STUDY ABOUT COIL SET OF STAINLESS STEEL STRIPS

Georgian Mihail NICOLESCU, Ionuț Lucian PRICEPUTU, Zorica BACINSCHI

Valahia University Targoviste, Doctoral School, Lt. Stancu Ion Street, No. 35, Targoviste - Dâmbovita,

E-mail: georgian.nicolescu@yahoo.com

Abstract: *This paper refers to coil set defect of very thin stainless steel strips. There are a lot of shape defects, simple or complex. The study and researches are very useful in clarifying the notion, finding the causes and some proposals in order to avoid and correction of the defect. Generally, the waviness of the strips causes a lot of problems for final products which are obtained by stamping and drawing. Difficulties are encountered both in the guiding phase and the cold plastic deformation itself. The precision requirements for semi-finished or finished products have exponentially increased, so the shape defects including coil set became an important research objective.*

Keywords : stainless steel strips, coil set, shape defect

1. INTRODUCTION

There are a lot of applications, products which are obtained by cold plastic deformation process. Because of noble properties offering by stainless steel, this kind of material is more and more used in any industry branch. In this context, both semi-finished materials and the finish products are usually high-class precision parts manufactured entirely by cold forming operations. Shape defects generate a number of defects on the finish products (e.g. shape and dimensional deviation, damage in dangerous section of the final part), because of internal tension existing in material.

The shape defects of stainless steel strips can be classified as simple (e.g. coil set, curl, cross bow, twist, crown, wedge) and complex (e.g. camber, edge waves, center / quarter buckles, saddle, herring bones). These defects are characterized by length variations concerning thickness of the material. Coil set is the most common and basic type of such defect. It is characterized by differences in length of coiling surfaces, interior respectively exterior - Figure 1. The defect can be corrected by bending the reverse of the material. For this correction to be permanently, the material should be deformed more than yield point.[Art H., 2002]

Coil set can be defined as deviation from flat shape of flat product. This defect appears as a curve in the sense direction of rolling, bending which has concavity to winding of the coil.

Coil set is a relatively new characteristic and requirement for stainless steel strips in additional to other very important requirements. It is more and more interest for this aspect in order to obtaining a high dimensional accuracy of parts made from these flat products.

The rapid and extensive changes in the processing by cold plastic deformation (including drawings) caused a delay in clarifying certain aspects regarding quality.

Defect known as coil set is not clearly defined and quantified nor in literature, nor in the relationship between partners. They tried at one point some clarification by internal documents of organizations (catalogs including defects, training supports, control instructions and so on), without clarifying many of the issues involved in defining, interpreting and measuring these notions.

Nor specific standard EN ISO 9445-1[ASRO, 2010] is not too generous information regarding coil set. So, this paper has as scope some clarify some aspects about shape defect of the stainless steel strips called coil set.

Currently, the manufacturers of stainless steel strips consider shape deviation (coil set) only if it is allowable values required by the final users, in relation to a particular length of sample taken. If measured method seems to be clear - Figure 2, aspects of place, manner and time of sampling to measure them are totally devoid of rules, leaving large interpretation spaces for all supported involved.

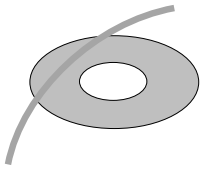


Fig. 1 – Coil set defect of the strips

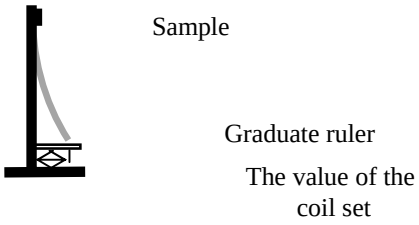


Fig. 2 – Stand for coil set measuring

2. OBTAINED RESULTS

The studies and research have been performed on four slitting lines, a wide one (maximum width 1300 mm) and three narrow slitting line (widths of processing up to 650 mm). There were analyzed materials with thickness between 0.1 mm and 0.8 mm.

On winding of the strips as a coils, the material tends to borrow the shape of the support on which is wrapped, the curvature of the formed coil. Outer entering diameter (it depends crucially on the sample coil set) is often different from the outer diameter of final coil because some division are required. It is obvious that the sample is taken only from the un-winding coils to be shipped, so from the final end (bottom). Sample so taken shall be proper to outside diameter of the coil. Conditions regarding the value of the coil set should be apply to the outer diameter of the coil, inside is not possible to impose due to the impossibility of sampling. Generally limited outside diameter of the coil to a minimum for reason of productivity and maximum value with regard to its transportation, handling, processing or storage. Currently, the maximum value deviation for coil set apply for any outer diameters which are obtained (included in required outer diameter range). It is preferred that the outer diameters of the coils to be processed as close to the maximum outer required diameter. This is necessary both for reasons of productivity, but also because the coil set is even smaller as the outside diameter of the coil is bigger.

Direction of investigation is more complicate because even if is not a history of semi-finish, it is expected that the wrapped material as coil copy its shape even more as storage time is longer; the defect is not visible immediately after the last processing even if the strip is un-winding from the formed coil.

The variation of the coil set value regard to storage time is almost impossible to determine.

Because of economic reasons, manufacturers do not produce stocks and the storage time on the process flow is minimal, the material is delivered very quickly. In fact, the lead time is very short in order to achieve the very short time for entire order. In the spirit of the same idea also we do not know the storage time from any final users.

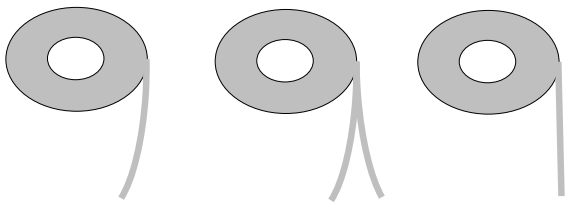
The sample is taken at a certain length specified whit a width of the delivered product. The samples are taken from slitting line because this line is the last line from process flow and thus, in principle, here is relevant and real coil set, caused by several deflection rolls.

In the vast majority of samples are taken from un-winding part and very few times from the already winding material. Looking at things in a logical order, when it held the material from the formed coil, there is some bending of the strip whose concavity is not always on the same side and whose amplitude is the same is not the same regardless of the material - Figure 3.

Analyzing defect known as coil set and taking into account the reverse bending (some cases from the previous figures), called negative coil set, the author asks whether the concept is correct in assuming that the shape of wrapped support, formed coil, it can cause a bending in reverse. The performed research sense is from effect and going in reverse of things of the process flow until on processing lines for semi-finished products. After it was found the bending, the next step in the study was to determine the bending type and magnitude of the wrapped strip in the last processing line.

Slitting process involves obtaining several pieces in same time (up to 30 strips). It is seldom cases where it is obtained only one strip because the wide strips does not usually get heavy duty parts, parts are also made with high dimensional accuracy, so the processed widths are relatively small (usually less than 650 mm).

Monitoring bending strips obtained after the final operation, were found types of bending with concavity on both sides and different amplitudes [Figure 3]. That means slitting lines through their design and technological parameters have influence on concavity of the strips ends (direction and amplitudes).



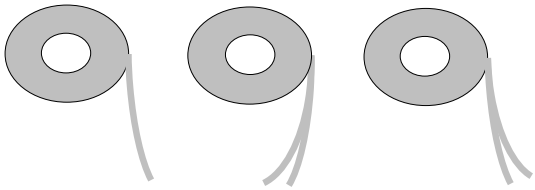


Fig. 3 - Concave, convex heads and different amplitudes of the held strips

In this context, some clarifications need to be made about the slitting process.

The shear is made so that burr orientation of the strips alternating from one strip to another (the burrs for one strip are oriented to the inner surface of the coil and the burrs of neighboring strip are oriented in reverse). Preferable the same orientation for all strips burrs, namely the inner surface of the coil. The inner surface of the coil (I) represents the surface from wrapped support (coil) and the outer surface (E), the surface from over the coil [Figures 4]. In order to achieve this condition requires changing wrapped surface of the strips in the lopper. The lopper is an area where running the strips of under its own weight on a relatively long length (about 4 ÷ 32 m) in order to compensate the differences in coiling length, differences due to deviations from flatness (often imperceptible to the naked eye), which translated also in thickness differences from a strip to another.

So, for $\frac{N}{2}$ strips (case "a") or $\left(\frac{N}{2} \pm 0.5\right)$ strips (case "b"), depends on base way of the shear, will be change the wrapped surface in the lopper.
where :
N – total number of strips;
the (a) case is valid for N even
the (b) case is valid for N odd

Historical data shows that the winding strips with burrs oriented to inner surface, significantly reduced the risk of another failure, winding defect, called telescopicity of the strip (coil) and also the majority of the end-users prefer that. It not change the surface for wide and thicker material, ie the material for the changing the surface would cause, due to their rigidity, shape defects (e.g. waves, twist, so on).

Principle schemes for processing of the coil without / with changing the coil surface - Figures 4.
These schemes are strictly dictated by the process flow based on existing defects on the two surfaces of the material detected in the inspection and by design of the processing lines. It is preferred that the surface with better quality to be wound externally (E).

In cases of the processing using the slitting lines which modify the type and amplitude of the bending the situation becomes worse if these lines are done and intermediate slitting

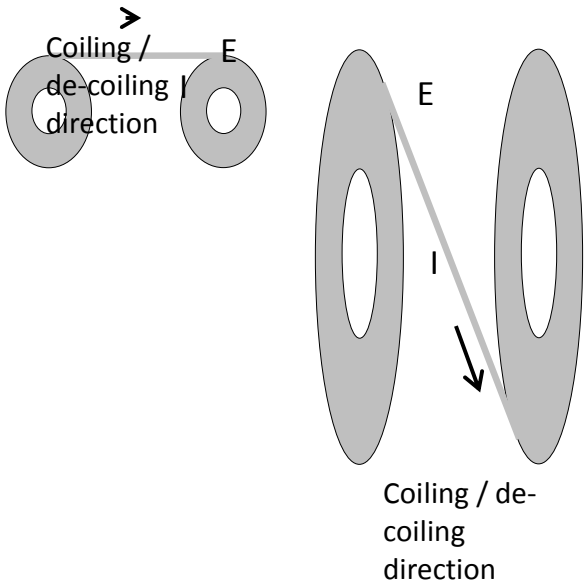


Fig. 4 – Principle scheme for processing of the coil without/with changing the wrapped surface

3. INTERPRETATION OF RESULTS AND CONCLUSIONS

In this context basically can not know with certainly the influence of the wrapped support (coil) on coiled strip in order to determine the defect called coil set, taking into account the diversity of bending coiled strip.

The coil set can be indentified and quantified only when the strip is wrapped without any bending before that. Otherwise, of course the wrapped support (coil) has an influence about bending but it is not possible to quantify and sometime intuition of the concavity.
It can be accepted that in case of the negative bending (to exterior –E- surface) of the strip, the wrapped support (coil) can compensate to a certain extent this negative bending.

Also, there were indentified areas in slitting line where the bending of the strip is modified. The deviations are not controllable because of limitations arising from the processing lines design (the diameters of the pinch or deflection rolls, possibility ensuring a winding strip angle, so on) in conjunction with the strip tensions that are necessary for those areas (between de-coiler and slitter, respectively between tension pad and re-coiler). Basically there

are slitting lines through design which amend or amplify their bending to the exterior and others which no affected the bending but through changing the strips surface in the lopper modify the bending orientation.

Although there were recorded values for these bending (coil sets), they are not relevant because for a many different processed semi-finish materials the values are very different as amplitude in conjunction with the type of concavity (positive or negative). So, that research can not be translated into laws of variation and also can not be generalized. In same time the characteristics of the processed and studied material, characteristics which are in fact the variations in the process, are very different for the same categories of the processed material : width, thickness, inner diameter, outer diameter, type of surface, steel grade, so on. In this context also the technological parameters are very different. One remark : in case of one narrow slitting line which can modify the concavity of the strips to the exterior (negative coil set) it observed that happens only for thin material (under 0.4 mm). The differences are not noticeable even if such bending amplitudes considering all these features.

However being exposed, it can say that in the specific technical areas it is used improperly called coil set for the shape strip defect found when we de-coiling the material from the coil. Because "coil" term is a misleading term, shape defect referring in including all bending which come from the entire process flow, not only from coil shape. The authors propose that the correct name of the considered defect is "remanent bending of the strip" not to mention something about coil that could be misleading. This remanent bending of the strip is other thing than coil set, but includes the latter. This new naming for this shape defect which is observed when it de-coiling the material from the coil, assimilated beside the shape imprint because of wrapped support (coil) and more malleable bending of the material during processing on final lines and not only.

The remanent bending of the strip for taken samples will be measured in the same manner - Figure 2.
Although measurement method involves reporting to the concavity of the strip to the exterior according to the vertical reference surface, in these circumstances is right and important that this remanent bending of the strip to be classified as positive or negative, depending on the concavity of the bending according to the direction of coil winding. Positive when the concavity is toward the inside (I) and negative when concavity is toward the outside (E).

As the concept of coil set was exhibited, another important observation would be that it can not be classified in any context as positive or negative because this shape defect in the sense of singular can have only one single orientation namely to the wrapped support (coil).

Certainly a collaboration with the users in order to clarifying this problem is a possible solution, in the context of the current economy detailed technically collaboration becoming a trend lately. On the one hand the producers realize that the benefits of the total orientation to the user's requirements. In same time, the users realize that only the producers through their experience can implement some technical requirements, requirements that the users are not able to express (expressed and un-expressed needs).

4. REFERENCES

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