

## Linear Motor Technologies for Chipless Cutting

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### Introduction

The use of coiled tubing is becoming more popular within Automotive and HVAC industries. The benefits are well recognised – coiled tubing brings logistical savings, less wasted material and crucially, it allows faster production.

The current outstanding issue is that today coiled tubing is available which has traditionally been supplied on straight lengths due to large diameter or material characteristics. In essence this means that small diameter steel tubing (4-12mm), as well as large diameter (15-25mm) aluminium and copper tubing, can already be supplied on coils. Some manufacturers are even joining tubes together just to make longer coils. Such tubes are typical for the automotive industry where they are used for making brake, fuel, power steering and air-conditioning parts.



Large aluminium tube coil



Large automotive brake-line tubing coil

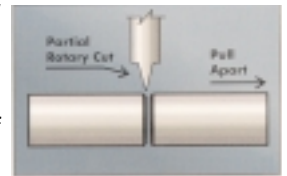
The large coils have set new requirements for decoiling and tube cut-off systems. To better meet these new requirements, T-Drill has developed a completely new chipless cut-off product with dedicated decoiling equipment that can fully meet all these challenges.

### Chipless Tube Cut-Off Basics

Chipless cut-off has definite advantages over standard practices in the field of tube cutting. The method makes no chips and noise level is low when compared to other tube cut-off methods. The tube cut-off method, pioneered by T-Drill, is also chipless. It is rotary cutting with a hallmark 'pull-apart' system. This means that initially the cutting disk penetrates the tube wall at about 95 per cent. Following this, the cut-length is separated by a pull-apart action. This

eliminates the ID reduction that would occur if the blade were to pass through the tube wall.

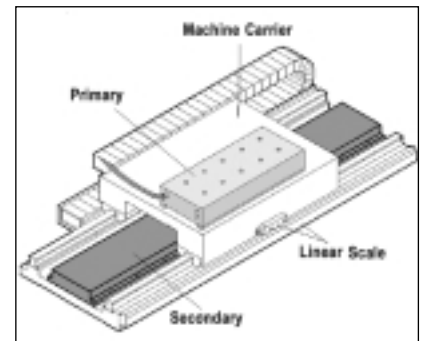
With this feature, the secondary operations are easier to carry out since the cutting quality is usually good enough for the secondary operations, without the deburring or chamfering of the tube ends. The method also allows easy chaining of different processes such as cutting and endforming/bending. This heralds a further efficiency bonus – tubes require no washing since the lubricant is biological and evaporative. Brazing or welding can be carried out even if there is still some left. Such an innovative concept – introduced by T-Drill – lies in the development of the feeding system that is based on linear motor technology.



### Linear Motor Principles

Linear motors provide direct linear motion without mechanical linkages as ball screws do. A permanent magnet linear motor can be thought of as permanent magnet rotary motor, whose stator and rotor have been cut along a radial plane and unrolled, so that it provides linear thrust.

The same forces of electromagnetism that produce torque in rotary motors are used to produce direct linear force in linear motors. The result is a flat linear motor that produces linear force, as opposed to torque, because the axis of rotation no longer exists.



Linear motor

The motors are typically supplied as construction kits. They include:

- The primary part contains the 3 phase coils
- The secondary part contains the magnets
- Machine carrier
- Linear measurement system

Linear Motors offer the following advantages over conventional solutions:

- **Direct Drive:** no backlash from leadscrews or other mechanical gearing and linkages
- **Non-Contact:** force is generated through an air gap, so there is no metal-to-metal contact and no wear
- **Simplicity:** only one moving part, no mechanical linkages
- **Travels:** no travel limits, as long as flatness and straightness are maintained
- **Velocity:** linear motors provide low to high velocities. From 1 micron per second to 350m/min

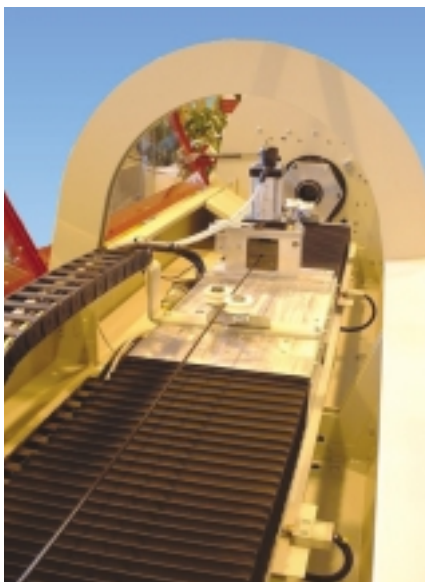
- **Acceleration:** Very high - up to 10 G's and more
- **Smoothness:** provides smooth operation because they don't rely on mechanical linkages
- **Accuracy and Repeatability:** submicron accuracy when coupled with an appropriate feedback device.  $\pm 0.001\text{mm}$  positioning accuracy achievable
- **Static Force:** static force up to 22,000N/motor
- **Maintenance:** almost entirely maintenance free
- **Life Expectancy:** under normal specified operating conditions, life expectancy can be indefinite

## Linear Motor Cut-Off Machine

The new chipless cut-off machine from T-Drill, type TCC-25 LM, uses the described linear feeding system for cutting tubes to length. This new technology provides very fast and accurate cut-off for various cut-lengths ( $< 6000\text{mm}$ ). It also has the power that is needed to feed and straighten tubes up to a diameter of 25mm, or coiled steel tubing up to 12mm diameter.



**T-Drill TCC-25-LM**



**Tube feeding system based on linear motor technology**

Until now T-Drill had used a pneumatic hitch-feeding system.

However, the company saw a progressive opportunity to improve cutting technology and established intensive research to meet the challenge.

This led to the proactive use of linear motors for tube cut-off and now the results are proven.

With tube cutting operations it was

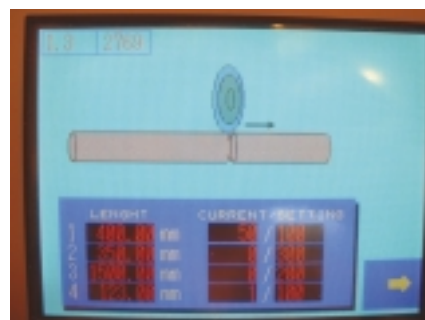
impossible to use the full capacity provided from linear motors, as cut-length tolerance is set 'only' to  $\pm 0.01\text{mm}$ . The reality remains  $\pm 0.1\text{mm}$  since there are still limitations that the natural laws of the tube cutting process establishes. An identical issue concerns the feeding speed and accelerations.

By experience T-Drill has found out that 3m/s feeding speed and acceleration of  $25\text{ m/s}^2$  are normally the maximum values – which, if keeping in mind the cut-quality and length tolerances – are very high compared to any other method.

## Multiple Differential Cut-Lengths Automatically with High Accuracy

What makes TCC-25 LM special is the ability to cut several cut-lengths automatically based on touch screen parameters.

These different lengths will be sorted automatically after the cutting operation by the sorting table. The automatic cutting of different lengths is a useful function when the assembly requires several cut lengths from the same tube diameter. Another useful application is to have single TCC-25 LM for cutting different length tubes for several bending or endforming machines that are all making different parts.



**Multiple cut-lengths automatically based on touch screen input**

## User Friendly Controls

The operator interface is a touch screen control panel. It includes advanced functions and diagnostics which are making TCC-25 LM very easy to use – even for a non-skilled operator.

From the control panel the operator can change settings and parameters.



**Touch screen controls**

## Straightener with Quick Changeable Rolls and Digital Read-Outs

In order to make tube straightening as easy as possible, T-Drill has developed a straightener that allows quick change of straightening rolls. Another improvement is the use of digital read-out for adjustment of the rolls.

Those who deal with tube straightening practices are aware of how tricky it can be to adjust a tube straightener. T-Drill is now using digital read-outs for straightener settings. This will provide great help as the basic setup can be recorded and loaded.



Quick changeable straightening rolls and digital readouts

Another matter is 'quick changeable rolls', an important feature if there is an important requirement to change a tube diameter regularly.

This system is just matter of 'pushing a button' to release the straightening roll switching it to another.

## Horizontal Decoiler for Heavy Coils

Linear feeding, just like any other 'hitch feed' method is based on three operations: acceleration, feeding and stopping. In order to handle this kind of 'feed-stop-feed-stop' operation, the decoiling



Dedicated decoiling equipment for heavy coils

equipment needs to be able to accept all these high accelerations and stoppages while still keeping the tube tight to avoid coil jamming and tube damages. The new decoiler design meets all those requirements.

## Auxiliary Equipment

TCC-25 LM can be equipped with NDT (non-destructive testing) or colour detecting equipment. NDT equipment can be used for detecting defects and/or joints on coiled tubing.

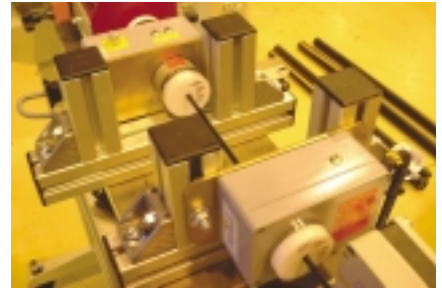
The advanced software will remove these bad sections from the coiled tubing automatically during the cutting process. It also makes sure that, in relevant scenarios, the wasted tubing will be minimized. If needed, the tubes can be marked or labelled by ink-jet/laser printer.

## Cut-Off with Integrated Endforming using Linear Motor Technology

Beside normal cut-to-length systems, T-Drill has used the linear motor technology for cut-off machines with an integrated endformer.

While all the linear motor feeding benefits have been explained, there is one important matter that needs to be explained when dealing with the issue of in-line cutting and endforming.

This is cut-length change-over-time. Everyone who has been working with cut-off machine using in-line endforming method knows, that cut-length setting can take long time. Sometimes even more than 30 minutes.



Non destructive testing (NDT) equipment

Now, with use of Linear Motor based feeding, the accuracy is so high that machine is able to cut and endform multiple cut-lengths fully automatically without any time loss.



Chipless linear motor based tube cut-off with integrated endformer

## Summary

It is likely that the industries will be using coils more frequently instead of straight length tubes. Coil sizes will also become larger. Tube diameters on coils are also likely to be larger and coiled steel tubing will be used more frequently.

With the TCC-25-LM linear motor based cut-off, a dedicated decoiling system, a new straightener with quick changeable rolls and advanced software, T-Drill aim to meet the most of these demanding cut-off applications.

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