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STRENGTH OF PLASTIC MOLDINGS OBTAINED BY RUNNING CASTING METHOD

The theoretical estimation and experimental results for strength of plastic moldings obtained by running casting method research have been presented.

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THE MATHEMATICAL MODEL FOR CONTROLLING THE COILING MACHINE FOR METAL STRIPS

The work is a contribution to solving the problems of the process of coiling the metal strip. The whole process of coiling on the model of the coiling machine is divided into five subsequent time periods. Experimental works are included in all the periods and are described by created mathematical models that were verified by means of experimental measuring. Achieved results of the experimental works prove theoretical assumptions for the creation of mathematical models and document that the faultless adjustment of coiling and feeding rollers is the necessary and most important condition for obtaining a tight coil with the required inner diameter.

The whole model of the coiling machine has 9 basic functions at its disposal that participate in the creation of the coil. Experiments prove that the synchronization of all the functions with the model requires the automatic control of at least some mechanisms.

1 Introduction. Problems of the process of coiling the metal strip are under solving. The main requirements for the coil of metal strip are connected with the subsequent cold rolling, with which the technology of rolling with tension is used and drums of uncoiling machines are usually able to implement a change in the inner diameter by 30 mm.

2 Coiling machines for strip coiling. The coiling machines form a coil by bending the metal strip between rollers. The coiling machines can be used for hot and cold coiling the strips, namely also for the strip thickness of more than 1,5 mm. What is a basic preference of coiling the strip over strip winding is a possibility of feeding the machine with the strip at its full speed; the angular velocity of the coil does not need to be regulated depending upon its increasing diameter. The machines are of rather simple construction and are, altogether, less demanding when used in the rolling mills in comparison with downcoilers [1]. In the efficient rolling mills, however, the downcoilers are utilized because the coiling machines do not enable perfectly tight winding of the coil, if increased attention is not paid to this requirement when designing the machine.

What is an important parameter of the coiling machine is its ability to form a tightly wound coil. The tight coil depends on the resultant movement of the coil during coiling, which is dependent upon a suitably chosen kinematic principle as described in [2, 3, 6].

By making the analysis of energo-force parameters of coiling, we shall obtain the equation of plastic bend (determination of the bending moment M) for metallic materials that is derived for the rectangular section ($b \times h$), symmetrical to the neutral axis in the form:

$$M = \frac{1}{2} W R_e \left[3(1 - \eta\mu) + \frac{2\eta}{k} + \left(\eta\mu^3 - 1\right)k^2 \right]. \tag{1}$$

In the equation (1), the section modulus at elastic bend is given by the relation: $W = bh^2/6$, R_e is the limit of material elasticity, η means the coefficient of material hardening, k is the relative dimension of the ordinate (see Figure 2.18 in [6]), η expresses the character of material hardening.

To determine the needed radius of coiling ρ depending upon the required radius of the coil r_z, the limit of elasticity R_e, the modulus of elastictity E and the thickness h of the coiled strip, the following equation can be written:

$$\frac{1}{\rho} = \frac{1}{r_z} + \frac{\overline{M} R_e}{Eh}. \tag{2}$$

The expression of the relative bending moment $\overline{M} = \dfrac{M}{M_k}$ for not harden materials, harden behind the limit of elasticity or behind the area of the yield point is given in [1].

3 Time periods of the coiling process of strips on the model of the coiling machine. On the basis of the constructional design and after elaborating the graphical documentation by the staff of the Department 340 a model of the testing coiling machine was built in the Škoda Plzeň plant. The testing model enables the coiling of coils having the size at the scale 1:3 to 1:4 to the size of real coils in the rolling mill. The material under coiling can be lead, aluminium alloys and steel of the thickness of 2–7 mm and the width of up to 100 mm.

One of basic requirements for the constructional design of the model, and thus of the real machine, was to secure the coiling of strips to coils of the predetermined inner diameter in the given tolerances.

The course of coiling the metal strips on the testing model of the coiling machine was divided into the following time periods:

1) putting the testing coiling machine into the starting position;
2) coiling to the required radius of coiling r_z;
3) transfer of the roller D to the position D_v;
4) proper coiling of the metal strip;
5) completion of the coiling process.

4 Mathematical models for the control of mechanisms. For the automatic control of the testing model of the coiling machine, it was necessary to build up mathematical models for the adjustment of rollers A, B, D, E, I, K, L, F, G, H, J in the course of the whole process of coiling the strip depending upon the length of the coiled strip. The rollers are adjusted into appropriate positions during the whole coiling by means of move mechanisms W_1 to W_{R9}, whose designations and functions are clear in Figure 1.

5 Measuring on the experimental model of the coiling machine. Experimental measuring on the model of the coiling machine was directed towards the testing of the mathematical model for the purpose of verifying the functions of mechanisms W_4, W_6 and W_{R9}, then the adjustment of the bending rollers D, E and feeding rollers A, B by means of checking distances v_D, v_E and d_{AB} into relevant positions. For various thicknesses of aluminium and steel strips and required radius of coiling r_z, corresponding values v_D, v_E , d_{AB} and ρ were determined; for the calculation of them a program for the PC was written [6].

All measurements were taken for the constant adjustment of feeding rollers A, B. The constant adjustment had been chosen with the goal to verify the necessity of setting continuously the feeding rollers under changing conditions, always for another radius of coiling. This fact means the worsening of conditions for the operational use of the real machine and requires a design more complicated as for construction.

The requirements related to the needed inner diameter of the coil (for $D = 200$ mm the tolerance is up to 15 mm, which amounts to 7,5 %), were fulfilled with the exception of one case given in [6]. From this point of view, it is then possible to state that, in virtue of measurements, the mathematical model for the function W_4 has been verified.

It has followed from the evaluation of measuring that it is necessary to set accurately the position of feeding rollers AB. It was derived in [6] that for the angle $\varphi = 0$ of the turning of the triple of feeding rollers E, D, I any shift of these rollers would not have been needed. This knowledge leads to the simplification of the constructional solving of the real machine. It is supposed that the turning of the system by the angle φ will enable a simpler introduction of the front end of the strip between the coiling (bending) rollers. On the model of the coiling machine, a possibility of the turn through the angle φ = 0 was verified. At the faultless setting of the rollers into appropriate positions, it was verified that at the correct application of the theory of creation of the first turn it was not necessary to turn the coiling rollers.

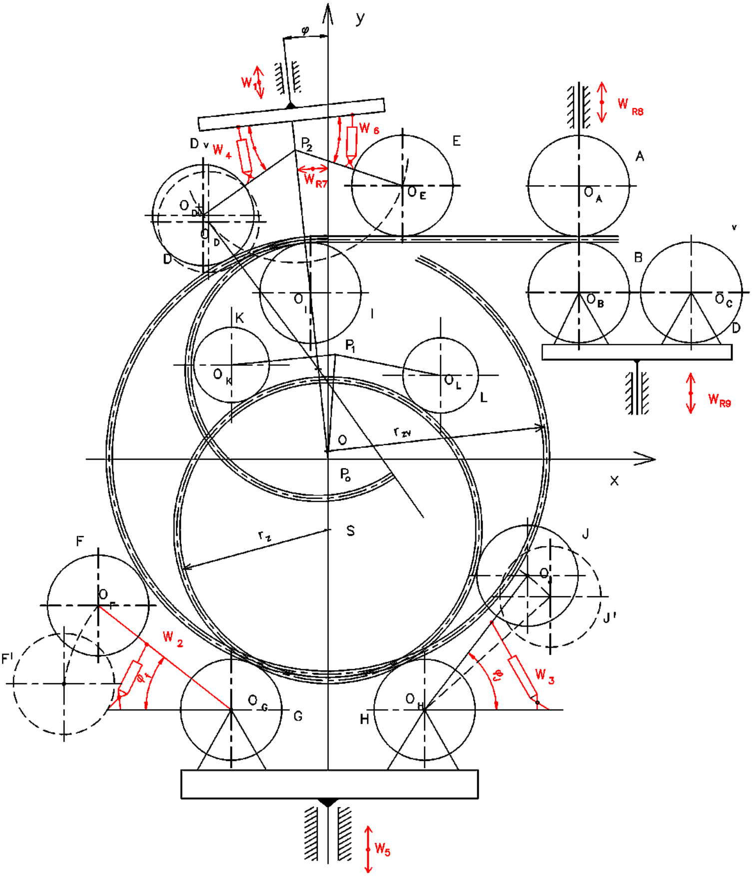

Figure 1 – The designations and functions of move mechanisms on the model of the coiling machine

If it is necessary, for constructional reasons, to change the setting-up of feeding rollers in relation to the axis of the strip, it is necessary to carry out the turning of the whole system towards the axis of rotation. This conception scheme was used in [4].

6 Conclusion. The mathematical model that solves the adjustment of all the rollers of the model of the coiling machine to the starting position was verified by means of experimental measurements. Results of the experimental measurements to verification of the principle of the formation of the first turn of the coil explained in chapter 4 in [6] prove that it is very important and necessary to adjust accurately the coiling rollers E, D, I and feeding rollers A, B, which is the most important condition for the formation of the coil with the required inner diameter and given tolerances. It is possible to state that the demand made on the inner diameter of the first turn of the coil of the metal strip has been met.

The tight winding of the coil without any spaces between particular turns is conditioned by the utilization of the suitable kinematic principle for strip coiling. The principle b) was used, described and theoretically justified in chapter 3 [6].

The model of the coiling machine must, equally to the real machine, enable the coiling of the strip into the coil with a flat front – i. e. non-telescopic coil. In the course of the experiment, it was found out that at non-corresponding ratio of the coil diameter to the strip width ($D_s >> b$), the instability of the coiling process occurred. For these reasons, guide rollers were placed on the loading table with the rollers F, G, H and J. They contributed to the stabilization of the process of coiling and secured the formation of the non-telescopic coil mainly during the first phases of the coiling process.

The constructional design of the model of the coiling machine makes it possible to unfinish the coiling of the end of the turn owing to the easy bending of the end away at the next potential technological treatment with the real operating machine. The incomplete coiling of the coil end can be solved with the model of the coiling machine in two ways.

The construction of the model of the coiling machine should have enabled the hot and cold coiling of the strip. Experimental works were done to simulate the hot coiling of the strip. Lead was chosen as a suitable model material, because its mechanical values approached the mechanical values of metals hot coiled. In the laboratory of the Department, coils are available that confirm the ability of the device to fulfill this requirement too [4–6].

The whole model of the coiling machine disposes of 9 basic functions that participate in the formation of the coil. Experiments confirm that the synchronization of all the functions with the model requires the automatic control of at least some mechanisms. The real machine, however, must be fully automated with reference to the connection with the rolling mill and incomparably higher velocities of coiling.

The knowledge obtained in the course of solving the problems is employed in the design of the real machine [6].

It has been theoretically verified and with the model of the coiling machine it has also been practically tested that the number of functions can be decreased to 5, designated u_1 to u_5, and thus the constructional demandingness of the real machine can be diminished, as documented in the conceptual scheme in Figure 2.

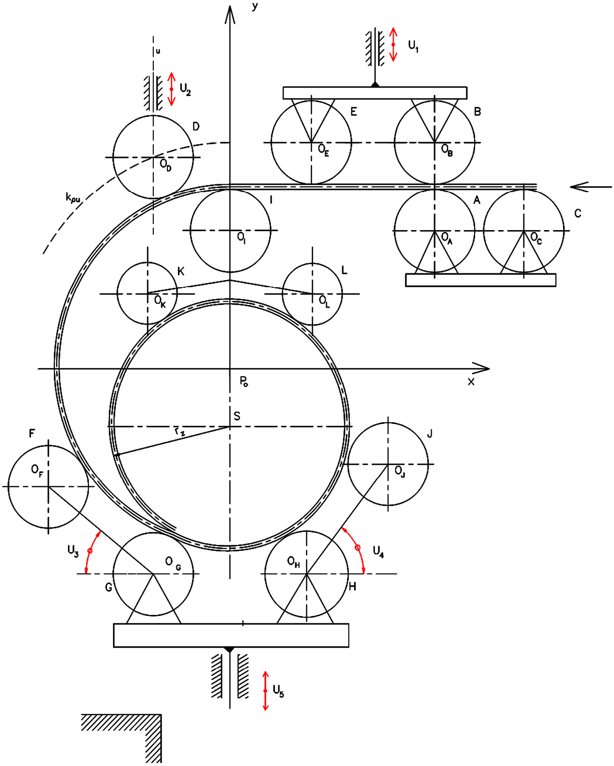

Figure 2 – Conceptual scheme for the real coiling machine

In the future the results of the work can be utilized for variant solving of the formation of the coil from steel strips hot rolled in the rolling mills of the type Steckel.

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АННА ПЛХОВА

МАТЕМАТИЧЕСКАЯ МОДЕЛЬ УПРАВЛЕНИЯ МАШИНОЙ ДЛЯ НАМОТКИ МЕТАЛЛИЧЕСКИХ ПОЛОС

В работе исследуется процесс намотки металлической полосы в рулон. Весь процесс намотки в модели наматывающей машины разделен на пять стадий. Для описания каждой стадии создана математическая модель, проверенная экспериментально. Полученные экспериментальные результаты подтвердили исходные теоретические предположения, которые легли в основу создания математических моделей, а также показали, что точная установка рулона и подающих роликов является необходимым и самым важным условием получения тугого рулона с требуемым внутренним диаметром. Вся модель намоточной машины имеет 9 основных функций, определяющих процесс намотки. Эксперименты доказывают, что синхронизация всех функций с моделью требует автоматического управления или, по крайней мере, частичной механизации.

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ИССЛЕДОВАНИЕ УСТОЙЧИВОСТИ ДВИЖЕНИЯ МНОГООСНОГО АВТОМОБИЛЯ В СЛУЧАЕ ВЫСОКОЙ РАЗМЕРНОСТИ ВЕКТОРА ЕГО СОСТОЯНИЯ

Описан один из возможных подходов к исследованию устойчивости систем высокого порядка. Рассмотрена задача неголономной механики об устойчивости прямолинейного движения многоосного автомобиля с передней и задней управляемыми осями. Взаимодействие пневматика с дорогой описана в соответствии с гипотезой Келдыша.

Дальнейшее увеличение производительности автомобильных транспортных средств невозможно без преодоления низкого уровня устойчивости их движения. Эксплуатационные свойства многоосных автомобилей изучены далеко не столь подробно, как простых двухосных. Ведущие зарубежные фирмы решают проблему создания многоосных машин качественно нового уровня в основном с помощью интуитивной эмпирики, требующей больших затрат для каждой модели. Решение этой задачи на стадии проектирования предполагает использование важнейших достижений фундаментальных наук. Распространение классических принципов механики на системы с неголономными связями и распределенными параметрами является на сегодня наиболее результативным. Эти методы широко используются в машиностроении.