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[54] **GRANULATOR DEVICE AND HELICAL-SHAPED CUTTERS THEREFOR**
11 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **241/61,** 83/342, 83/345, 241/73, 241/236
[51] **Int. Cl.** **B02c 21/00**
[50] **Field of Search** 83/303, 341, 342, 345, 673, 906, 913, 923; 241/61, 73, 236, 18

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ABSTRACT: Granulator device for quietly shearing brittle or stretchy materials such as various types of plastics as well as thin metal into small pieces which can be easily handled. A pair of meshing cutters used in the device comprise helical toothed members such as gears which have each had their tooth shapes modified from a standard form so as to exert a scissors-type cutting action on work material fed to them as a continuous web, as individual pieces, or a combination of the two.

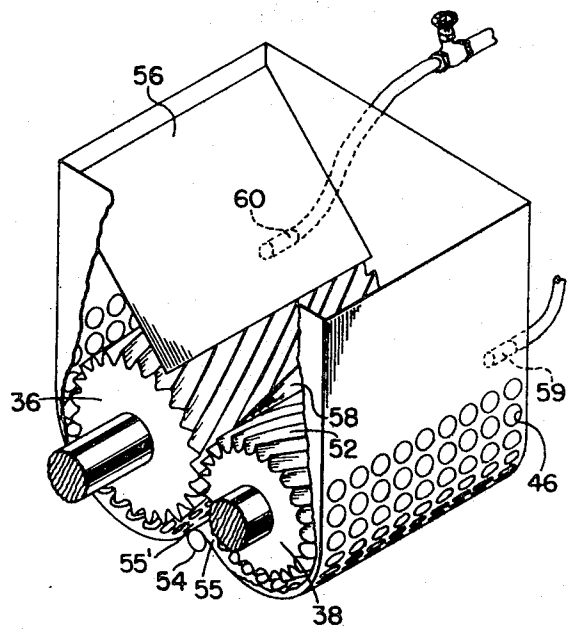


Fig. 1

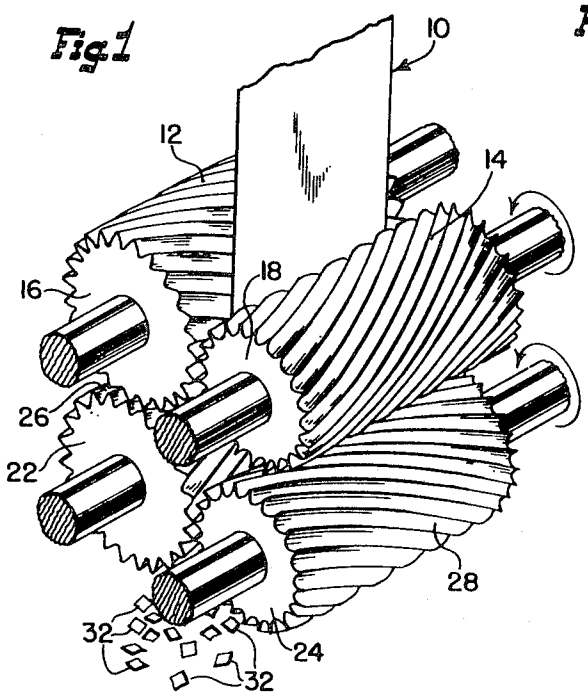
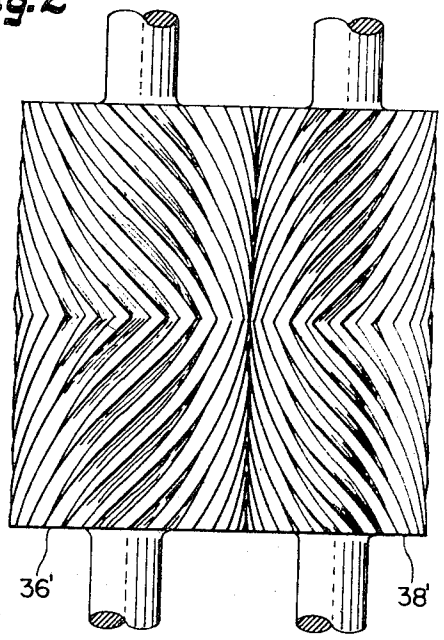


Fig. 2



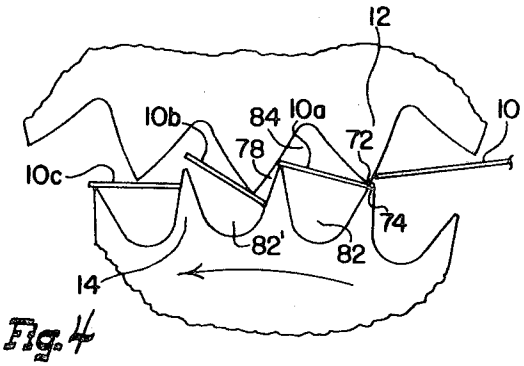


Fig. 4

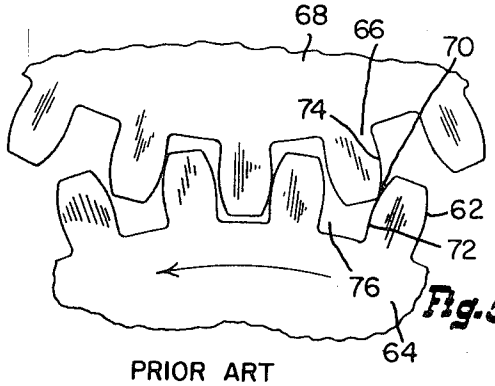


Fig. 5

PRIOR ART

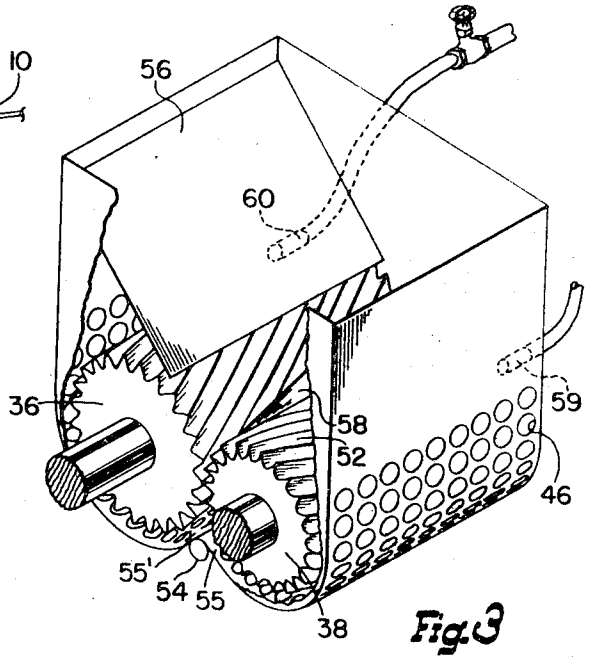


Fig. 3

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GRANULATOR DEVICE AND HELICAL-SHAPED CUTTERS THEREFOR

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of application Ser. No. 724,833 filed Apr. 29, 1968, now U.S. Pat. No. 3,529,777.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to cutting devices for reducing relatively large and unwieldy pieces or webs of material to a size which can be handled readily. The invention particularly relates to a device for reducing a continuous web and/or cutouts of scrap material formed incident to an article-forming operation to a size which can be easily handled and readily mixed with new material for reuse without the necessity for utilizing several handling and reduction steps.

2. Description of the Prior Art

Devices for reducing web or individual pieces of scrap material to a smaller more usable size are readily available. Many of such devices are commonly referred to as hammer mills and comprise a shaft rotating at high speed upon which is mounted a crushing element consisting of either fixed or pivoted hammers or cutters. Most such hammer mills reduce the material by impact while it is in suspension by driving it against a breaker plate where a great deal of reduction takes place. By placing a perforated cage or screen under the hammers the material will be acted upon by the hammers until it has been reduced to a small enough size to be discharged through the openings in the cage or screen. Although devices of the hammer mill variety are capable of granulating material, they suffer from the considerable disadvantage that the cutting operation produces an extremely high noise level due to the impact of the hammers on the material. The devices are also somewhat inefficient to their capacity to handle material since there are generally only a few blades on a cutter. Because of the extremely high noise level common to prior art granulators as well as their relatively large size it has been commonplace to locate the granulator equipment in a remote location relative to the article-forming equipment in an attempt to reduce the noise level with respect to the ears of workers associated with the article-forming equipment. Obviously, by positioning the granulating equipment in a remote location it is necessary to either install a conveying system for carrying the material to be granulated to the granulators or else to collect it where it is produced and carry it to the granulators. In the case of scrap material in the form of a web from which articles have been punched, it is usually necessary in the absence of conveyor equipment, to wind the web material on reels and then carry it to the granulator where it is unwound. These steps require the use of additional machines and personnel.

SUMMARY

It is an object of this invention to provide a granulating device which is extremely quiet and capable of being used to close relationship to a device producing scrap as a byproduct of a forming operation.

A further object of this invention is to provide a granulating device which can receive and readily dispose of material fed to it either continuously in the form of a web, in batches including several thicknesses of material, or in a combination of continuous and batch-fed material.

Another object of the invention is to provide a granulating device which can handle either brittle or stretchy materials.

Another object of the invention is to provide a granulating device which has cutter members which are readily manufacturable on conventional lead forming equipment.

A further object of the invention is to provide a granulator device having cutters which can easily cut the work placed between them without excessive loading or wear and whose cutting ability increases when plural layers of work are presented to them at one time.

An additional object of the invention is to provide a granulator device which is extremely compact, efficient, and inexpensive to produce and maintain.

These objects are achieved by the granulator device of the present invention which preferably comprises two sets of cutters which are arranged to cut material fed into them into diagonal strips as it passes through the first set of cutters and into generally diamond-shaped or square pieces as the diagonal strips pass through the second set of cutters which have their cutting edges arranged at approximately right angles to the cutting edges of the first set of cutters. Each of the sets of cutters is comprised of a pair of cutter members having a plurality of helically arranged cutter teeth having the same lead angle but of opposite hand. The cutter members are preferably formed on lead cutting machines such as are commonly used to form gears or helical cutters. Hobbing and milling machines are examples of such machines. Where the cutters are formed on gear forming equipment they are given tooth shapes which differ considerably from the conventional involute tooth form.

In order to provide an effective shearing and penetrating action on one or more layers of material passing between the cutting teeth, the teeth on each cutter member are preferably quite thin at their tips. To permit cut stock to exit freely after cutting, the teeth are mounted to be only in slight overlapping engagement and of a size that they constitute only a small portion of the tooth space. The axes of the cutters are preferably mounted to provide profile contact at the tip of each gear but only a slight degree of overlapping engagement of the teeth. The overlapping engagement must be sufficient to keep the teeth in mesh and permit one cutter member to drive the other. The overlap also permits the teeth to engage each other at a point spaced from a plane connecting their centers so that the teeth coact like a pair of scissors. Since the profiles on the teeth only contact at the tips, they stay in contact along their axial length as they rotate relative to each other. The cutting edges are in continuous contact along the lead and present no problem with loss of contact carryover since they have many pairs of corresponding teeth which are in engagement with at least one point on their mating surfaces at all times.

Although it is preferable to use two sets of cutters to cut the work to a desired size in a single pass and achieve maximum handling capacity, it is also possible and often desirable to utilize only a single set of cutters. When a single set of cutters is used, it is necessary, if a small sized product is desired, to recirculate the cut strips and pieces. Recirculation, such as by means of a perforated screen will reduce the material to a size which will pass through the perforations, Such a system has less capacity than a system with a double set of cutters but has many advantages including: lower cost, requires less space, and has an ability to reduce the final product size to a dimension far less than the spacing of the cutter teeth by utilizing a finely perforated screen.

The teeth of each pair of cutters coact in the fashion of a pair of scissors in that the mating teeth move continuously into sliding contact with each other along the entire length of a line defined by the intersection of their tips and one side edge as the cutters rotate. The cutter teeth overlap each other over only a small portion of their length at any one time and are withdrawn from engagement as soon as they have performed their cutting function. The teeth of the cutters of the present invention may be quite easily sharpened by removing only a small amount of material from their outer diameters. However, sharpening is rarely necessary since the teeth have a very long life due to the fact that their extremely thin tips act to easily penetrate the material being cut and thus do not cause extensive radial loading of the teeth. Furthermore, once the teeth have penetrated the material they are merely in sliding engagement with each other such that the main tangential loading consists merely of the force exerted by the driving gear on the driven gear to cause it to rotate. Although the driving force exerted by the driving teeth on the driven teeth is sufficient to maintain the cutting edges in contact for cutting

fairly brittle materials like polystyrene plastic, it is sometimes desirable to apply a slight additional amount of tangential loading to the teeth to positively assure a cut on the first pass when cutting thin extremely elastic material such as polyethylene sheeting. Although such additional tangential loading could be applied by adding a drag effect to the driven cutter (such as by means of a friction clutch) such loading is not generally necessary if a recirculating screen is used due to the fact that incompletely severed material will be carried around the outside of the cutters and represented to them for cutting until it has been granulated to the desired size. Due to the particular design of the teeth wherein at least one cutter has very large spaces between its teeth a great number of layers of material can be accommodated between them. As the thicknesses of material in the tooth spaces build up due either to the presence of incompletely severed material or multiple thicknesses of newly presented material, they exert a tangential force on the cutting edges which places them in tighter contact with each other and insures a severing of the work. This particular property of the cutting teeth renders them able to cut only web stock of vastly differing materials which is fed to them continuously, but also permits them to cut small pieces of material which present themselves to the cutters in batches which sometimes include several overlapping layers.

The forgoing and other objects, features and advantages will be apparent from the following more particular description of a preferred embodiment of the granulator device of the invention and the cutters used therewith, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a device incorporating two cooperating pairs of the cutter members of the invention and showing the cutting of a sheet of material into little pieces;

FIG. 2 is a top view of cutter members similar to those shown in FIGS. 1 and 3 but having their helical teeth in a herringbone pattern.

FIG. 3 is a perspective view of a modified form of the device shown in FIG. 1 wherein only one set of cooperating cutter members is used;

FIG. 4 is an enlarged sectional view showing the relationship of a pair of coacting cutters relative the material being cut in a plane perpendicular to the axes of a pair of cutters; and

FIG. 5 is an enlarged sectional view similar to FIG. 4 but showing the relationship of a pair of ordinary mating involute gears of the general type ordinarily produced by the tool used to produce the cutters of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, material to be granulated such as a web indicated generally at 10 is fed downwardly into the bite of intermeshing teeth 12 and 14 on an upper set of cutter members 16 and 18 respectively. Since the teeth 12 and 14 are arranged helically about the cutter members 16 and 18, they will progressively cut the material 10 into a plurality of parallel strips which will drop downwardly. The diagonal strips of material 10 will then enter the bite of a second lower set of cutter members 22 and 4 which have helical cutter teeth 26 and 28 respectively arranged at approximately right angles to the cutter teeth 12 and 14. Because the teeth 26 and 28 are at an angle to the teeth in the first of cutters, the parallel strips of material which leave the first set of cutters will be cut transversely and will emerge from the second set of cutters as little square of diamond-shaped chips 32.

FIG. 3 shows a modified form of an apparatus which is generally similar to the apparatus of FIG. 1 in that it utilizes a set of cooperating cutter members 36, 38 which may be identical to the cutter members 16, 18 or 22, 24 shown in FIG. 1. Inasmuch as material fed into the bite of cutters 36, 38 cannot be cut into small chips or squares in a single pass through the cutters, a recirculating screen 44 is placed around the cutter members in close proximity thereto. The screen 44, which has perforations or holes 46 around its entire lower portion severs as a guide or restraining member for keeping pieces of cut material which are not small enough to be discharged through holes 46 in contact with cutter teeth 50, 52 so that they will be carried around the cutters and presented to the bite of the cutter as many times as might be necessary to cause them to be cut into a size sufficiently small to be discharged through the holes in the screen. The spacing of the screen 44 from the cutters 38, 36 by a support bar 54 to form material accepting throats 55, 55' is somewhat critical. If the support bar 54 is too close to the cutters the throat 55 formed between the cutters and screen cannot accept the large volumes of material cut by the cutters at their maximum feed rate and the material may back up and either reduce the cutting rate or act like brakes to slow or stop the cutters. When the support bar 54 is too far from the cutters, a portion of the material to be recirculated may tend to mat upon the screen 44 and block the discharge of small pieces of material through the holes 46. At a proper spacing, the throats 55, 55' will not only pass the maximum output of the cutters 38, 36 but will insure that the material to be recirculated is held close enough to the cutter teeth 52, 50 so as to either be moved directly or indirectly by them. For the particular cutters shown in FIG. 4, a spacing of 0.125 in. has been found to be quite suitable for use with material of a thickness of about 0.031 in. In order to help prevent the recirculated pieces of material from flying upwardly out of the device, a pair of cover plates 56, 58 are mounted relative to the cutters. The cover plates 56, 58 also serve an added function of funnelling material fed to the device into the bite of the cutters. The cover plates 56, 58 are especially useful for insuring continuous feeding of material through the apparatus when the material being cut is in the form of individual pieces fed in batches, as compared to continuous web material. Without some type of cover plates, such material, especially if it is slippery, may occasionally lie flat over the bite of the rolls and form a bridge which will hold and prevent the feeding of additional pieces of material. The cover plates 56, 58 help prevent this "bridging" by causing the majority of material dropped into the device to slide toward the bite at an angle rather than dropping with its plane surface horizontal. Since a single pair of cutters (FIG. 4) will tend, due to the helical pattern of its teeth, to drive the recirculated material to auger fashion to one end of the cutters, a stream of compressed air from nozzles 59, 60 may be directed in the opposite direction between the cutters of the cover plates 56, 58 to redistribute the material and even out the cutting loads on the teeth. To avoid the use of air and achieve fairly even distribution, the cutters may be given a herringbone rather than a straight helical pattern as shown at 36', 38' in FIG. 2.

For the sake of simplicity, the representations of the invention as shown in FIG. 1 and 3 have omitted many details such as the frame, bearings, mounting devices and drive means. It should be noted though, that the principles of the invention demand that only one of the pairs of cutters in each cutter set be driven and for this reason the cutters must be accurately and rigidly mounted relative to each other. The mounting must permit the driving cutter to always maintain driving contact with the driven cutter even though the cutter teeth overlap by a very slight amount.

The particular shapes of the cutter teeth in each cooperating set of cutters is not critical as long as cooperating teeth move into initial contact with each other along their lead lines at the intersection between their outer diameters and tooth profiles so as to provide a shearing action which is maintained continuously as new portions along the length of the tooth are brought into contact during rotation of the cutters.

In order to better explain the distinctions between cutter teeth such as those shown in FIG. 4 which have been formed by an ordinary gear forming hob and normal gears formed by a similar hob, a showing of the meshing relationship of ordinary gear teeth is set forth in FIG. 5. In FIG. 5, a tooth 62 of a driving gear 64 enters engagement with a tooth 66 of a driven gear

68 at a point 70 on its involute surface 72. The involute surface 72 of tooth 62 then remains in sliding contact with the involute surface 74 on tooth 66 until the teeth move out of contact. It is easy to see that such a design could not effectively be used to cut and dispose of sheet material since the tips of the teeth would interfere with entry of material to the point 70 where cutting might conceivably be expected to take place. Furthermore, the material would not be sheared by the passage of two edges past and alongside of each other as in the cutters of the invention but would tend to be pressed against the involute surface 74 at the tip of tooth 66 by the surface 72. To obtain any possibility of severing, the tooth loading would have to be extremely high and the tips of the teeth made sharp and unchamfered, a condition which would cause excessive wear on the involute surfaces, and a rapid rounding of the tip edges. Also, after severing, the severed material would most likely be jammed into the tooth space 76 as tooth 66 moves further and further into the tooth space. The jammed material would almost certainly remain in the tooth space and would build up until the gears 68 and 64 were forced apart and their cutting contact lost.

To achieve a cutting action which is much quieter, and far more efficient than a hammermill, the cutters 16, 18 of the present invention are formed with a tooth shape quite different from the ordinary gear teeth of FIG. 5 so that their teeth 12, 14 respectively will shear the work material continuously at all times during their rotation and will move the work at their own rate of rotation. This is quite in contrast to a hammermill where there are only two or three cutters and the cutting action is one of chopping or punching.

The desired cutting action can be achieved by forming the cooperating cutters in a variety of ways and with varying shapes. Generally, the cutters can be formed on any type of lead-forming equipment which will produce helical gears or cutters. The particular shape shown in FIG. 4 can be produced with a standard hob by using over and undersized blanks.

To function in a granulating device in accordance with the invention, the cooperating cutters 16, 18 must have the same helical lead so that one cutter can drive the other and so that successive points along the line 72 on which the tooth form intersects the outer diameter to any tooth 12 will engage successive points on a similar line 74 on its mating tooth 14 as the cutters rotate and for the entire length of each tooth along the cutter body. The shape of the teeth must also be such that at the point of cutting, the cutting edges of the teeth will be moving past each other in a generally radial direction. Such a cutting action means that the teeth 14 need only exert the relatively small force on the work material which is necessary to shear it as compared to punching it or crushing it. Since this force is relatively small and transmitted substantially radially from the point of contact to the cutter body, the teeth may be made quite thin at their tips. As the tips are made thinner, their ability to penetrate the work increases and the cutting forces are reduced still further. The theoretical limit on the thinness of the tips of the teeth is controlled generally by the strength required to permit the driving teeth to drive the driven teeth. A further limitation on tip thickness can be introduced by the fact that the profiles of the teeth should be relieved back to their tips to insure that the respective teeth can only engage on their leading edges. Such relief also reduces the possibility of previously cut work material getting between the teeth as they overlap after cutting in the region 78 and forcing the succeeding teeth out of engagement. Also, depending upon the particular type of tool and method used to form the cutter teeth, the teeth might have to be formed with an undercut back of the tip which would weaken the tip. Although thinner teeth perform more efficiently since they penetrate material with less effort than thicker teeth, it is possible for the width of the tooth at its maximum depth of penetration of a tooth space of a cooperating tooth to have a width as great as 40 percent of the tooth to tooth distance as measured on a circle through the teeth at the point of maximum penetration. For the teeth 14 shown in FIG. 4 this width figure would be about 15 percent as compared to a width of about 50 percent for a conventional gear tooth 62 as shown in FIG. 5.

Another important distinction of the cutters of the present invention is that they are mounted so that they have a limited amount of overlap. Some overlap is desired to permit cutter 18 to drive cutter 18 and to insure that the cutting edges 74, 72 will slide over each other to shear the work material. However, the overlap should be limited so that the tooth spaces 82, 84 will be kept relatively open after cutting to permit the cut pieces 10*a*, 10*b* and 10*c* of the material 10 to assume the approximate positions shown in FIG. 4 wherein they can freely exit from the teeth and not become jammed in the tooth spaces 82, 84. A penetration of the teeth of one cutter into the tooth spaces of a mating cutter of about 25–35 percent has been found to give good results.

Occasionally, when the cutters 16, 18 are used with thin slippery material such as polyethylene, the driving force of cutter 18 on cutter 16 without some supplemental drag force added to cutter 16 may be insufficient to prevent the material from moving parallel to the sides of the teeth at points 72, 74, and being corrugated and carried around the cutters rather than cut and released. Even though such a situation is rare, it is of no particular concern since it can be seen in FIG. 4 that if the layers of material 10*b* in tooth space 82′ were multiplied so as to fill the tooth space entirely, additional layers would, in moving from space 82 to space 82′, be compressed due to the fact that the teeth 12, 14 are closer together than they are in tooth space 82. The material 10*b* being compressed would then exert a force to move teeth 12, 14 away from each other and thereby bring cutting edges 72, 74 into tighter contact whereby they would completely cut the next material contacted.

Although cutter members having the requirements set forth herein can be made by many processes, the particular properties of the cutters shown in FIG. 4 will be described. The process used to make the cutters was one of hobbing an oversized and an undersized blank with a single hob brought into the work to a point just short of "topping" (touching the root of the hob to the work). To enable a comparison to be made between the hob produced cutters of FIG. 4 and a standard gear produced by the same hob, the table below includes data relating to such a gear also.

Gear Tooth Data

Gear Tooth Data	Standard Gear	Cutter 18	Cutter 16
Number of Teeth	34	same	same
Normal Diametral Pitch	12	same	same
Pitch Diameter	4.0069	same	same
Lead	12.58808	same	same
Helix Angle	45°	45° RH	45° LH
Normal Pressure Angle	20°	same	same
Outer Diameter of Gear	4.1735	3.750	4.500
Root Diameter	3.8135	3.250	4.000
Hobbing Depth	0.180	0.250	0.250

Although 12 pitch cutters have been described, it is possible to use various pitches depending on the size chip desired and the strength of the material being cut. A 12 pitch cutter will provide a chip about one-quarter inch wide and is quite suitable for thin sheet material. For cutting up stronger or thicker material, such as thin metal or the sprues and gating material which results from a plastic molding operation, a lower pitch cutter is preferred for its extra strength. Although the particles produced with a low pitch cutter are much larger than with a cutter having a higher pitch, they can recirculated to any size desired by use of an appropriate screen.

While the invention has been shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that variations in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. Granulator apparatus for cutting material comprising an elongated first cutter member having a plurality of helically arranged cutting teeth, a second cutter member having a plurality of helically arranged cutting teeth meshing with and driving said plurality of cutting teeth of said first cutting means for mounting and rotatably driving said first and second cutter members with the driving side edges of the tips of the teeth on said second cutter member being in driving engagement with the driven side edges of the tips of the teeth on the first cutter member, the lines of intersection of the outer peripheries of the cutter members with said side edges forming cutting edges which cooperate to shear material placed between them immediately prior to the time at which the side edges on the second cutter member commence to overlap the side edges of the first cutter member and permit the cutting edges of the second cutter member to drive the cutting edges of the first cutter member, the tips of said teeth of the second cutter member measured along a circle at their maximum depth of overlapping penetration into the tooth spaces of the first cutter having a thickness no greater than 40 percent of the tooth to tooth distance between corresponding points of adjacent teeth as measured along the same circle, the maximum overlapping penetration of the tips of the teeth on said first and second cutter members being limited to facilitate exit of cut material from the tooth spaces, said shearing engagement taking place progressively and continuously along the length of several teeth at one time at points spaced from a plane containing their axes.

2. The granulator of claim 1 wherein said first and second cutter members comprise a first set of cutters which are adapted to shear material fed downwardly into their bite into a plurality of parallel strips which are formed at an angle to their direction of feed which is equal to the helix angle of the cutters forming them; said granulator further including a second set of cutters mounted adjacent to said first set and having its bite directly beneath the bite of the first set, the second set of cutters comprising third and fourth cutter members which are similar to said first and second cutter members respectively except that the helix angles of their teeth are arranged transversely to those of the cutter members positioned directly above them, whereby the parallel strips of material fed to them by the first set of cutters will be transversely sheared into generally rectangular-shaped particles.

3. The granulator of claim 1 and further including recirculating means for receiving material sheared by said cutter members and ejecting any portion of the material which is of smaller dimension than a predetermined size and carrying the remaining portion of the material upwardly around the cutter members and representing it to the bite of the cutter members.

4. The granulator of claim 3 wherein said recirculating means includes means for moving material being carried upwardly around the cutter members in a direction longitudinally of the cutter members and opposite to the general longitudinal direction in which the material is moved when it is engaged by the helical cutter members.

5. The granulator of claim 4 wherein said means for moving material comprises a source of air which is directed against material being recirculated to the cutter members to cause it to be moved and evenly distributed over the length of the cutter members.

6. The granulator of claim 3 wherein said recirculating means comprises screen means which is positioned adjacent the bottom and outer peripheral side portions of the cutter members, said screen means being perforated with openings corresponding in size to the size of the largest particle of cut material to be ejected, said recirculating means further comprising deflecting members for intercepting cut material guided upwardly by said screen member and directing it into the bite of the cutter members.

7. The granulator of claim 1 wherein each cutter member has its helically arranged teeth in a herringbone pattern wherein the teeth along one longitudinal portion of the cutter have a helix angle arranged transversely of the helix angle of the teeth of an adjacent longitudinal portion.

8. The granulator of claim 1 wherein said teeth on said second cutter member have a maximum tooth penetration into the tooth spaces of the first cutter member of 35 percent of their length and a maximum tooth thickness of 25 percent of said tooth to tooth distance, the sides of the teeth on said first and second cutter members being relieved behind their cutting edges to prevent contact of the teeth of said cutters except by their cutting edges.

9. A pair of cutting members for use in a granulating device comprising: a first rotatable, generally cylindrical cutting member having a plurality of helically arranged teeth, at least a portion of which are of a predetermined hand and arranged along its outer periphery at a predetermined helix angle relative to a plane passing through the axis of the cutter member; a second rotatable, generally cylindrical cutting member having a plurality of helically arranged teeth adapted to be positioned in driving meshing engagement with the teeth on said first cutting member the teeth on said second cutter being of an opposite hand and of an equal but opposite helix angle relative to the teeth which they engage on the first cutter member; said teeth on each of said cutters having cutting edges which are adapted to cooperate to shear material fed into their bite and to transmit driving motion of said second cutter members to said first cutter member, said cutting edges being defined by the lines of intersection of a side profile of each of said teeth with its outer periphery, said teeth on said second cutter member having tips which are of a thickness measured along a circle at their maximum depth of penetration into the tooth spaces of the first cutter member of no more than 40 percent of the distance between corresponding points of adjacent teeth on the same circle, the penetration of the teeth of the second cutter into the tooth spaces of the first cutter being limited, the teeth on at least one of said cutter members being relieved along substantially their entire profiles rearwardly of their cutting edges to prevent contact of the teeth of the two cutter members except at their cutting edges, the cutters being arranged so that a plurality of first cutter teeth penetrate tooth spaces in the second cutter simultaneously.

10. A pair of cutting members in accordance with claim 9 wherein the teeth of said second cutting member are of less thickness than the teeth of the first cutting member at any point of equal penetration of either into a tooth space of the other, said second cutting member being smaller in outer diameter than the first cutting member.

11. A pair of cutting members in accordance with claim 9 wherein the thickness of the teeth of said second cutting member on the outer periphery of the cutter is less than 20 percent of the tooth to tooth distance on the periphery.

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