Save Material and Improve Your Cable Quality.

Nano-Dies - Big Diamond Dies that Work Better and Cost Less - Cable Compacting

There is a new type of Compacting and Stranding Die which is saving Cable Manufacturers a huge amount of money and trouble.

It is called a Nano-Die, NCDC Die or Nanocrystalline Diamond Composite Die if you prefer the full wording. Bore Diameter Range Ø1.2mm to Ø60mm.

The cost of these dies is low, but it is not the cost of the dies that matters so much.

What matters is the greatly improved raw material utilization that Nano-Dies enable you to achieve. If you are changing from tungsten-carbide dies, fully compliant power cables may now be manufactured using up to 0.2%-3% less Copper or Aluminium. This is a huge saving. If you are currently using PCD dies, 0.2-2.5% savings may still be possible.

Nano-Dies hold a +0 tolerance for 500- 800 km of cable compacted. Due to their extremely fine grain surface, Nano-Dies also have lower friction than other dies.

Lower friction means less damage to conductors, which means better electrical conductivity. This in turn means that conductors may be slightly lightened. Hence the improved Copper or Aluminim utilization.

Nano-Dies cost 2-8 times less on average than PCD dies. They hold tolerance about the same length of time as PCD dies – longer in some cases. Hence, PCD Compacting Dies are still useful at the really small diameters, but they are no longer cost-effective above Ø3-4mm in Compacting and Stranding processes.

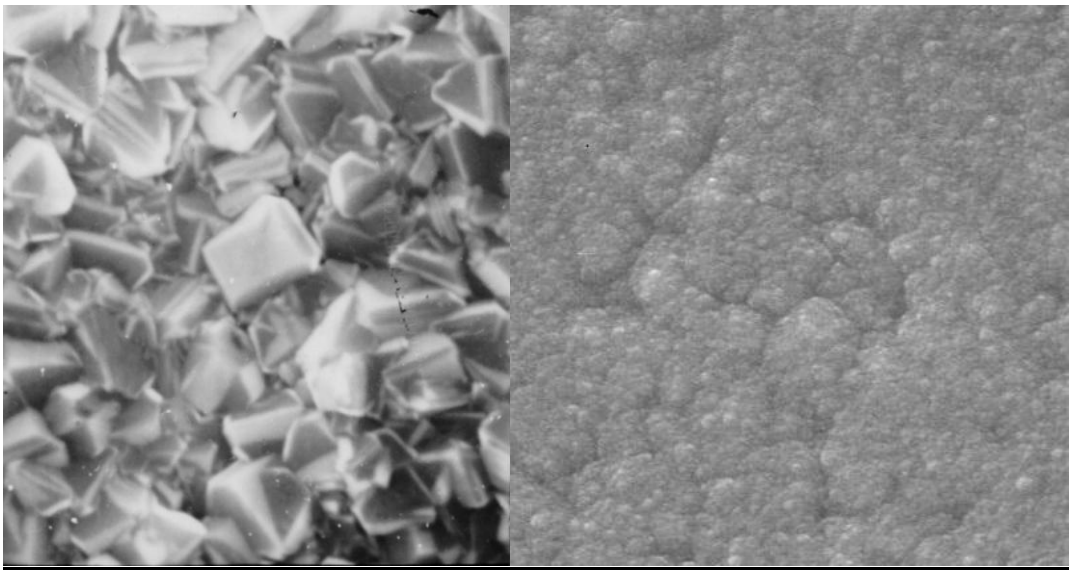
Nanocrystalline Diamond Composites are <u>all diamond</u>. The diamond particles are all oriented in the same direction, like soldiers standing in close formation. This compares with the random orientation of PCD particles, which are held together using a much softer filler material. The result in the case of a Nano-Die is an extremely smooth, low friction surface which is 3.5-4 times harder than a PCD surface.

Summary of Manufacturing Process:

2 or 3 layers of Nanocrystalline Diamond coating are grown on the surface of a completed Tungsten Carbide nib in a high vacuum, high temperature process known as CVD. The initial layer has a polycrystalline structure (like fine grain PCD material), but the top layers form a single structured diamond crystalline coating with individual crystals in the nanometre range of sizes. The uni-directional all-diamond crystal structure provides immense strength and hardness, exceeding the hardness of PCD material. The extremely fine crystalline structure also yields superb surface quality and gives rise to the popular name "Nano-Dies".

Contrasting the difference between the surface of a PCD die (left) and a Nano-Die (right)

4,000 x Magnification



Specific Trial Details:

Many trials have now been conducted on Nano-Dies, officially and unofficially, yielding results between 10 and 20 times overall die life improvement over Tungsten Carbide dies in Copper and Aluminium Stranding and Compacting operations.

A typical trial result: Tungsten Carbide dies were used to achieve 50 km of fully compacted Copper Cable before the dies went out of tolerance. Nano-Dies were then used for comparison, resulting in 800 km of fully compacted Copper Cable at +0 tolerance.

COPPER CABLE TRIAL RESULT: NANO-DIE IMPROVEMENT FACTOR = 16 (Die Life). But this was not the main benefit of using Nano-Dies. With some small but important changes to the cable design, Nano-Dies then enabled savings of 2-3% in Total Raw Material. This is the main benefit of using Nano-Dies.

Copper Cable Expectations: 0.2% to 2.2% achievable material savings.
Aluminium Cable Expectations: 1%-3% achievable material savings

Justification:

Easy Justification – Price/Performance: Nano-Dies cost 2-8 times less than PCD dies but they frequently hold tolerance almost as long as PCD dies. It is true in general that PCD dies can be recut and Nano-Dies cannot be recut, but this is not significant, especially at the larger diameters. The chance of finding a suitable recut diameter for a large PCD die is fairly low. Hence Nano-Dies are a very clear winner.

Improved Raw Material Utilization – Some Minor Adjustments to Cable Design are Required: When replacing either PCD or TC dies, the primary justification for specifying Nano-Dies for Cable Stranding and Compacting operations is extremely simple. The cost of the dies is less, sometimes very much less than the cost of the material saved. However, some minor adjustments to the design of your cables is necessary in order to enjoy the full benefit of up to 0.2%-3% Copper or Aluminium savings.
See http://www.nano-die.com/press for further information.

Power Saving: Electrical power savings have been reported by users since switching to Nano-Dies. The surface of the Nano-Dies is much smoother, generating much less friction. Hence less force is required to draw the factory's products and this translates directly into lower energy bills. This is not a huge saving overall, but it is clearly observable.

Looking at the detailed comparisons:

(a) Compared with Tungsten Carbide Dies: In round figures, Nano-Dies cost roughly 3 to 5 times more than the equivalent Tungsten Carbide dies and they hold a +0 tolerance for the entire life of the die. The Nano-Die working life is between 10 and 20 times longer than the working life of TC dies. The surface finish achievable on the cable is also noticeably superior when using Nano-Dies.

(b) Compared with PCD Dies: PCD Compacting and Stranding Dies are available up to around Ø30mm [1.2"]. Nano-Dies are available up to Ø50 mm [approx. 2"]. In round figures, Nano-Dies cost around 3 to 6 times less than the equivalent PCD Dies. Nano-Dies also hold +0 tolerance a bit longer than PCD Dies, due to the additional surface hardness provided by their single crystal structure.

(c) Compared with dies employing other Surface Coatings: The hardness of Nanocrystaline Diamond Composites is 3.5 to 4 times greater than ANY other die coating material.

Standard Casings:

Large Casings: Very large casings become too hot during the CVD manufacturing process. This requires special precautions to be taken to prevent damage to the nanocrystalline diamond coating. This slows down production of Nano-Dies. A 10% or 15% surcharge is applied when casings are specified which are larger than the limits set out below.

Small Casings: Die Cases smaller than the minimum sizes shown in the table below can be supplied if required, but they are not recommended. Nano-Dies benefit from being strongly mounted in generously sized casings, in order to provide maximum support for the nanocrystalline diamond surface structure. Sanxin cannot accept responsibility for the performance of any Nano-Dies supplied in casings smaller than those recommended in the table below:

Nano-Dies – Table of Standard Casings

Die Bore Dia. Range d (mm)	Std Casing (mm)		Min. Casing Size (mm)		Larger Casings (A) 10% Surcharge		Larger Casings (B) 15% Surcharge	
	Dia.	Height	Dia.	Height	Dia.	Height	Dia.	Height
3<d<10	40 +8/-0	25 +5/-0	40	25	48<D<60	30<H<37.5	60<D<100	37.5<H<62.5
10<d<15	50 +10/-0	30 +6/-0	50	30	60<D<75	36<H<45	75<D<125	45<H<75
15<d<25	60 +12/-0	35 +7/-0	60	35	72<D<90	42<H<52.5	90<D<150	52.5<H<87.5
25<d<30	70 +14/-0	40 +8/-0	70	40	84<D<105	48<H<60	105<D<175	60<H<100
30<d<40	75 +15/-0	40 +8/-0	75	40	90<D<112.5	48<H<60	112.5<D<187.5	60<H<100

Notes on Using Nano-Dies for Compacting and Stranding Applications:

1. Make a visual check that the Nano-Die inside coating is in good condition before use.

2. Place the die in the die holder and run guide wires into the die.

3. Special Attention :

3.1 Avoid using a hammer or other hard object to hit the die whilst loading or unloading the die from its holder. The surface of the nanocrystalline diamond layer may be damaged by sudden shocks.

3.2 To improve the die life, guide wires should be adequately annealed and all welding burs and ridges should be rounded.

4. Special notes on stranding Aluminium wire:

4.1 Use moderate Area Reductions to avoid any possibility of Aluminium from the surface of the wire becoming detached and sticking to the working surface of the die. [Galling].

4.2 If the die is intended for stranding both Copper and Aluminium wire, best results will be achieved if the die is used on Copper before it is used on Aluminium.

4.3 Aluminium sticking to the working surface of the die may be reduced or eliminated by lubricating with industrial alcohol or transformer oil. Special purpose lubricants have been developed for this process. It is essential to eliminate this problem if it occurs. If necessary, the die can be polished by placing it in a lathe, then using very fine emery paper and diamond powder to polish the surface of the die.

5. The die is worn out if the coating layer inside the die is worn through. Change to a new Nano-Die.

Specifying Nano-Dies for Compacting and Stranding:

There are four things to specify:

1. Be sure to specify the Material being Stranded or Compacted (usually Copper or Aluminium Cable). If the die will be required for use on both types of material, this too should be specified.

2. Specify the bore of the die

3. Specify the required Casing Dimensions (Diameter and Height).

4. Specify the Compacting Ratio, as defined on the following page:

Compacting Ratio: This is defined as the total cross-sectional area of all wires entering the die, divided by the cross-sectional area of the die. If desired, just specify the total number of wires entering the die and their diameters.

The ideal target values for Compacting Ratio are as follows:

Copper Cable: 0.95 to 0.97

Aluminium Cable: 0.90 to 0.92

The above figures are optimum, but some variation is acceptable. However, Compacting Aluminium Cable with a Compacting Ratio >0.92 tends to cause Galling (Aluminium sticking to the working surface of the die).

If the Compacting Ratio figure is >1.0, the nature of the process has changed. Cables lose their flexibility when Compacted too tightly. Furthermore, the material is no longer being Compacted, it is being Drawn. Dies for Drawing processes generally require different working profiles in order to operate without problems.

Calculating the Compacting Ratio – Example:

In this example, a die with a bore of Ø9.90 mm has 7 wires entering it. Each wire is Ø3.67 mm:

We use the formula for the area of a circle $A = \pi \times D^2 \times 0.25$ (where $\pi = 3.14159$)

Total number of wires entering die = 7

Diameter of wires entering die = 3.67 mm

a1 = Total cross sectional area of wires = 74.049 mm² [$7 \times 3.14159 \times 3.67^2 \times 0.25 = 74.049$]

a2 = Total cross sectional area of die bore = 76.977 mm² [$3.14159 \times 9.90^2 \times 0.25 = 76.977$]

Compacting Ratio = a1/a2 = 0.962

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