



CONDUCTOR COMPACTION PROCESS

I. Compaction Process for Circular Conductors

Compaction process for copper and aluminum stranded conductors is a relatively easy job in the manufacturing process, but is very important for the high quality of obtained compacted conductors and quality of power cables.

Conductor stranding is generally performed on a machine with planetary motion and without planetary motion machines so-called “Rigid Stranding machine.” There are also stranding machines with high speed line with the central stranding system called as “Central Stranding machine.”

All of these types of machines have special devices on which are placed main stranding blocks with compaction heads for the dies and rollers for complete compacting process.

With the new generation of machines, Stranding block has the ability to carry the main stranding die and more cassettes for pairs of rollers with the possibility of rotating rollers which may achieve “prespiraled conductor”. The number of cassettes for support pairs of rollers can to be two, three or four in one stranding block after each Carriage.



Photo 1.

The main die is usually round shape, and it only serves to guide of stranded wires in the proper layer. This die can be fixed, as is usually the case, but it may be a free or driven by rotating. Beyond the point of stranding, or directly at the projected distance, there is set of the tools for compaction process that is done in two ways:

- *Hard (Compaq) dies or*
- **Profiled roller pairs.**



**Is there exist dilemma how to use compaction process of copper and aluminum conductors:
with diamond Compaq dies, or
specially profiled rollers?**

The both systems are in use many times and, for many process engineers, there is a dilemma which compaction process is a better system that is simpler, more efficient and more productive....

In this presentation we like to make a comparison between the two systems for compaction and explain the practical effects in production on the basis of experience in working with both compaction systems:

A. Compaction process with using of hard Compaq dies.

a). Advantages:

1. Calculation of the working diameter and profile die design is very simple.
2. Using in production is also simple.
3. The roundness of compressed conductor is almost always ideal.

b). Weaknesses:

1. Manufacturing of Compaq dies is very complex and expensive.
2. Price of Compaq dies is high. For all cross-sections over 185 mm² the price of set Compaq PCD dies is noticeably the higher level, than set of rollers for the same conductor.
3. The working life of the Compaq dies is limited due to the high stress of working surfaces, heat and abrasion during manufacturing and normal working time. The working life is relatively short, no more than 800 km compacted conductor.
4. The heating of conductor during manufacture is very high, after passing through the dies and cooling is necessary. As usually there are many cooling methods, with: cold air, alcohol, organic volatile solvents, etc...
5. Compacting process requires much greater pulling power, when uses Compaq dies, which leads to additional load of the engine and its overheating so they often it must to provides additional cooling.
6. The increasing of pulling power causes difficult stress ratio of driving engine and increases the consumption of electricity and thus increases the costs of production.
7. In many cases it is necessary to make the line speed reduction of over 30% and thus reduces the productivity of the stranding line.
8. The total filling factor is difficult to reaches 90% in compacting process with hard diamond dies.



9. The reduction ratio of diameter cannot be higher than 5% and a decreasing is lower in each successive layer, and the lowest is in the last layer.
10. Small reduction ratio in the last layer requires increasing of thickness of the semi conductive layer in production of power cables above 20 kV. The thickness increasing of semi conductive layer caused the increasing in the consumption of insulating materials and all other materials up to the final production of the cable.

B. Compaction process with using of profiled rollers.

a). Advantages:

1. The use of rollers in manufacturing is not complicated.
2. Reduction of line speed does not exist. The stranding machine can works with a maximum designed speed, because it does not impose to reduce of the manufacturing speed during compaction process with rollers.
3. The heating of conductor during compaction process is smaller and does not requires the cooling.
4. The Rollers wearing out is minimal and the working life of the rollers is much longer than the working life of the Compaq dies up to one million kilometers without repairing of rollers.
5. The Diameter reduction rate can be above 10% for each stranded layer and filling factor can achieve up to 94%.
6. The degree of reduction of the last layer is also achieved about 10% and it can get the correct round form and well surface smoothness what make possible decreasing of thickness of semi conductive layer and increasing the quality of cable.
7. Reduction of diameter and thickness of semi conductive layer provides significant savings in insulation materials and all other materials up to the manufacturing of the last layer of the outer sheath up to 7% in accordance with design of power cables..

b). Weaknesses:

1. Design of working profile of rollers is very complicated and requires a lot of experimentation and research. This is the main reason why low numbers of manufacturers of cables use the compaction process with specially profiled rollers.
2. Stranding block and rollers supports must be of good quality and on the many old stranding machines it must be replaced with new, before start up compaction process with rollers.



3. Number and arrangement of wires in the stranded conductor is different from the arrangement in stranded conductor without compaction. The calculation of the wire diameter is not simple.
4. The less number of bobbins with wires causes rotation of Carriages with an imbalance which causes additional burden of rotating elements and additional bearings load in particular on the machine.
5. The roundness depends on the extra high quality of the tools. The high quality of tools require trained operators and high precision setting for all pairs of rollers especially the last two pairs of rollers.
6. The production of high quality circular compacted conductors with specially designed open type or penetrated type of rollers is very important for good quality of compacted conductors. Open rollers can be used in the event that the cassettes are in high quality and where possible fine adjustment centricity of rollers.
7. If it is not possible to fine adjust centricity of rollers to each other must be used penetrated type rollers where the centricity achieves during the development and manufacturing of each pair of rollers.

The raw-material for manufacturing of rollers is high quality tool steel with 60 HRC of hardness after hardening. The working place of rollers must be grinded and high polished after hardening.

The tolerance of working place of rollers must be less than 0,02 mm.

The roundness of compacted conductor is in accordance with IEC and VDE standards.

The design of rollers for compaction of round form of stranded conductors is protected with patent No: 9413/84 – P - 676/84. Belgrade, Serbia.

The main requirements for the production of compacted conductors are well designing and high quality manufacturing of rollers for compaction process.

ARRANGEMENT OF ROLLERS				
For round compacted conductors per Carriages				
+6	+12	+18	+24	+30
Two pairs	Two pairs	Three pairs or four 1)*	Four pairs	Four pairs
EL	EL	EL	EL	EL
RO 1	RO 1	RO 1	RO 1	RO 1
		RO 2	RO 2	RO 2
		(RO3)	RO 3	RO 3

Notice: 1)* - If it is the last layer; EL – elliptic form; RO – round form



MIROSCABLE
ENGINEERING

MIROSCABLE ENGINEERING d.o.o.
11010 Belgrade, Braće Jerković 72
tel/fax 00 381 11 2493 905



Photo 2. This conductor is compacted with rollers.



Photo 3. This conductor is compacted with hard dies



Photo 4. The same cross section, but are with different arrangement and diameter of wires.



Photo 5. Compacted conductor is also with rollers.



Photo 6. One of the most used rollers



II. Sector Shaped Conductors

The sector shaped conductors usually apply by low voltage multi-core power cables and HV & EHV power cables so called Milliken cables.

In these cases conductor compacting process uses only profiled rollers. The high number of cable factories use only one pair of rollers after each Carriage. The filling factor in this process is smaller and compactness and roundness of the complete cable is not good.

In recent years, more often it used by at least two pairs of rollers in compacting process and each stranded layer after the first, or second is compacted with two pair of rollers and even last layer with three pairs of rollers for good quality of finish product. With this way can to get finally compacted conductor of the highest quality.

The manufacturing of the sector shaped conductors with two and three pairs of rollers is developed before many years and tested in production of sector shaped conductors of the high quality.

The filling factor of these conductors achieves 92 – 94 %. Conductor is uniform & glib and there are no lateral bulges.

It is very clear looks on the Photo 7 and the place of the start of compaction process with horizontal pairs of rollers.

The first pair of rollers so called as the “vertical” rollers and the second pair of rollers so called as the “horizontal” rollers.

SCHEDULE OF ROLLERS For sector shaped conductors per Carriages.									
1+6	+12	+18		+24			+ 30		
Vertical	Vertical	Vertical	Horizontal	Vertical	Horizontal	Vertical	Vertical	Horizontal	Vertical
▼	▼	▼	▶▶	▼	▶▶	▼	▼	▶▶	▼
▲	▲	▲		▲		▲	▲		▲



MIROSCABLE
ENGINEERING

MIROSCABLE ENGINEERING d.o.o.
11010 Belgrade, Braće Jerković 72
tel/fax 00 381 11 2493 905

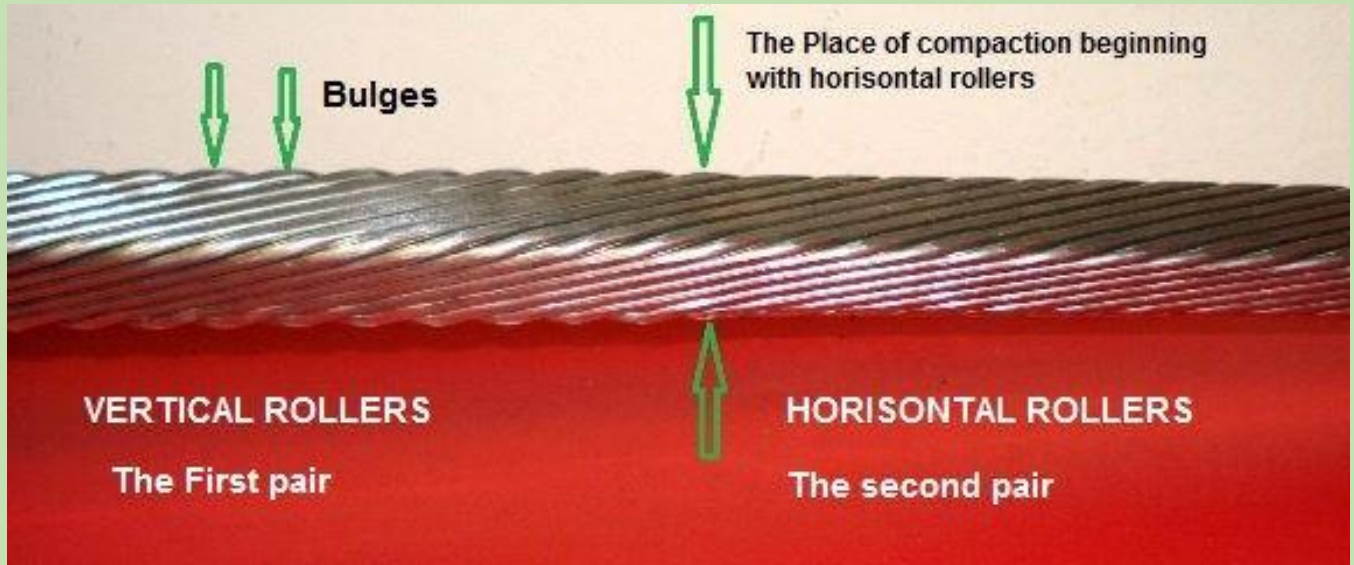


Photo 7. This photo shows the position where start to compact of horizontal rollers.



Photo 8. Compaction & roundness are very well.

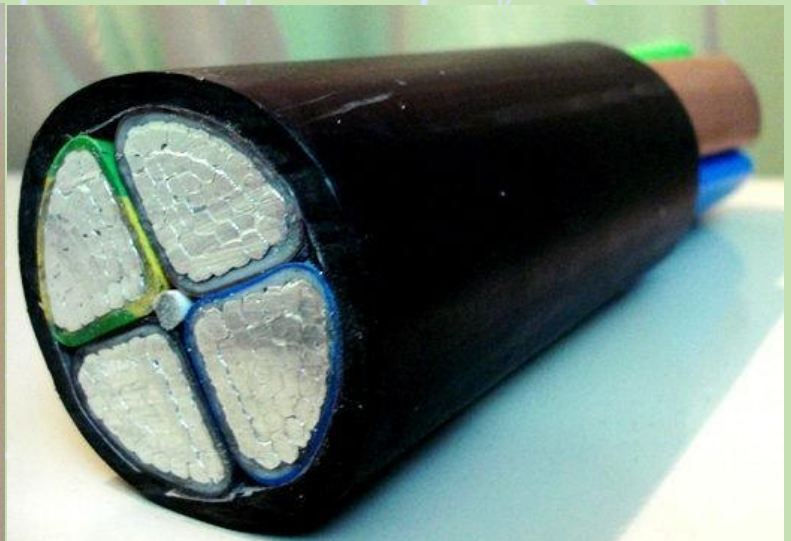


Photo 9. Low voltage cable



Photo 10. Milliken conductor with segments manufactured **with** using horizontal rollers.

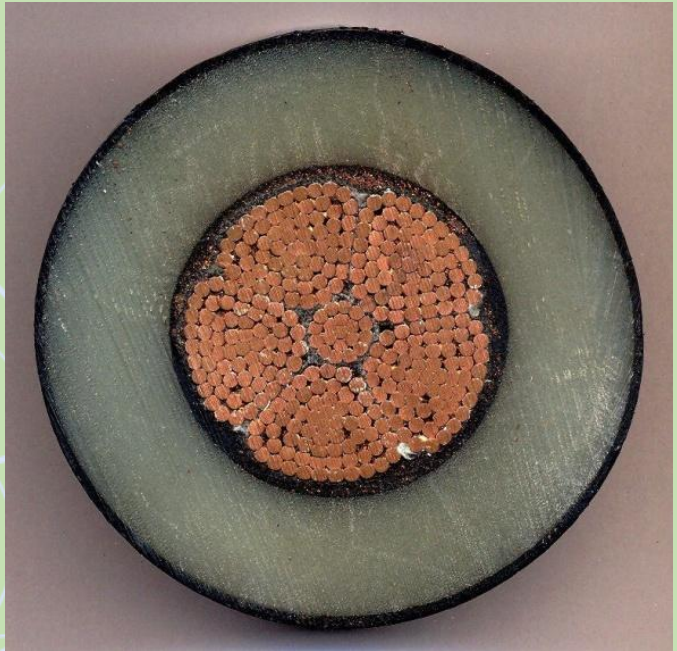


Photo 11. Milliken conductor with segments manufactured **without** applying of horizontal rollers.

The long term of experience shows that all of stranding machines can to produce good quality compacted conductor with rollers for compaction, if it is well designed and well profiled rollers for compacting and robust the support for the rollers or compaction head.

The advantage of these models is that are very well designed. It is important for the production process that couples of the rollers are at the minimum possible distance from each other. It is also important to adjust the centering rollers done accurately and easily.

Conclusion of business

If it is carefully analyzing all the parameters, it can to conclude that practical is not exist dilemma:

- *Conductor compaction process with rollers can to get a higher quality of product. Filling factor is very high and significantly higher than filling factor achieved with Compaq dies.*
- *Compacted conductor with rollers is better prepared and is more suitable for larger electric load, after finishing of complete cable.*
- *Cable diameter is smaller and thus achieves savings in insulation and other materials up to 7% depending on the cable designs.*



- *The linear speed of machine is not decreases and can to realize the maximum possible productivity of the line.*
- *The working life of rollers is many times longer than Compaq dies.*

Only these several factors are sufficient to justify investment in the compaction process with rollers, because investment in this type of tools can to put back capital which is invested, for a very short period, if production runs at optimal capacity.

All these arguments are sufficient also for the manufacturers of stranding machinery. Selling of machines with a set of rollers for compaction process of round and sector shaped conductors is practical sale of stranding machine with compaction technology and in this case the manufacturer really has a special advantage and this certainly increases the rating of the machine manufacturer and selling price of stranding machine can be higher also.

The following images illustrate an example for reconstruction of a very old machine for stranding which now produces the highest quality of round and sector shaped compacted conductors.



Photo 12. This is very old rigid stranding machine.



Photo 13. Only rollers & cassettes are new.

Theoretical and practical conclusion

1. For the production of larger diameter of wire needs fewer number of dies in rod break down machine can have a greater production capacity.
2. Machines for stranding can also work with a larger capacity. Speed to loading and unloading is higher, because the 30 bobbins less for loading and unloading (for example) if it is design stranding and arrangement achieved with 61 wires than 91 wires in rigid stranding machines.



3. Savings in electricity consumption during the manufacture of wire and then during the stranding process is not low.
4. The smaller number of wires reduces the amount of empty spaces between them compacted wire and enables higher current loads.
5. A higher number of wires allows greater amount of empty spaces and thus creates resistance for cooling of conductor and prevents higher current loads.
6. The high degree of compaction of large diameter wire obtained higher homogeneity of conductor and thus better conductivity and lower electrical resistance. This can be seen on the photos: 2; 8; 10.
7. Stranded and well Compacted of homogeneous segments obtained stranded wire better roundness which also influences the increase in current load cable.
8. The high degree of compaction of stranded conductor reduces the size of the central conductor and thus increases the homogeneity of complete stranded conductor, photo 10.
9. For a good quality of compaction the design with 91 wires required a larger number of pairs of rollers for compaction.
10. We can manufacture of the rollers of excellent quality for every design, size and number and arrangement of wires that the customer requires, but always we suggest design with smaller number of wires if it is possible.
11. The all of these suggestions are made on the basis of our long term and extensive experience with the tools for production of high quality compacted conductor.
12. It is quite possible to design and produce all types of rollers for low voltage cables in the construction of 3 + 1/2 ropes, so that the sectors of the phase conductors have the angle of 101° , and with the neutral conductor with angle of 57° , this way it is possible to create the smallest diameter of the cable with excellent quality and savings of raw materials

MSc Miroslav Pavlovic, dipl.eng.

General Manager