(54) METHOD AND APPARATUS FOR CONTROLLING THE THICKNESS OF EXTRUDED STOCK

(71) We, THE GOODYEAR TIRE & RUBBER COMPANY, a corporation organised under the laws of the state of Ohio, United States of America, of 1144 East Market
5 Street, Akron, Ohio, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly descri-
10 bed in and by the following statement:—

This invention generally relates to process control and more specifically to a method and apparatus for accurately and automatically controlling the cut length thickness
15 of a continuously extruded elastomer that may be applied as tread stock in the manufacture of vehicle tires.

At present, the elastomeric stock used for tire treads is extruded is a continuous
20 sheet form of the desired width, cooled, and cut to the required length for a particular tire circumference. The thickness of tread stock has heretofore been controlled by an extruder operator monitoring the weight of
25 the extruded material since its weight is directly related to the material thickness.

Monitoring of the extrusion is accomplished manually by an operator comparing the weight of a running length of con-
30 tinuous extrusion as it passes over a running-weigh-scale (hereinafter referred to as the RWS) to the weight of a cut length of the material taken at a check weight scale (hereinafter referred to as the CWS) after
35 the extrusion is cooled and skived. The tread stock specification is established at the CWS with the RWS providing a means for the operator to make a first approximation inasmuch as the RWS and CWS are at
40 separate locations in the process. If, for example, the operator has determined that the weight and thus the thickness of cut tread stock is too high as taken at the CWS, he may vary the speed of a take-away belt posi-
45 tioned at the exit orifice of the extruder. By

increasing the belt speed, the extrusion is stretched and therefore a thinner tread stock will result. When the CWS value of tread stock is within specification, the operator again checks the weight value at the 50 RWS that produced the correct tread stock thickness and thereafter attempts to maintain the RWS at this value. Alternately, if the CWS value is too low, indicative of a thinner tread stock, the take-away belt may 55 be slowed down with the result being a thicker extrusion.

Thus, it must be appreciated that the present system of maintaining cut length extrusion thickness is primarily an operator 60 oriented operation and leaves much to be desired. For example, the operator is limited in the number of checks that may be made and during the time he is "zeroing-in" on the correct RWS weight a length of ex- 65 trusion will have passed that may have to be scrapped because it is out of specification as determined at the CWS. Further, the accuracy of the adjustments are at most a hit-and-miss propostion being dependent on 70 the operator doing the checks. In addition, changes in the extruded material are continually taking place due to environmental conditions and it is difficult to monitor the material often enough to maintain con- 75 tinual quality of cut tread lengths.

The present invention provides in one aspect a method of controlling the thickness of cut lengths of extruded elastomer in an apparatus which comprises an extruder for 80 providing a continuous sheet length of elastomeric extrusion, a variable speed take-away conveyor belt to vary the thickness of the extrusion as it leaves the extruder a running-weight-scale to measure the weight 85 per unit area of the continuous extrusion, a cooling train to set the extruded elastomer, a skiver to cut the continuous extrusion into specific lengths, and a check-weigh-scale to measure to cut length weight; 90

the method comprising the steps of:

A. sampling the weight of the extrusion at the running-weigh-scale each second;

B. computing and storing one-minute averages of the running - weight - scale samples;

C. sampling the weight of the cut lengths of extrusion at the check-weight-scale;

D. comparing the check-weight-scale value to the oldest stored running-weight-scale one-minute average to obtain a targeted running-weight-scale value;

E. comparing the targeted running-weight-scale value to the newest stored running-weigh-scale one-minute average to obtain a deviation from the targeted value if one exists; and

F. converting the deviation from the targeted running-weight-scale value to a control signal for increasing or decreasing the speed of the take-away belt to vary the thickness of the extrusion in accordance with the amount of deviation as it effects a change in the take-away speed of the belt.

In another aspect the invention provides an extruder for providing a continuous sheet length of elastomeric extrusion, a variable speed take-away conveyor belt to vary the thickness of the extrusion as it exits the extruder, a running-weigh-scale to measure the weight-per-unit-area of the continuous extrusion, a cooling train to set the extruded elastomer, a skiver to cut the continuous extrusion into specific lengths, and a check-weigh-scale to measure the cut length weight; and

A. means to sample the weight of extrusion passing over the running-weight-scale each second;

B. means to compute one-minute averages of the running-weigh-scale samples;

C. means to store the one-minute running-weight-scale averages;

D. means to sample the weight of the cut lengths of extrusion at the check-weigh-scale;

E. first comparator means to compare the check-weight-scale samples to the oldest stored running-weigh-scale one-minute averages to obtain a targeted running-weight-scale value;

F. second comparator means to compare the targeted running-weigh-scale value to the newest stored running-weigh-scale one-minute average to obtain a deviation from the targeted value if one exists; and

G. converting means to convert the deviation from the targeted running-weigh-scale value to a control signal for increasing or decreasing the speed of the take-away belt to vary the thickness of the extrusion in accordance with the amount of deviation as it effects a change in the take-away speed of the belt.

It is thus possible to provide an automated control system that is fast and accurate and which is capable of maintaining tread stock thickness within a closer tolerance than heretofore possible.

The method and apparatus is capable of detecting system malfunctions at an early stage such as to eliminate long lengths of extruded scrap material.

Further, tire tread extrusions that exhibit uniformity in thickness and therefore offer increased quality than heretofore possible may be produced.

The single drawing is a block flow diagram illustrating a prefered feedback control method according to the invention.

Referring to the drawing, a process line for extruding elastomeric material is generally indicated by reference numeral 10. The line conventionally comprises an extruder 12 for producing a sheet of elastomeric extrusion 14 that is carried away by a conveyor 16 being driven by a motor 18. The conveyor is generally referred to as a "take-away belt" and its purpose is to control elongation of the extrusion according to the take-away speed of the belt. The extrusion 14 is carried across a running-weigh-scale 20 to provide a measure of the weight per-unit-area of a typical section of the continuous extrusion as it passes thereover. From the RWS the extrusion passes through a cooling train 22 to establish a "set" in the material so that it may be handled further by a skiver 24 that cuts the extrusion into a suitable length for production use. For example, in a tire manufacturing facility the extrusion will be the tread portion of a tire and it is therefore cut to the desired tire circumference. Upon leaving the skiver the cut length tread sections are weighed at a check-weigh-scale 26 to make certain that all treads are within a thickness specification since the weight is directly related to the thickness of the extrusion.

A control system generally indicated by reference numeral 30 is provided to adjust the take-away belt speed and thus the thickness of the extrusion 14. Accordingly, a sample of the RWS measurement is taken once every second at 32, which sample is an electrical signal indicative of the weight of extrusion on the RWS 20. These one-second samples are averaged each minute at 34 to provide a RWS average weight of material for a specific length on the RWS. The one-minute RWS averages are next stored in separate registers "A" to "n" generally indicated by reference numeral 36. While the "A" register accepts the newest RWS one-minute average, the "n" register stores the oldest RWS average with the number of "n" registers dependent upon

the time it takes for the extrusion that was first weighed on the RWS to pass through the cooling train 22 and skiver 24 and ultimately to the CWS 26. For example, if it takes six minutes for the material first weighed at the RWS to reach the CWS, the "n" register is the 6th register and the oldest stored RWS average is six minutes old and corresponds to the extruded material that was sampled on the RWS six minutes ago.

To continue, the CWS is also sampled at 38 and the signal indicative of the CWS value is compared at 40 to the oldest stored RWS average in the "n" register to provide a targeted RWS value 42 (i.e. what the RWS valve should be when the apparatus is working perfectly).

The targeted RWS valve is next compared at 44 to the newest stored RWS average in the "A" register to provide a deviation control signal 46 if a deviation between the two exists. The deviation control signal is used to control the drive motor 18 and thus the conveyor belt speed to correct the extrusion thickness in accordance to the amount of the deviation.

The advantages of the above-described system should now be apparent. Firstly, the response time of the system is faster than what could be achieved by an operator-controlled system. Secondly, the system stores past history and because it does, it is able to hold the cut length extrusions to a much tighter tolerance than could be achieved by an operator. Thirdly, the system is able to detect process malfunctions such as feed-strip breaks, etc., in a shorter time, thus eliminating long lengths of scrap material.

WHAT WE CLAIM IS:—

1. A method of controlling the thickness of cut lengths of extruded elastomer in an apparatus which comprises an extruder for providing a continuous sheet length of elastomeric extrusion, a variable speed take-away conveyor belt to vary the thickness of the extrusion as it leaves the extruder, a running-weigh-scale to measure the weight per unit area of the continuous extrusion, a cooling train to set the extruded elastomer, a skiver to cut the continuous extrusion into specific lengths, and a check-weigh-scale to measure the cut length weight; the method comprising the steps of:

A. sampling the weight of the extrusion at the running-weigh-scale each second;

B. computing and storing one-minute averages of the running-weigh-scale samples;

C. sampling the weight of the cut lengths of extrusion at the check-weigh-scale;

D. comparing the check-weigh-scale value to the oldest stored running-weigh-scale one-minute average to obtain a targeted running-weight-scale value;

E. comparing the targeted running-weigh-scale value to the newest stored running-weigh-scale one-minute average to obtain a deviation from the targeted value if one exists; and

F. converting the deviation from the targeted running-weigh-scale value to a control signal for increasing or decreasing the speed of the take-away belt to vary the thickness of the extrusion in accordance with the amount of deviation as it effects a change in the take-away speed of the belt.

2. A method according to Claim 1, wherein the running-weigh-scale one-minute averages are stored in a series of "A" to "n" registers, the "A" register accepting the newest computed one-minute average while the "n" register stores the oldest one-minute average, the number of "n" registers being equal to the number of minutes the extrusion takes to pass from the running-weigh-scale to the check-weigh-scale.

3. Apparatus for controlling the thickness of cut lengths of extruded elastomer comprising: an extruder for providing a continuous sheet length of elastomeric extrusion, a variable speed take-away conveyor belt to vary the thickness of the extrusion as its exits the extruder, a running-weigh-scale to measure the weight-per-unit-area of the continuous extrusion, a cooling train to set the extruded elastomer, a skiver to cut the continuous extrusion into specific lengths, and a check-weigh-scale to measure the cut length weight; and

A. means to sample the weight of extrusion passing over the running-weigh-scale each second;

B. means to compute one-minute averages of of the running-weigh-scale samples;

C. means to store the one-minute running-weight-scale averages;

D. means to sample the weight of the cut lengths of extrusion at the check-weight-scale;

E. first comparator means to compare the check-weigh-scale samples to the oldest stored running-weigh-scale one-minute averages to obtain a targeted running-weight-scale value;

F. second comparator means to compare the targeted running-weigh-scale value to the newest stored running-weigh-scale one-minute average to obtain a deviation from the targeted value if one exists; and

G. converting means to convert the deviation from the targeted running-

weigh-scale value to a control signal for increasing or decreasing the speed of the take-away belt to vary the thickness of the extrusion in accordance with the amount of deviation as it effects a change in the take-away speed of the belt.

4. Apparatus according to Claim 3, wherein the means to store comprises a series sequence of "A" to "n" registers, the "A" register accepting the newest computed running-weigh-scale one-minute average while the "n" register stores the oldest computed one-minute average, the number of "n" registers being equal to the number of minutes the extrusion takes to pass from the running-weigh-scale to the check-weigh-scale.

5. A method of controlling the thickness of cut lengths of extruded elastomer substantially as described with reference to and as shown in the drawing.

6. Apparatus for controlling the thickness of cut lengths of extruded elastomer substantially as described with reference to and as shown in the drawings.

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