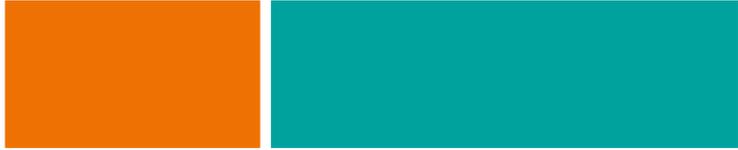


Belt Tracking In Tunnel Ovens



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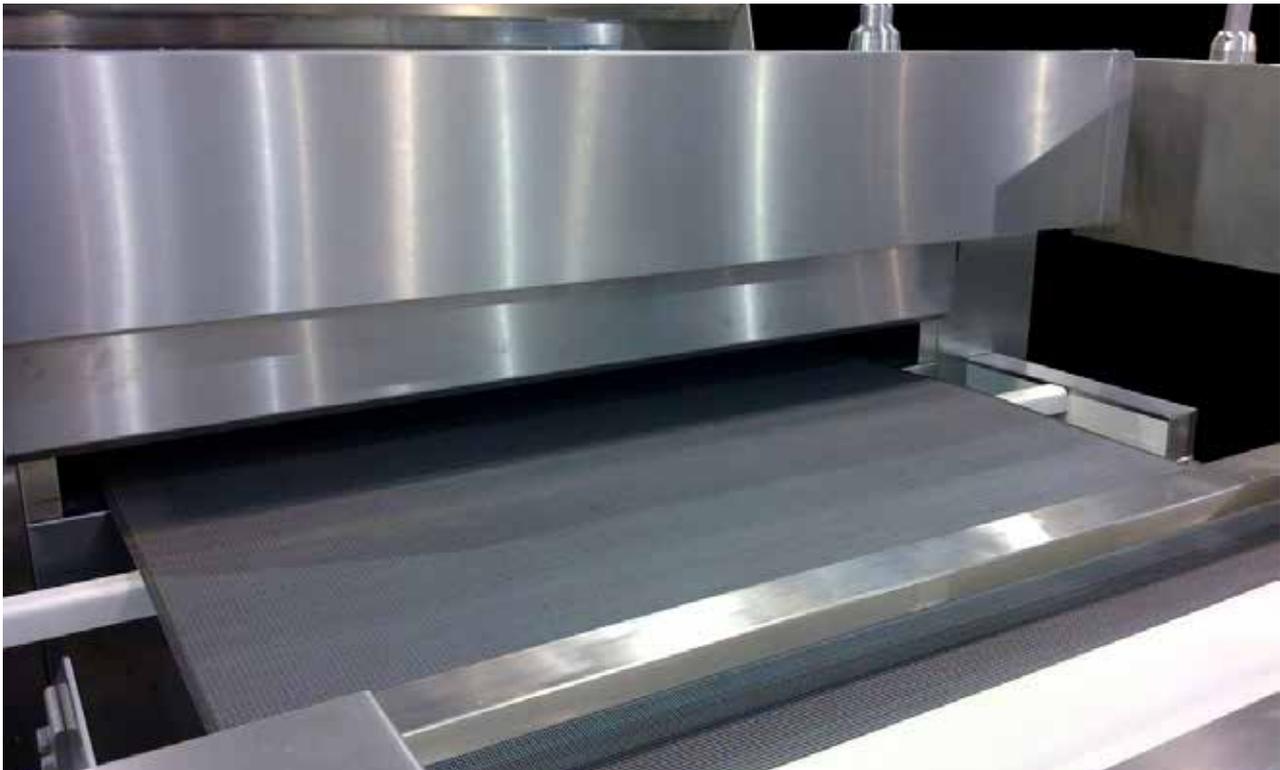
Reasons for Tracking

When operating a tunnel oven the issue of proper belt tracking will always be on the agenda and of greatest importance for a good, smooth and trouble free oven operation.

In this respect the bigger the oven gets, both in length and width, the more ambitious belt tracking becomes.

In addition, today's tendency to increase the baking speed to values of >35 metre/min. adds another challenge to the belt tracking issue.

So, to spend some careful thoughts on how the belt tracking can be done to satisfaction, is of real priority for the oven manufacturer and operator.



Feeding / entry zone of a tunnel oven

Belt Tracking Influences

I. Oven Layout & Temperature:

- the 3 principle oven parts of entrance / oven chambers / exit and their design
- operating temperatures

II. Oven Drive & Tensioning Equipment

- drive of the oven with its system of driving drum(s), turning drum and support rollers
- tensioning station and guiding equipment

III. Belt Design & Tolerances

A belt can be:

- solid, of open or closed mesh structure
- with or without crossbars
- heavy or light weight
- with welded or looped edges
- stainless or mild steel

All these 3 aspects have to be well thought of and thoroughly evaluated for a proper tunnel oven operation. Even minor inaccuracies can have great negative effects on tracking and cause substantial problems.

Now let's go into details...

(In doing so I mainly reflect on experience ascertained with mesh belts and here mainly Z-belts, the most frequently used belt type)

I. Oven Layout & Temperature

I.a Alignment

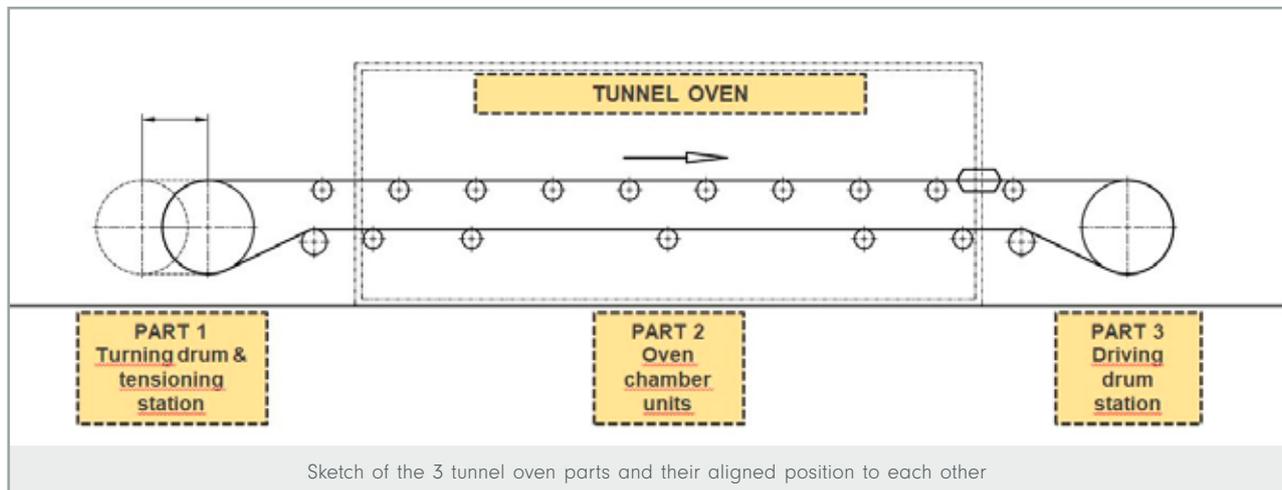
All 3 principal oven parts: entry / oven chambers / exit should be in a straight line. Greatest care has to be taken during installation of the oven line on this issue, with several and repeated size controls, that this alignment is given. Otherwise even the best belt cannot run without any tracking problems.

If under operational conditions a baking belt is permanently running and tending to one side, this is nearly always an indication that something is wrong with the oven alignment.

The best way to control and check it is with diagonal measuring either with a rope or a laser, i.e. check **the dimension from the right edge point of the entry to the left edge point of the exit** and compare it with **the dimension from the left edge point of the entry to the right edge point of the exit**

The figures ascertained should be identical. If not, the alignment needs to be adjusted.

As examples I recall cases in Egypt and Spain, where the belts were perfectly in centre of the turning drum at the entry but 30 - 50 mm out of centre on the driving drums at the exit. After aligning the position of the driving station the belts were running properly.



I.b Length of oven sectors

1. In a tunnel oven, the proportion of the belt length inside and outside the oven should be roughly the same to achieve an "average tensioning behaviour" of the belt, which has direct effects on the tracking.
2. In tunnel ovens with either very long entrance (feeding) zones or discharging zones this ratio is not given. Bigger sections of the belt length are "cold" compared to the "heated" belt parts. This makes belt tracking more challenging, since belt behaviour is different between heated and cold.

Apart from the tracking such situations increase also the risk that belt edges are slightly bending up or down. The tracking issues resulting from this "constructional disadvantage" can / could be reduced in some lines, giving the ovens either a "pre-heating roof section" at the entrance or a "heat-covering roof" at the oven exit.



Example of a heat-covering roof at the oven's exit

I. Oven Layout & Temperature

I.c Temperature

1. The higher the operation temperature in the different oven chambers the more the belt structure elongates and the more sensitive the belt gets to tracking irregularities.
2. Also make sure, that the temperature spreading in the oven is equal over the oven / belt width. Otherwise you will get a different stretching behaviour in the belt leading into tracking irregularities.
3. Be aware, that the belt is cooling down when returned below the oven chambers to the oven entry with the product feed. So here the belt mesh structure will shrink again and shows a different tracking attitude. Maybe think of protecting the belt against heat loss in that bottom area to reduce temperature differences within the total belt length.

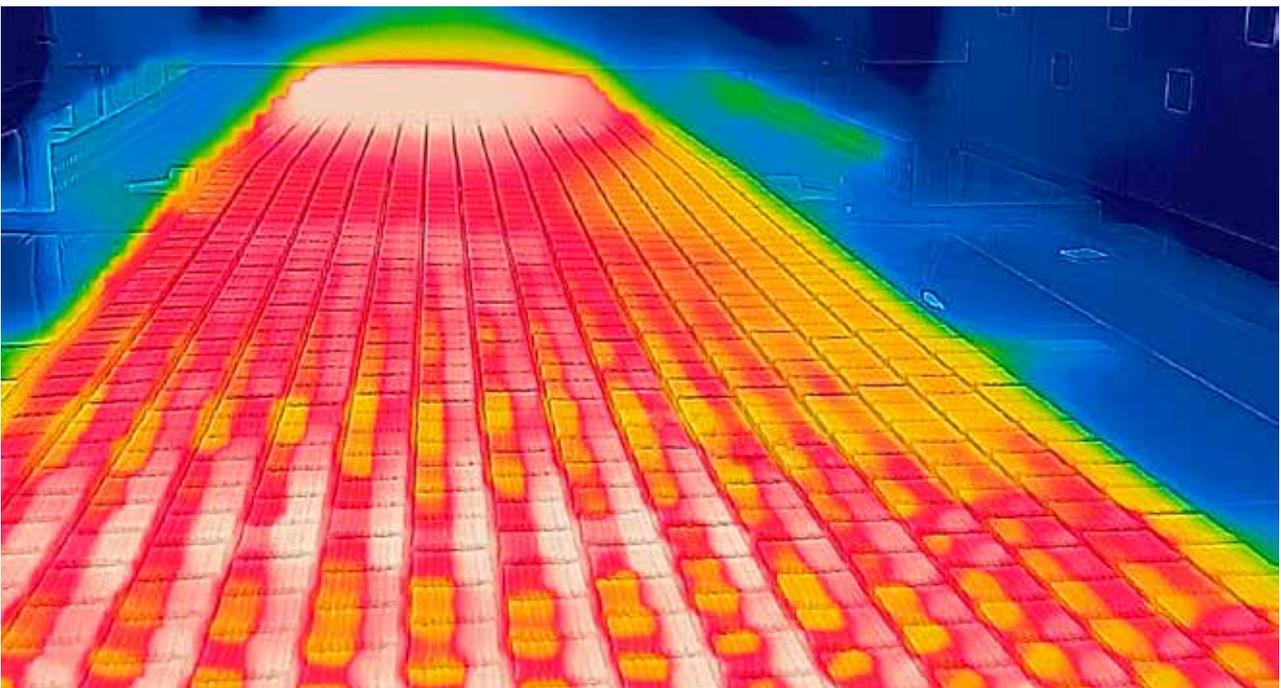
I.d Surrounding temperature

1. Cooling down of a belt always results in the shrinkage of the mesh structure. So with regard to tracking necessities, running a tunnel oven with its belts in a heated production hall is different from running it in a cold environment.
2. There are influences of the different seasons of the year as well as between the geographical climate zones, in which ovens and belts are operated.
3. If a belt is operated permanently on 24/7 basis, tracking necessities and behaviour are different from a belt in non-permanent use.
4. Be aware that an oven operating next to an outside wall of a plant in a colder climate might lead to temperature differences in the oven along the belt width and consequently in mesh stretching differences.
5. Here are some examples:

In Germany there was an oven, where belt tracking problems could be solved by closing some permanently open "ventilation" plant windows in the wall next to the oven..

We had a case in Spain, where tracking problems in the oven could be solved by giving the outside wall, next to which the oven line was erected, another layer of insulation for protection against the cold outside temperatures in autumn and winter.

In Greece tracking problems in oven lines in a plant, that was only running 5 days a week, could be substantially reduced by heating the production hall on a reduced level over weekends in winter and slowing down the heating-up of the oven lines at the beginning of the production week.



II. Oven Drive, Tensioning & Tracking Equipment

II.a Type of drive

When it comes to the oven drive there are 2 different types:

- the 1-cylinder drive
- the 3-cylinder drive

The by far bigger number of tunnel ovens have the 1-cylinder drive, i.e. at both ends of the oven there is just one cylinder drum. On the entrance side one turning drum and on the exit side one motor driven cylinder pulling the belt through the oven.

With the 3-cylinder drive there is a combination of 3 (smaller diameter) motorized rollers at the exit getting the belt running. With regard to tracking this system gives the belt a greater position stability, but the disadvantage of this drive system gets clear with the a "slightly strange" assertion:

"The good thing with a 3-roller drive is, that it keeps the belt in position...The bad thing with this type of drive is, that it keeps the belt in position"

In other words, it is a much more difficult tracking task to get a belt back from a bad out of centre position to a good centred position.

And, on a side note, the 3-cylinder drive has a much higher mechanical impact on the mesh belt structure, which reduces the operational lifetime.

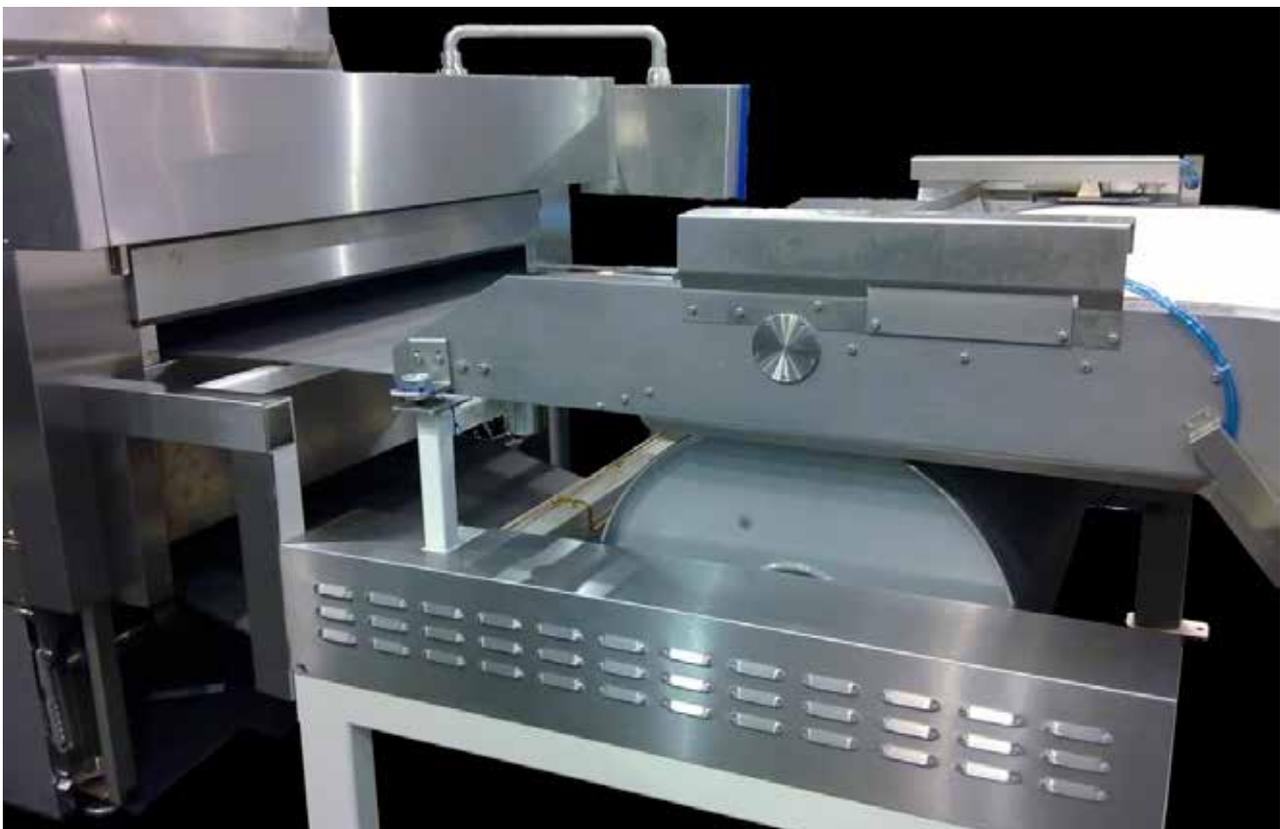
II.b Drum diameter

Here the statement is short and simple:

"The bigger the drum diameter in a tunnel oven for both the driving and the reversing drums, the better for an easier belt tracking (and the lifetime of the belt)"

That is the reason why today all new tunnel ovens have drum diameter of min. 600 mm up to 1000 mm. If a tunnel oven has big drum diameters the belt is more receptive for tracking impulses.

On another side note, I have come across several clients on this globe, who changed for these reasons the drive of their oven(s) from 3 cylinders to 1 cylinder.



Oven feeding area with big diameter turning drum

II. Oven Drive, Tensioning & Tracking Equipment

II.c Support rollers (distance and arrangement)

The system of how the belt is supported, when running through the oven, has an impact on its tracking behaviour, too.

First, the question of how is the support done:
the 3 p-by guide rails (only found in some very old and smaller ovens)

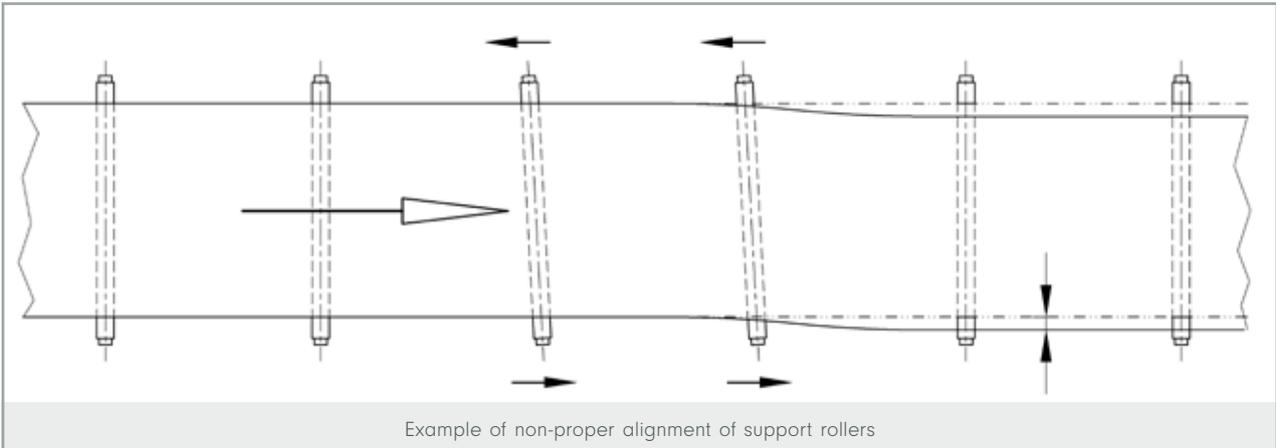
- by skid bars (still in use, but mainly in smaller ovens)
- by support rollers



Not advisable. Non-solid support rollers

Today support rollers are the most frequently used one, since there are no size limitations for the tunnel oven, both in width and length, when it is used. Indeed this is also the best support when it comes to help belt tracking. But some "little details" should be considered to avoid mistakes:

1. Some OEMs build their ovens with a support roller distance of 1.5 m, some with 1 m only.
⇒ Be aware that the smaller the distance is, the more stable the belt will run.
2. Solid support rollers should be given preference to support rollers, made of disc section placed in intervals on shaft bars along the width.
⇒ (Mesh) belts should rest entirely over their whole width on the support roller.
3. Support rollers must be aligned horizontally all on the same level to give the belt a smooth surface in the oven.
4. And they must be put by all means in a proper 90 degree angle to the belt running. If not, they will "track" the belt negatively.



Example of non-proper alignment of support rollers

Remark:

For the support rollers there are adjusting possibilities at each side of the oven. It is best not to give them a central position there, because this allows tolerances, but to give the roller the position fully to one side, since this position has no tolerances.

We once had a case with a client in Indonesia where most of his tracking problems with his (big) belt in a (long) oven could be solved by giving all the support rollers in the oven the "tolerance free" limit stop on one side.



Support roller fixing at the tolerance free limit stop

II. Oven Drive, Tensioning & Tracking Equipment

II.d Type of tensioning

Today most tunnel oven lines have hydraulic or pneumatic tensioning cylinders. In older days tensioning was very often done by weights, making it a bit more difficult to find the proper figure and having disadvantages when cooling down.

Often it is thought that with increasing tensioning the belt tracking can be improved, but this is not the case.

O.k., a certain tensioning force is needed so that the belt is not slipping on the drums during operation. But too high tensioning has negative influences on the tracking since its running is much more difficult to manipulate and the belt starts vibrating.

⇒ **So tensioning should be as low as possible!**



A too high tensioning of >4 bar



A good tensioning with an indicating label for the maximum force

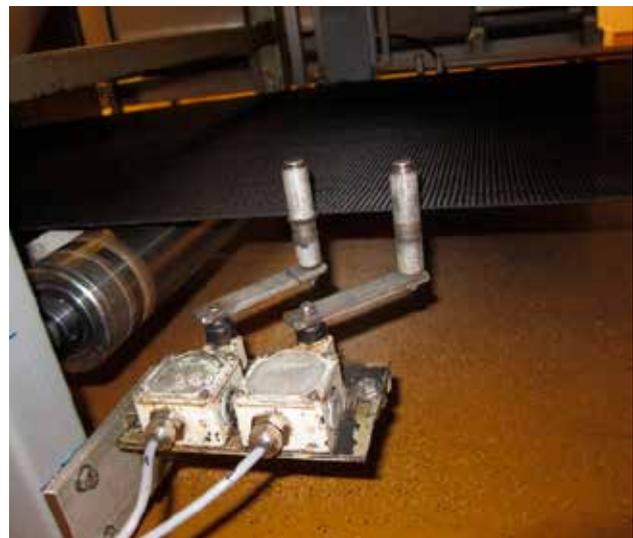
II.e Tracking equipment

For the tracking there should be a separate hydraulic or pneumatic station preferably by means of an electronic position sensor and a tracking cylinder. Bigger ovens often have 2 such tracking stations, but it is not a must. Smaller ovens are run with just one tracking device.

The belt should be in a good centred position when it gets back on the turning drum. So this one tracking device should be in the lower part of the oven return in short distance to the turning roll. It is also important, that this device is soft reacting and not pushing the belt from the "extreme" left side to the right or vice versa.

To give the tracking cylinder a better grip to the belt one might give it a heat resistant silicon coating.

Finally, no need to say, that there should be no big distance between the position sensor and the tracking cylinder, especially with no (support) rollers in between. This will "manipulate" the results of the tracking sensor.



Tracking sensor in the lower oven section

II. Oven Drive, Tensioning & Tracking Equipment

II.f The function of side rollers

One of the severest mistakes that can be done, is to use the vertical side rollers at oven entry or exit for belt tracking.

They have an emergency function only and consequently their distance to the belt edge should be not too close, based on the formula:

$$\text{belt width} + \sim 50\text{-}60 \text{ mm} \Leftrightarrow \text{distance between support rollers}$$

Why is it so?

The above formula takes into consideration:

- A - the production width tolerance of the belt
- B - that even the best belt has a variation in the "self-running straightness" of $\sim 1\%$ of the belt width
- C - that in the beginning each belt has an "oversize" in width to compensate the shrinkage under tensioning and operational conditions

Some oven lines use vertical rollers as the signal giver for the tracking station. But, if possible, this should be avoided. Often contacts of the belt edge to the side rollers will damage the edges in the long run (especially if the belt has welded edges).



A too high tensioning of >4 bar



A good tensioning with an indicating label for the maximum force



Example for guiding disc with a (good) distance to the belt edge

II.g Guiding discs

In older and smaller ovens quite often support rollers with side guiding discs for tracking can be found. What has been said about vertical side rollers applies, generally speaking, also for these guiding disc rollers. In the course of time their frequent contact might do harm to the belt edges.

III. Belt Design & Tolerances

So eventually we talk about the (mesh) belt that is used in the tunnel oven and what aspects, influencing the tracking, one should be aware of:

III.a Belt quality

In most tunnel ovens mesh belts made of mild steel quality, which comes along in different trading names, are used. But occasionally, depending on the baked product, stainless steel is needed.

All mesh belts are made of cold drawn wires, if they have a diameter smaller than ~ 6 mm. The cold drawing process has considerable impacts on the mechanical properties of the wires:

- it makes them much harder by increasing the tensile strength
- the range between the minimum and maximum tensile strength gets very big
- for stainless steel wires the mechanical properties are considerably higher than for mild steel
- because of its alloy elements like chromium or nickel
- the mechanical properties can vary considerably from one section to another within one belt, since it is not produced from one wire coil only

The higher the mechanical properties of the mesh belt wires are, the more tensioning forces in the oven are needed as part of the tracking.

And, the higher the belt tensioning, the higher the risk that the belt starts to vibrate during operation.

So it should be in the interest of the oven operator to get a homogeneous mesh belt with no big variations in the mechanical properties within the belt and with not too high tensile strength values.

A good belt producer should be able to A) influence this and B) give information about these values for their belts.

III.b Belt type & crossbar

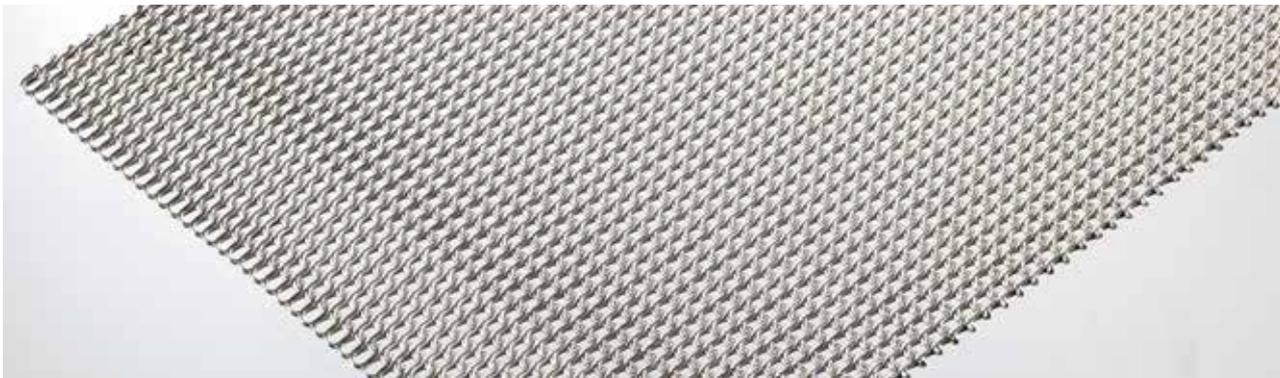
When it comes to mesh belt, be aware that those with crossbars in their mesh structure handle much better tensioning forces and are consequently easier to track than those just consisting of spiral wires.

For the crossbars there are belt types with crimped wires, which should be given preferences compared to the design with plain wires. The crimped crossbar keeps the spiral wire in position when the belt is tensioned. So the tensioning forces are absorbed equally over the width which is good for the tracking.

III.c Mesh structure

Of great importance for a good belt tracking is an equal and rectangular mesh structure, especially for rolled baking oven belts (a.k.a. Z-belts) which are made just of flat rolled spirals.

⇒ The regularity of the mesh structure has the biggest influence on the tracking characteristics of a belt.



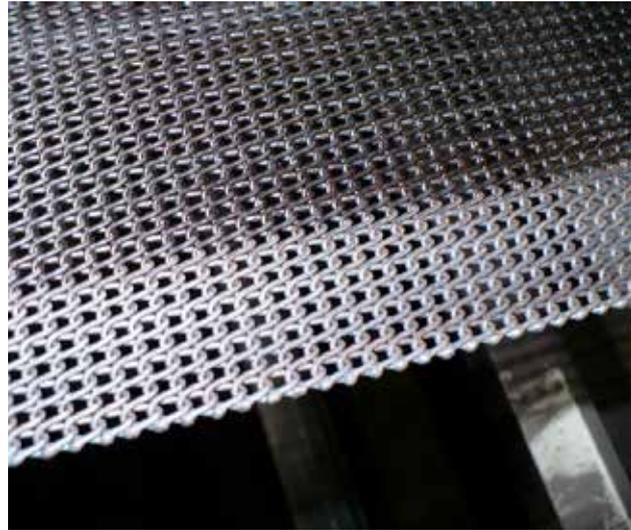
Example of a top quality Z-belt with excellent mesh structure (type F4012)

III. Belt Design & Tolerances

III.d

You can control the regularity quite easily with just some checks on the stretched non-tensioned belt:

2. Count the number of meshes of your belt with random checks at different places along the belt.
⇒ Does your belt have the same number of meshes everywhere?
2. Do random dimensional checks of the mesh openings.
⇒ Did all these measurements show the same figures?
3. How is the overall appearance of the mesh structure?
⇒ Does your belt show an equal regular pattern?
4. Is the belt's row of meshes straight or running in a bow or wave? (You can check this easily with a (self-made) angle metre)
⇒ Does the mesh row run rectangularly and straight to the belt edge?



Z-belt with a very regular mesh pattern (type F4015) installed in an oven



Z-belt (with looped edges) with a non-rectangular row of meshes



The same type of belt (with welded edges) showing a nearly perfect 90° row of meshes (and the angle metre to check it)

A good mesh structure of the belt makes your life much easier, when your oven line is running.

Don't forget that under operational conditions this structure changes. So especially the mesh's angularity should be controlled regularly and is an indication for the wear life of the belt.

It is the mesh structure that shows the main difference between belts from different suppliers.

With a quality belt from a good supplier these changes are only minute, even after several years of operation.

III. Belt Design & Tolerances

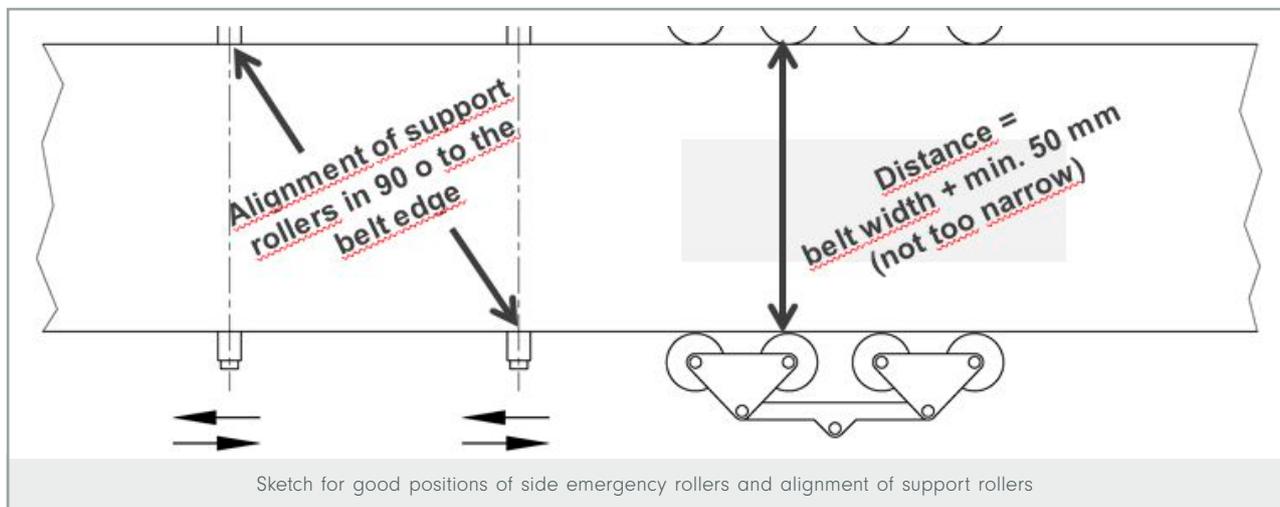
III.e Mesh tolerances

One should know the possible width tolerance and straight running characteristics of the belt installed in the oven and take these values into consideration for the position of your tracking sensors.

1. The width tolerance of your belt depends on your mesh size but can easily be plus/minus ~10 mm. A high quality rolled baking oven belt is in the range of less than. +/- 5mm.
2. Even the best mesh or Z-belt produced shows a variation in the "straight running line" of ~1% of the belt width (without any impulses from the tracking station).

So not considering these figures will lead to an "over-reacting" of the oven's tracking system and result in, what I call, "a nervous belt".

In other words, give your tracking sensors and emergency guiding rollers sufficient space. The distance to the belt edge should be, depending on belt width, 20-30 mm at each side.



III.f Overall mesh straightness

When controlling your belt during running, do certain sections move like a "banana" or a "sabre"?

Then this is a sign, that these parts are out of straightness.

A mesh belt is never made of one piece. Z-belts for example are used in total lengths of up to 270 metres. This cannot be made in one piece but only produced from segments.

So greatest care has to be taken, that all these segments are made with the same tolerances and mesh appearance, which requires high standard production. Only then a proper overall mesh straightness can be achieved.

The main criterion for this is a good rectangularity of the spiral row.

If your belt in some section is moving too much to one side (>20-30 mm, which is width tolerance plus standard tracking deviation)) the overall mesh straightness is not good.

You have a "banana" and this belt section, if not the whole belt, must be replaced.

III.g Belt edges

Mechanical damages to the belt edges can influence the tracking negatively. So it is best to repair them immediately and to maybe even replace this damaged part.

Belts with looped edges are less sensitive to damages by side touches than the ones with welded edges. On the other hand, they are thicker in the edge area compared to the rest of the belt and often damages by and to the transfer knives at the oven's exit appear.

Mesh belts with welded edges are regarded by many users as more stable and less flexible in their mesh structure, since crossbar and spiral wire are firmly connected by welding.

Because of this some suppliers concentrate on producing welded edges belts

III. Belt Design & Tolerances

III.h Belt tensioning

With the increase of the belt tensioning the tracking forces have to be increased, too. A too high tensioning might make tracking difficult if not impossible and has some other negative impacts:

- A the belt might start to vibrate and product falls off
- B the belt edges might bend up- or downward since in the edge area it cannot stretch to the same degree than in the belt centre
- C high tensioning increases the permanent mechanical impact on the belt's wire structure and leads to a shorter operational life time.



III.i Belt connection

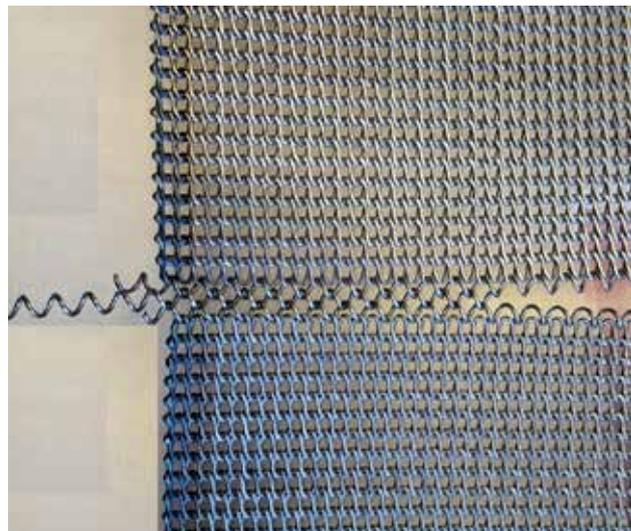
Here is your checklist for connecting:

1. Do belt connections at the joining ends thoroughly and properly.
2. Do the connection with through going spirals or cross-bars over the whole width.
3. Z-belts need 2 connection spirals, one from each side.
4. Take care that there is no change in mesh's angularity of the joining pieces.
5. Especially for rolled baking oven belts take care that there is no width difference in the two belt ends joined. Such width "jumps" might appear and can be overcome by the use of some "adapter spirals"

The higher the mechanical properties of the mesh belt wires are, the more tensioning forces in the oven are needed as part of the tracking.

And, the higher the belt tensioning, the higher the risk that the belt starts to vibrate during operation.

⇒ Non-properly made belt connections are predetermined trouble points for tracking issues.



Example of an indirect Z-belt connection with 2 more adapter spirals to overcoming small width differences of connecting ends

It should be strongly advisable for a quality conscious enduser to ask details for all these questions from the oven and belt supplier.

Satisfactory replies are part of the proof for quality.

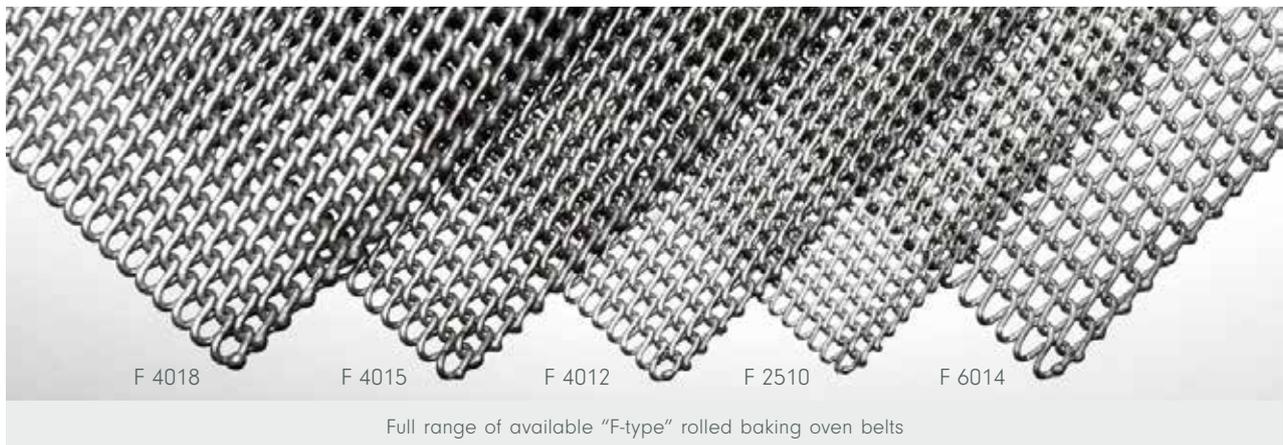
Quality might have its price but will result in long operational life times, low maintenance and low risk of "negative surprises".

Having seen the "ups and downs" of oven and belt operations at countless locations around the globe, let's end this article with some "Dos & Donts" for the belt:

- Buy a quality belt with small production tolerances and good equal mesh structure.
- Give this belt "a chance to run on his own"
- Do the tracking by a separate tracking station with a sensor system for the tracking impulses
- Don't use vertical side rollers and avoid side discs for the tracking
- Don't overdue the tensioning => tension with the lowest possible force.
- Watch out to not get a "nervous belt"
- Take care of mechanical edge damages and, if they occur, repair them immediately
- Do regular maintenance

If in doubt, ask questions!

The quality belt supplier, I am coming from, considers helping clients as partners as part of our service.



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