

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 \varnothing 1.2mm to \varnothing 50mm.

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. Fully Compliant Energy Cables may now be manufactured using up to 2-3% less Copper or Aluminium. This is a huge saving.

Nano-Dies hold tolerance to +0 for 500- 800 km of cable compacted. Due to their extremely fine grain surface, Nano-Dies also have lower friction than other dies. Hence they do less damage to the micro-structure of an energy cable's conductors and this leads to lower electrical resistance, if the same amount of raw material is used.

Manufacturers are driven by the need to use enough raw material to be certain of manufacturing a fully compliant energy cable. This means (among other things) using enough raw material to ensure that an Electrical Resistance Test is passed for any cable manufactured. But Copper and Aluminium are very expensive commodities. So, if the raw material can be used more consistently and economically and if the individual conductors are less damaged by the manufacturing process, now it is possible to make small adjustments to the cable design to ensure that the Electrical Resistance Test is passed, but using less raw material than before. In this way, an absolutely excellent result is obtained. Your company will ship fully compliant energy cables manufactured to tighter tolerances, exhibiting a better

surface finish and you will enjoy huge raw material savings at the same time.

[See <http://www.sanxinamerica.com/nanodiesavings.pdf>].

Nano-Dies cost 3-6 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 \varnothing 4-5mm in Compacting and Stranding processes.

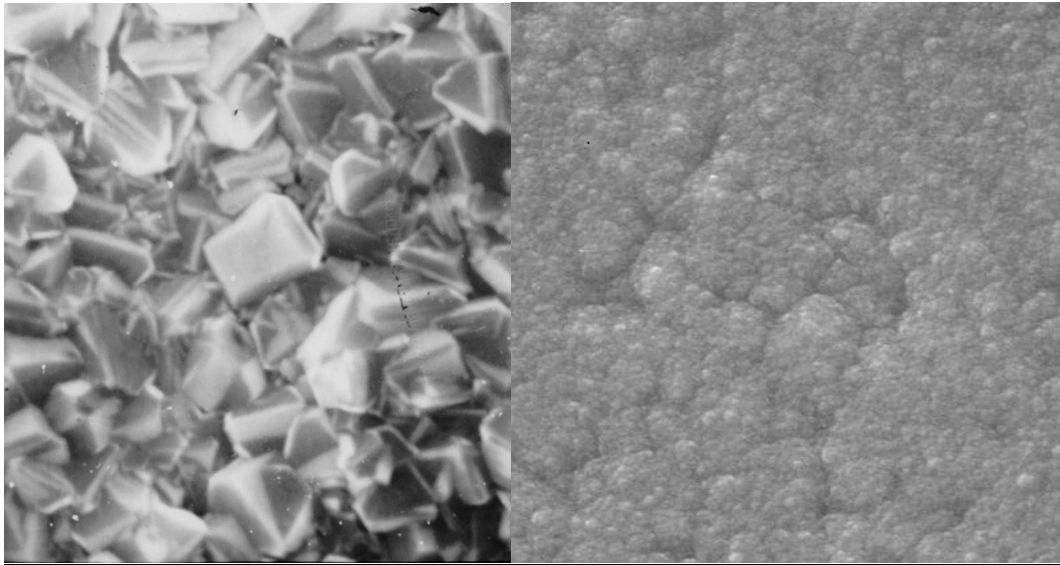
The Single Crystal Structure of Nanocrystalline Diamond Composites is the reason why they outlast PCD dies. The NCDC manufacturing process results in a die which is harder than ANY other commercially viable surface process can achieve. Surface friction is much lower than PCD dies.

Summary of Manufacturing Process:

2 or 3 layers of Nanocrystalline Diamond coating are applied to the surface of a completed Tungsten Carbide die 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 single 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). That was nice. But it was not the main benefit of using Nano-Dies. With some small but important changes to the cable design, Nano-Dies then enabled improvements of 2-3% in Raw Material Utilization. This is the main benefit of using Nano-Dies.

Justification:

Easy Justification – Price/Performance: Nano-Dies cost 3-6 times less than PCD dies but they hold tolerance slightly longer than 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 practically zero. 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 insignificant compared with 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 2-3% Copper or Aluminium savings.
[See <http://www.sanxinamerica.com/nanodiesavings.pdf>].

Power Saving: A plant manager has reported significant power savings 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.

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 Nanocrystalline Diamond Composites is 3.5 to 4 times greater than ANY other die coating material.

Standard Casings:

This subject is important due to the Nano-Die manufacturing process.

Large Casings: Very large casings become very hot during the CVD deposition process. This requires the process to be stopped a number of times while the casings cool down to safe levels, so as not to damage the nanocrystalline diamond coating. Consequently, manufacture of Nano-Dies with very large casings is less efficient than when the casings are of moderate or standard dimensions. 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 (next page):

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 NCDC 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 NCDC 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 NCDC Composite die (but the worn die may still be used as a normal TC 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 here:

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

$a1 = \text{Total cross sectional area of wires} = 74.049 \text{ mm}^2$ [7 x 3.14159 x 3.67² x 0.25 = 74.049]

$a2 = \text{Total cross sectional area of die bore} = 76.977 \text{ mm}^2$ [3.14159 x 9.90² x 0.25 = 76.977]

Compacting Ratio = $a1/a2 = 0.962$

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