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PRODUCTION TECHNOLOGY OF HELICAL CONVEYER FOR GROCERY PURPOSES

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ABSTRACT

Enclosed contribution deals with analysis of application of roll bending manufacturing technology of spiral conveyor for food processing industry purposes. Furthermore this article describes proposal of new technological method, namely usage of hybrid technology of machining and forming. As applied material is proposed cheaper carbon steel provided with ceramic coating to be used. An original solution of proposed technology is result of cooperation Technical University of Brno, Department of Mechanical Technology and ISS in Kurim, Czech Republic and was successfully tested and verified in an industrial application on device for food processing industry.
Key words: roll bending, spiral conveyor, ceramic coating.

1. INTRODUCTION

It has recently been possible to see a concentration of creative powers for the development of known technology principles for material moulding and their current applications. The worldwide shortage and increase of raw material and energy prices require searching for new technology directions – material interaction. Metal-metal pairs of various properties and dimensions in mutual continual connection or metal-non-metal pairs require new approaches for investigation of the given problems[1].

Exploration of the indicated trends requires the cooperation of VUT Brno with industrial practices and with other schools, as was the case with designing a new manufacturing technology of a spiral conveyor for tube packing machines. The new technology should be more efficient, it should achieve as high savings of material as possible, energy saving and decreasing of manufacturing labour, even in case of piece or small lot production. The new technology must be designed with regard to current applicable environment regulations.

2. SAMPLE SPIRAL CONVEYOR PROPERTIES

The spiral conveyor is a part that performs a rotating movement and basically conveys various food products for the purpose of dosing, packing and subsequent dispatch. If its surface contacts different material, friction is generated, which leads to wearing of its functional surfaces [2].

Industrial practice in the Czech Republic usually produces fixed spiral conveyors of a **smaller diameter**, i.e. with 10 – 15 mm diameter of spigot (core) and about 30 – 50 mm external diameter of spiral for the food industry area [2]. They are mostly made of austenitic Cr – Ni steel from rod semi-products by cutting, e.g. milling or welding. Moulding or manufacturing in plastic is also possible. In foreign countries, flexible spirals are made in diameters e.g. 55, 75, 90, 125 mm [6] respectively, by special single purpose rolling machines and the diameter of the spiral with fixed core conveyors reaches 700 mm.

3. EXPERIMENTAL PARAMETERS OF THE SPIRAL CONVEYOR

To check the new manufacturing technology of spiral conveyors for food industry purposes, samples were experimentally produced with the spiral diameter (D) from 18 mm to 48 mm, with the core diameter (d) from 12 mm to 16 mm and respectively spiral pitch (B) from 26 mm to 56 mm.

As an example in the report a chosen sample of the spiral conveyor is presented with the core diameter d = 13 mm, external spiral diameter D = 38 mm, pitch B = 38 mm and thickness of the spiral A (further in the text “s”) = 2 mm. The material used for the core and the spiral was 11 373 steel with regard to existing basic documents that were available for the experiment [3].

With the usage of lit. [3] it was found that:

$$\frac{h}{s} = \frac{\frac{(D\text{-}d)}{2}}{s} = \frac{\frac{(38\text{-}13)}{2}}{2} = \frac{25}{4} = 6,25 \doteq 6$$

For $\frac{h}{s} = 6 \Rightarrow$ from diagram. on Fig. 2 results ratio $\frac{h}{R} = 0,95 \Rightarrow R = \frac{h}{0,95} = \frac{12,5}{0,95} = 13,15 \doteq 13mm$

Ultimate curve radius R = 13 mm corresponds with the spiral conveyor core diameter d = 2 R = 26 mm; under these conditions the current technology of belt rolling on a template (without pre-tension) can be used.

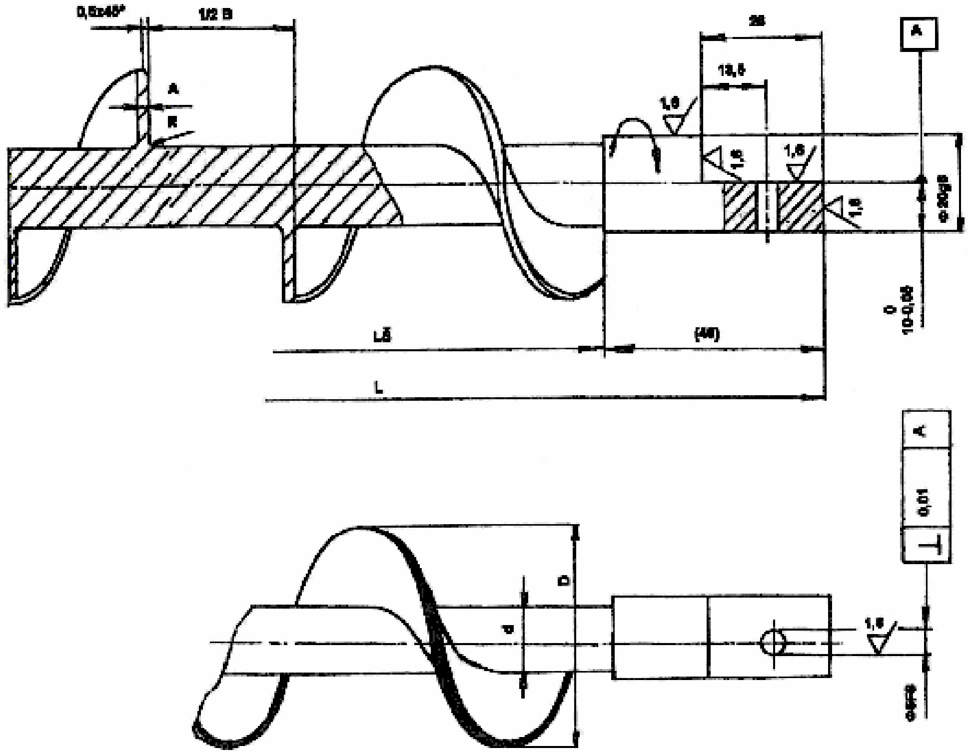

Fig. 1 – Experimental parameters of sample spiral conveyor with carrier

With regard to the fact that a diameter d = 13 mm was designed for the experiment, belt rolling with a quality (plain) spiral surface is not practicable with current technological procedures. Even in the case of enlarging the core diameter up to d = 16 mm with the other dimensions preserved, the ratio is $\frac{h}{s}=\frac{11}{2}=5,5mm$ and from the diagram in fig. 2 it is $R=\frac{h}{0,99}=\frac{11}{0,99}\doteq 11mm$, which corresponds to the spiral conveyor core diameter d = 2 R = 22 mm, which is also unacceptable. Enlarging the core diameter (d) is negative owing to transport space volume decreasing between the homothetic sides of the spiral (see dimension B in fig. 1) for experimental diameter D = 38 mm and pitch B = 38 mm. Furthermore, it is necessary to bear in mind that during bending with a small diameter R, which is principally the rolling technology, the bent section is deformed, i.e. the square section changes to a trapezoidal one. In the pressurized area the thickness of the spiral grows; in extreme cases the edges get undulated [5].

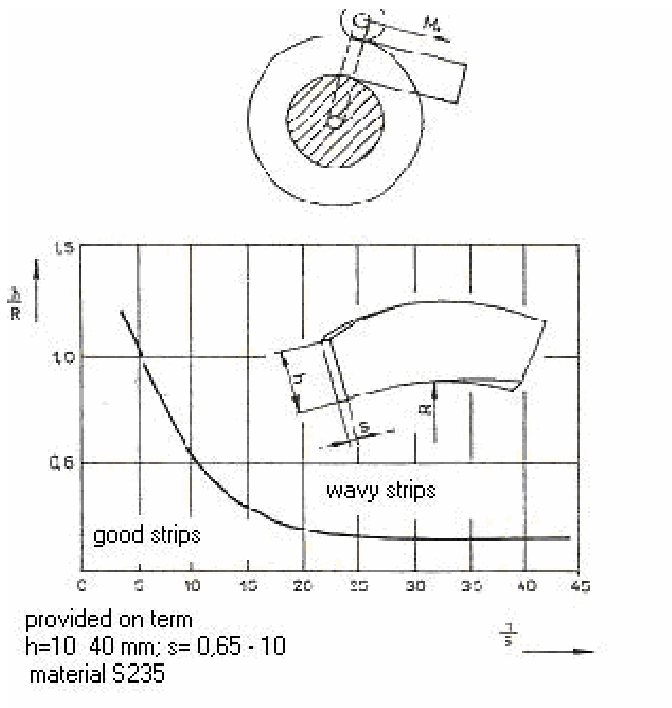

Fig. 2 – Marginal grade of the belt rolling on a template (without pre-tension) [3].

4. NEW TECHNOLOGY FOR SAMPLE SPIRAL CONVEYOR MANUFACTURE

The spiral was made of cheap carbon steel S235 construction and from defined diameter of bar steel semi-product by metal cutting on a standard lathe. The required diameter of the internal spiral was made by drilling on the same machine. To determinate the required dimensions by calculations we started from the premise that with greater pitch the cavity of the spiral is reduced in size. To comply with the required pitch of the spiral conveyor thread an exactly defined slot width was made in the core with regard to the growth of the spiral width by the thickness of ceramic powder coating. After the spiral thrust, the end of the core was equipped with a carrier by pressing-on with overlapping. After the dimension check 3 samples were degreased and blasted with brown corundum of grain size 0.63 ÷ 0.90 mm under the pressure of 0.4 MPa. The coating itself was done by the means of a plasma device from Plasmatechnic A. G. (Switzerland). Plasmatic gases Ar + H_2 were used and 500 A power. Additional materials used: NiCr 80/20 w. 0.05 mm for the interlayer and consequently Al_2O_3 + 13 % TiO_2 powder from Metco (USA) of grain size 25 ÷ 45 μm. One sample piece was provided with the ceramic powder GTV 40.01.1 (Germany) that was authorized in the Czech Republic as suitable coating for food industry purposes (expert opinion of the chief hygiene officer ref. mark HEM – 3435-4.9.98/29129).

Chosen sample dimensions were as follows:

- initial core diameter: ∅16,3 mm
- after coating: ∅ $16,7^{+0,1}$ mm
- initial spiral width: 1,6 mm
- after coating: $2,1^{+0,1}$ mm [4]

A greater thickness of the coating was applied on the pressing edge of the conveyor spiral. This surface can be ground if necessary, e.g. manually with garnet paper. Experimentally produced samples were successfully tested in industrial use by a testing machine.

5. ECONOMIC ASSESSMENT AND FURTHER DEVELOPMENT

Compared to current technology of making spiral conveyors by means of milling into full material of austenitic steel 1.4301, the use of the new technology saves 60 ÷ 70 % costs with regard to the size of the spiral diameters and the size of the worm core in the tested dimensions interval.

In later periods other combinations of steel materials were also tested, e.g. the core of austenitic steel 1.4301 and the spiral of carbon steel E335 construction due to compactness at greater pitch of the worm, which in the final stage of manufacturing was coated with ceramic paint of the spiral conveyor. Further the optimisation of the spiral conveyor core diameter was carried out with the purpose of its reduction with the given spiral diameter and pitch while preserving the functionality of the spiral conveyor. Two experimentally produced samples of spiral conveyors D = 38 mm are shown in fig. 3 and compared to the sample with the smallest experimentally made spiral diameter D = 18 mm.

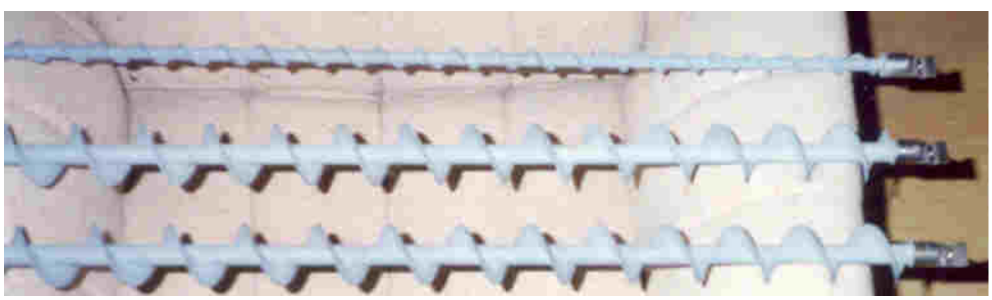

Fig. 3 – Experimentally made samples of spiral conveyors with ceramic coating

6. CONCLUSION

The purpose of the development work in laboratories of BUT in Brno, at the Institute of Engineering Technologies, was to attest a new technology of spiral conveyor manufacture. Furthermore, to optimise parameters of testing samples of worms with cores (fixed spirals) in cooperation with industrial praxis for the manufacture of food machines. Total cost savings and compliance with environmental criteria were achieved.

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IZRADA HELIKOIDNOG KONVEJERA ZA TRANSPORT U OBLASTI PROIZVODNJE HRANE

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REZIME

Dati rad bavi se analizom primene procesa savijanja vavljcima u izradi spiralnog konvejnera za potrebe transporta u oblasti industrije hrane. Pored toga ovaj rad opisuje predlog novog postupka izrade datog konvejnera i to hibridnom obradom, primenom tehnologije skidanja strugotine i obrade deformisanjem. Preporučuje se primena jeftinog ugljeničnog čelika sa keramičkom prevlakom. Opisano originalno rešenje je rezultat saradnje između Tehničkog Univerziteta Brno-Odseka za mehaničke tehnologije i IIS iz Kurima, Češka. Ovo rešenje je uspešno testirano i verifikovano u industrijskoj primeni u oblasti proizvodnje hrane.