Safe and efficient robotic removal of high strength steel straps from coils

To cope with the remarkable increase in recent years in the demand for high strength steel strip, coil producers have had to use higher strength steel straps to hold the coils securely during transport within the steelworks or to customers. Because of the higher coil locked-in stresses and the more highly stressed straps, strap removal is a particularly challenging task, when cut, the straps can whip and raise concerns over equipment damage or personnel safety. There is also the possibility of the coil partially and rapidly unwinding. To address these issues Tebulo Industrial Robotics has developed a new robotic de-strapper specifically designed for the safe de-strapping of high strength steel coils.

The increase in demand for high strength steel in recent years, particularly in strip form, can be explained by the fact that this material offers substantial cost reductions in its many product applications, through weight savings (thinner sheets) and its capacity to improve product performance. Specific examples are in the automotive sector, other areas of transport and the offshore oil and gas sectors.

High strength steel (HSS) is a generic term for steel qualities that are stronger than ‘standard’ steel qualities, but in recent years steel producers have developed (and continue to develop) ever more ‘high strength’ and ‘ultra-high strength’ grades.

Steel strip is typically coiled after rolling into 30-40 tonne coils which usually require three to five straps per coil to hold the coils secure during transport within the steelworks or to customers. HSS grades, however, because of their higher strength (and hence residual or locked-in strength) require either more straps (up to 12 per coil) or the use of higher strength/thicker steel straps to hold the coils securely. HSS straps are under considerable tension so their removal is a particularly challenging task. When cut, the straps can whip and raise concerns over equipment damage or to personnel safety. There is also the possibility of the coil partially and rapidly unwinding.

Tebulo is an industrial robotics company which produces tailor-made robotic solutions for material handling, welding, hot and cold marking and/or tagging of coils, sheets or slabs. To address safety issues over coil de-strapping, some years ago Tebulo developed a robotic de-strapper which detects the straps over the full width of the coil, and removes them. It comprises a robotic arm similar to those used in car manufacture with the de-strapping tool attached, and uses bespoke software. The robot sits at the side of the process line as shown in Figure 1.

Because the size (diameter/width), position, number of straps and position of the strap lock varies between coils...
the robot head detects these and adjusts accordingly.

The first machine was supplied for a pickling line in Canada in 2004 and many units have been supplied worldwide since. Although the system has been very successful, this particular design is unsuitable for HSS coils with the thicker and stronger straps.

This relates to the fact that the material typically has a double breaking force compared to traditional strapping materials and, when cut, the HSS strapping material shoots away with explosive force due to the extremely high internal tension of the strapped roll of steel. The time was right, therefore, to optimise and further develop the de-strapper for safe removal of these new high strength straps.

ROBOT HEAD DEVELOPMENT

Cutting tool

In the development of the new de-strapper head, our engineers searched for the optimal balance between a blade with the proper geometry, the correct cutting angle, cutting forces and minimum wear and tear. To determine the correct cutting and deformation behaviour, we started by recording the process on a high speed video. Subsequently, we created a complex mathematical cutting model and conducted force analyses which eventually led to the new design with a substantially improved cutting head.

In order to cut the new HSS straps the single blade knife has to somehow slide underneath the straps. This is quite a challenge since these new straps are extremely tightly wrapped around the steel coils. The cutter blade angle (the angle by which the blade slides under the straps) was modified so that it slips under the strap, but the angle is not so sharp that it is too weak. As soon as the cutter slides under the strapping material, the strap is lifted and cut with minimum damage to the coil. Blade material has been changed and is now produced from a higher strength material and includes a unique hardening process such that the wearable parts now have a lifespan of the cutters used for standard strength steel coils.

Strap clamping

For extra safety the cutting tool now has two clamping units instead of one, preventing the strapping from shooting away as the strap is cut. The strap is clamped to the coil. The new de-strapper uses laser technology in conjunction with bespoke software to detect the straps such that as soon as the strap is cut, it is automatically pulled away and transferred to the strapwinder.

Overall design

To flexibly carry out the three functions of sliding under the strap, cutting and holding in a single movement, much greater force is required, so we modified the hydraulic system to create it. Also, design of the entire construction has been improved and stiffened with very little weight increase. Figures 2, 3 & 4 show various views of the de-strapper in action.
OPERATION
Coil measurement, strap detection and first strap removal takes about 50 seconds. Removing each subsequent strap takes about 30 seconds.

DISPOSAL OF WASTE MATERIALS
In the industry there are two main disposal systems: strap choppers and strap re-coilers. Tebulo has traditionally preferred coilers (strapwinders) as they have fewer wearing parts and require lower maintenance. The strapwinder is a device that collects the cut straps and coils them up and compresses them for recycling. The strap is pushed out of the winder and it either falls onto a conveyor that transports the strap to a scrap container or it is collected in a bin which is emptied by another robot into the scrap container.

For the new de-strapper the strapwinder has been upgraded (strengthened) so has to cope with the higher coiling forces needed to process the very high strength steel straps into a compact waste material package. An additional design change has minimised the risk of the cut straps getting caught within the strapwinder’s press area where the strap is wound and compressed and which might otherwise cause a stoppage or safety issue. Also noteworthy is the fact that the new strapwinder design is very low maintenance and has a minimum of wearing parts. The new design may be used for standard straps as well as for high strength steel straps, although the former de-strapper remains available in our product range for the removal of conventional straps.

FIRST MODELS
Each new de-strapper comprises a clamping and cutting unit, laser system for the detection of the number and exact position of straps and to perform a diameter measurement. Each machine is specifically tailored to customer requirements and may be equipped with various options. These include a scanning functionality for roll material shape recognition, coil detection, width scanning detection, bar code scanning and camera for access control or product number identification.

The first two new de-strappers, including control units, hydraulics and robot tools, were delivered to a high strength steel producer in Finland in the middle of 2018. With this new de-strapper on the market, we expect that the use of HSS for straps will significantly increase, since strap removal can now be handled in a safe and affordable manner. MTS

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