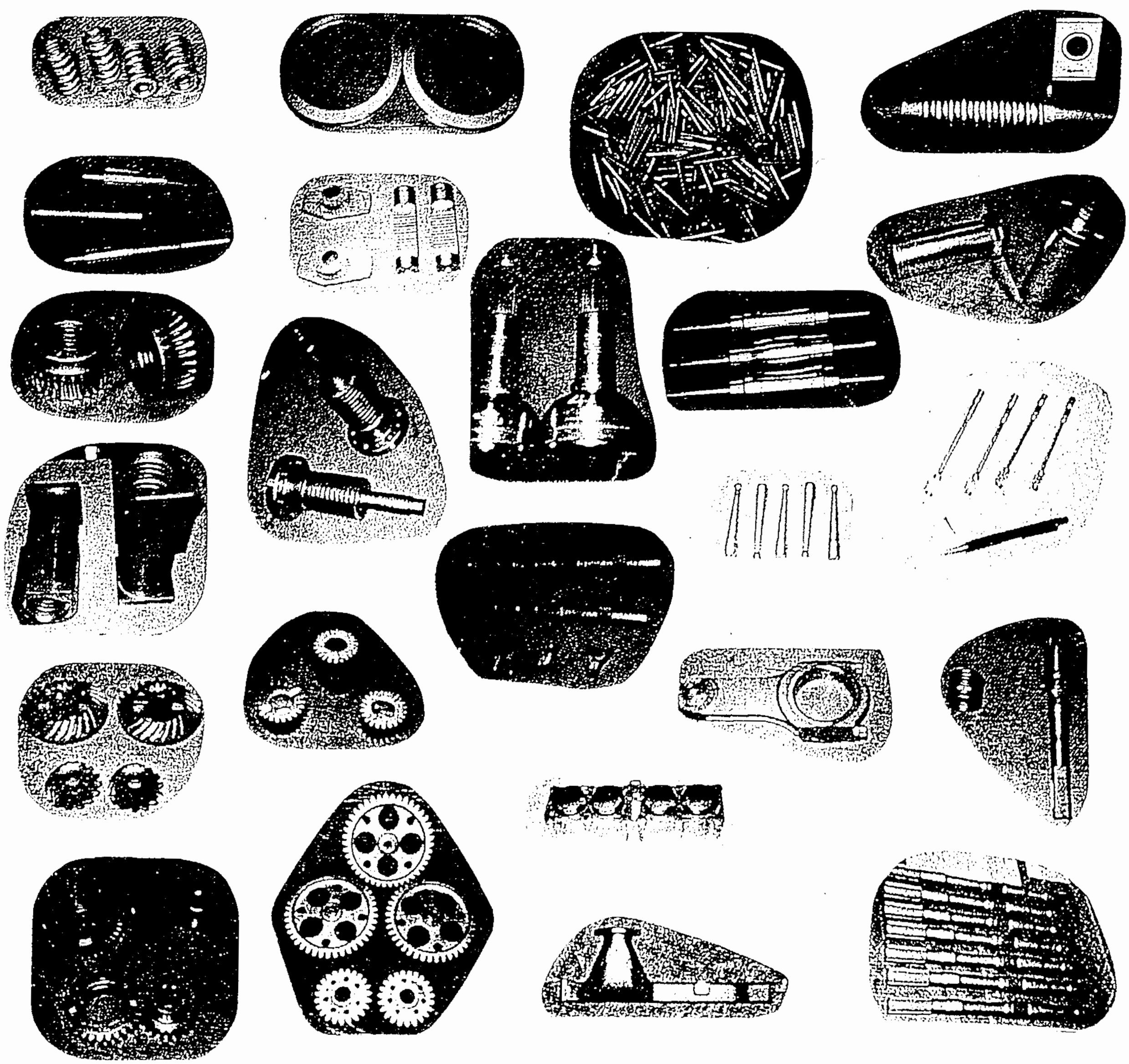
8) SCM Castellated Shaft (against abnormal abrasion electric erosion)

C Company   5 times or more

9) Aluminium Wheel   A Company   3 times or more

10) Copper Welding Electric Pole (a small number of spatter)

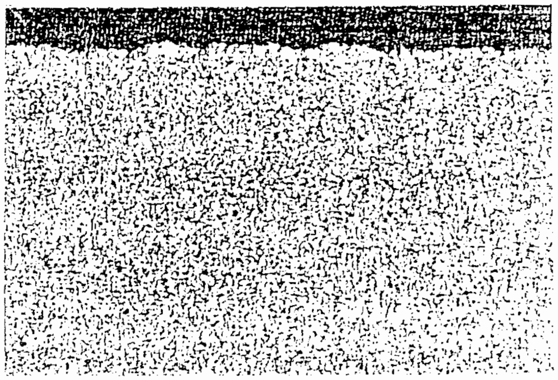
N Company   7 times or more



3-12 Deformation of Structure of Aluminum (Extruded Material)

When the WPC Treatment is carried out for an aluminum extruded material; Picture ㉗, on the structure of the treated material; Picture ㉘, solution treatment and recrystallization are performed.

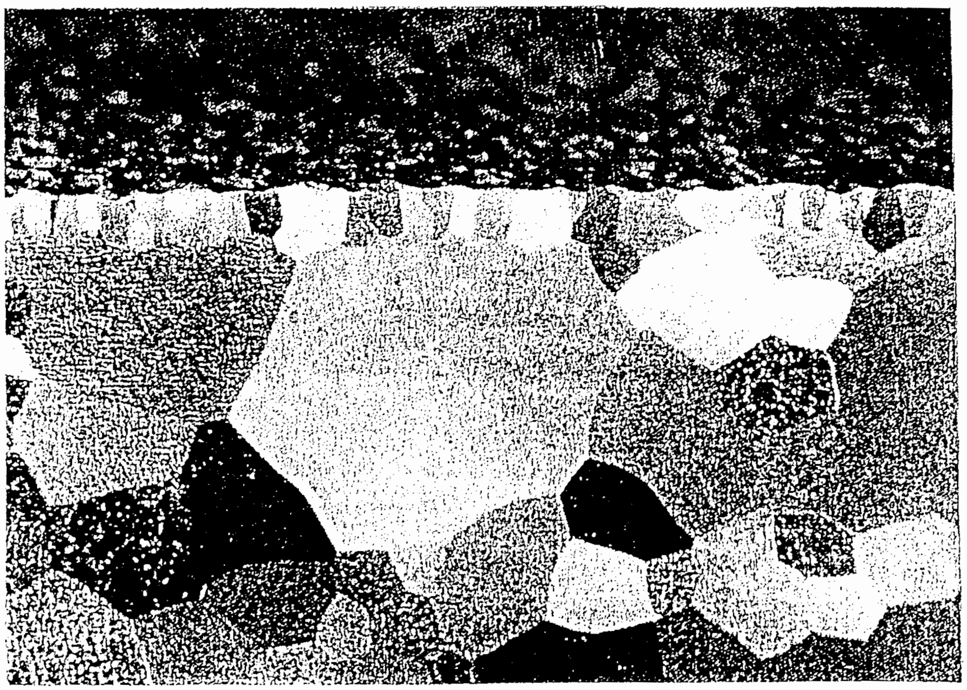
㉗ Untreated products ×100



㉘ WPC treated products × 100

3-13 Deformation of Structure of Aluminium

shot peening treated layer (recrystallized structure of aluminum)



5. Effects of Shot Peening Blast

1) Fatigue life can be extended.

2) Abrasion resistance, pitching resistance and tipping resistance can be improved.

3) Stress corrosion, intergranular corrosion, electric erosion and the like can be prevented.

4) Low temperature embrittlement can be prevented.

5) Sliding resistance and flow resistance can be decreased.

6) (Ambient) Noise can be reduced.

7) A separating layer can be diffused in a surface diffusion treatment.

8) Structural deficits and pin holes of iron casting products can be repaired.

9) Distortion can be prevented in a surface diffusion treatment.

10) Metal can be coated.

11) Adhesion in painting, plating, coating and the like can be strengthened.

12) Electric resistance can be lowered and magnetic field can be stabled.

13) Noise can be prevented.

14) Sliding resistance can be increased.

15) Armoring, trimming and descaling can be performed.

6. Conclusions

Referring to the peening effects for the cutting tools, dies, and precision instruments, have been explained, each structure's deformation, refining, recrystallization and hardness, the internal residual compressive stress of structure-surface, actual embodiments of working and the like in the WPC Treatment.

However, the above explanation does not include every application of peening treatment. The peening treatment can be applied to every kind of metal product and utilized in wide area of technical field. However, actually, the peening effect can not be sufficiently utilized in Japan. The reason of this i as follows; The optimum working conditions of peening treatment are changed so as to correspond to the metallic product's component, material, heat treatment condition, service condition and the like. Thus, the optimum working conditions can not be selected correctly for the peening treatment so that the actual peening effect can not be attained. Then, the peening treatment has bee considered not to be so useful.

Since the peening effect is limited due to service conditions and the like, it can be proposed to combine the peening treatment and other surface treatments for remarkable effects. Therefore, it is sure that the application of peening will be further developed. In the end, we would like to express our appreciation to Mr. F. Kubota Development Section Chief of Hamamatsu Netsu Syori Kougyo Co., Ltd. and Mr. T. Kouda Technical Department Manager of Tanaka Netsukou Co., Ltd. for permitting us to use their pictures.