

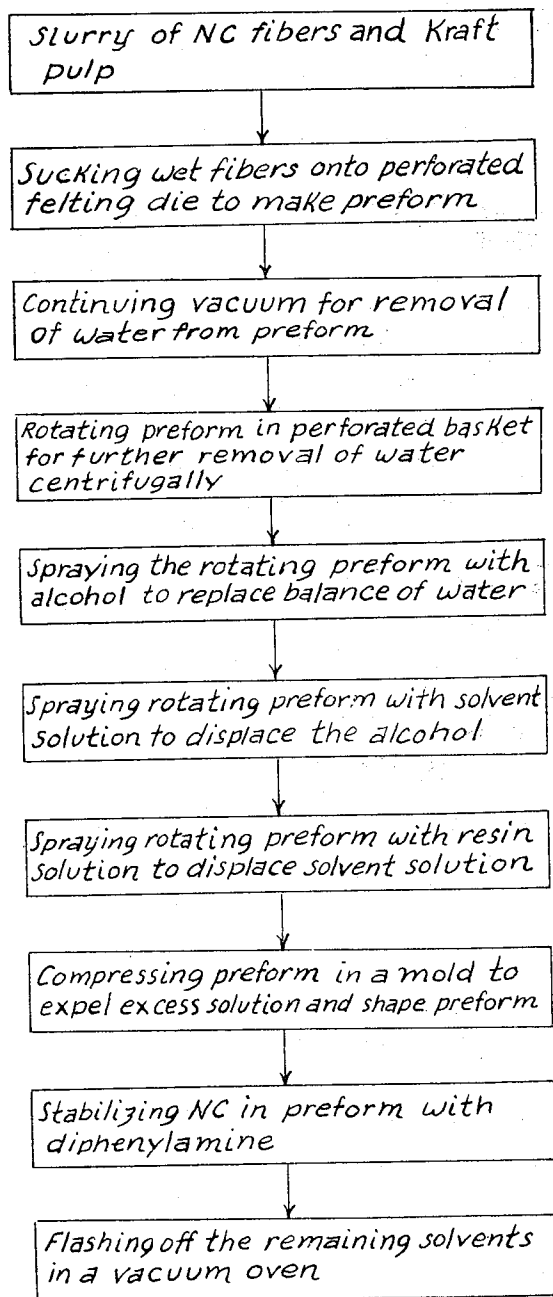
Oct. 28, 1969

R. F. REMALY ET AL

3,474,702

FELTING PROCESS FOR MAKING COMBUSTIBLE CARTRIDGE CASES

Filed Dec. 16, 1965



INVENTORS,

Robert F. Remaly
William P. Shefcik
Malcolm B. Nelson

BY: Harry M. Saragovitz,
Edward J. Kelly &
R. P. Gibson

ATTORNEYS.

1

3,474,702

FELTING PROCESS FOR MAKING COMBUSTIBLE CARTRIDGE CASES

Robert F. Remaly, Olympia Fields, William P. Shefcik, Glenwood, and Malcolm B. Nelson, Park Forest, Ill., assignors, by mesne assignments, to the United States of America as represented by the Secretary of the Army
Filed Dec. 16, 1965, Ser. No. 513,872
Int. Cl. F42b 33/00; C08c 17/16

U.S. Cl. 86—1

1 Claim

ABSTRACT OF THE DISCLOSURE

A combustible cartridge case comprising felted nitrocellulose (NC) fibers impregnated with resin, and mixed with kraft fibers to impart strength. In making the case, the fibers from a slurry are made into a porous preform, excess water is removed mechanically, the preform is impregnated in a mold with resin in a solvent solution, and the solvent is then flashed off in a vacuum.

This invention relates to combustible cartridge cases and a method of preparing such a case that will conform to military requirements.

Previous investigation in this field was primarily concerned with the resolution of the basic ballistic problems related to the development of certain compounds and methods such as those covered in the application of Kieth F. Beal et al., Ser. No. 318,453, filed Oct. 23, 1963, entitled Felting Process for Making Combustible Cartridge Cases. During the testing of these compounds it was evident that the formulation was unacceptable for artillery application because of the copious quantities of muzzle smoke which were produced on firing.

It is therefore an object of this invention to produce a cartridge case that is completely combustible on firing with no excessive emanation of smoke.

Primarily this object is accomplished by felting nitrocellulose (NC) fiber into a porous form of a cartridge case and impregnating the form with a resin for the production of a felted combustible cartridge case that has proven eminently feasible and applicability has been demonstrated in 37 mm. gun, 76 mm. gun, 90 mm. gun and 105 mm. howitzer.

The drawing consists of a flow chart illustrating the steps of the method of this invention.

Acrylic, polyvinyl and phenolic resins give greatest strength to the felted NC structure. The choice of resins is predicated on the effect upon ballistic performance, muzzle smoke and storage stability, as well as, physical strength. The resin selected was Formvar 7/95 "S", a polyvinyl-formal resin, and the principal reason for this selection was that of the resins tested, it gave the best physical properties at both high and low temperatures, was compatible with the nitrocellulose and most suitable for use in the process. When fired in a 37 mm. test weapon, there was no muzzle smoke or residue.

There is great latitude in the choice of NC fiber to be used for the combustible case structure, final choice of the fiber, length and grade could and should be selected by their effect on the physical strength of the combustible case. When the NC fiber is in reasonably uniform condition, bleached kraft fiber in the amount of about 20% by weight (on the basis of dry NC fiber) is added and dispersed within the NC fiber for the purpose of adding wet strength to the NC fiber which is thereafter felted into flat sheets. Bleached kraft fiber alone may be used for a consumable cartridge case but contributes no energy to propellant system.

There are two basic problems which must be overcome in accomplishing the object of this invention;

2

First, since the combustible case material itself must burn up in the gun chamber prior to the projectile leaving the gun muzzle, it is necessary that the material have a sufficiently high burning rate.

Second, since the cases were heretofore fabricated by wrapping a coated gauze strip on a rotating mandrel in convolute manner, it was difficult to produce a geometry other than a simple cylinder, such as the bottle-necked 90 mm. case; thus the fabrication of cases with exaggerated tapers could only be done by hand which is fatal to efficient production. These problems have been overcome by the present method.

Cotton linters were found to produce higher tensile strengths (1680 p.s.i.) than the wood pulp NC (860 p.s.i.) and were therefore preferred. The process employing cotton linter NC fiber is as follows:

Cotton linter NC fiber is mixed with bleached kraft pulp in a stock tank, and the mixture is made up to 400 gallons with water. To keep the fibers in the stock tank in suspension, the fiber slurry is recirculated continuously. Sufficient slurry is then withdrawn from the stock tank to charge the 1000-gallon felting tank to the desired consistency. The felting die, made of perforated sheet metal and covered with a 40-mesh brass screen, having the approximate shape of the desired casewall, is lowered into the tank, a vacuum line is opened, and the water in the slurry is drawn through the perforated die while the fibers are deposited on the surface of the brass screen. After sufficient fibers are deposited on the die, it is raised from the felting tank, continuing the vacuum so that air will be drawn through the wet preform. Then a thin rubber or plastic sheet is placed over the preform and atmospheric pressure acting upon the sheet in opposition to the vacuum applied to the inside of the felting die is used to expel some of the excess water. Finally compressed air is admitted to the inside of the die to aid in the removal of the preform from the die.

In the present method the fiber preform is placed in a split-cavity mold which has the dimensions of the desired combustible casewall. A neoprene bag is placed inside the preform, and the mold is locked. As air pressure is applied to the inside of the neoprene bag, the wet preform is compressed against the mold and the free water is squeezed out, leaving a water content of about 25-30%.

The preform must then be dried to a point where its moisture level will be compatible with the solution of the organic resin with which it is then to be impregnated. This drying is accomplished in an oven at approximately 140° F. Since the NC fibers have a tendency to dust as the moisture content is reduced to about 2%, the case structure becomes hazardous at this point due to the extremely high burning rate of fine NC fibers.

In the foregoing treatment of making felted combustible cartridge cases the felted preforms are dried in an oven before being impregnated with resin. This drying process creates production problems due to possible fire hazards because of the combustible nature of dry nitrocellulose and precautionary measures must be provided, such as, temperature control, oven isolation areas, and deluge systems for safety measures. In the interest of increased production, the water may be removed from the wet preforms without a definite drying step, so that a steady flow of preforms are supplied in the over-all production process. This variation in the treatment may be accomplished by placing the wet preform from the felting die vertically within a perforated metal basket and rotating at a predetermined velocity; as the basket rotates, the interior of the preform is sprayed by a nozzle which is passed vertically down the length of preform; first an alcohol spray is used to displace the water in the preform, next the alcohol is displaced by a spray of alcohol-toluene-water

system (same solvent used to form a resin solution for impregnating the perform, and finally, the solvent system is displaced by the resin solution. Centrifugal forces aid displacement of one liquid by another. Thereafter, the resin-saturated preform is removed from the metal basket and is then subjected to the bag moulding process step and continues through the remainder of the production line as heretofor described in detail.

After a definite time interval, the bag is vented to the atmosphere and the preform is removed from the cavity mold and placed in a vacuum oven, where the major portion of the volatile solvents is flashed off. Final drying of the casewall is accomplished in an air circulating oven.

The following ballistic data was obtained from 90 mm. combustible case firings:

best formula for the combustible cartridge case and the range of selected constituents is as follows:

	Percent
Formvar resin 7/95 "S" -----	12-21.6
Diphenylamine -----	1-1.8
NC (lacquer grade 12% N) -----	70-78
Bleached kraft fiber -----	7.8-9

It is evident that good control of case density is a critical requirement in the felting procedure, if the cartridge cases were to be completely consumed on firing. While experiment showed that there is correlation between case density and ballistic behavior, it is a fact that to eliminate smoke and obtain complete consumption of the cartridge case in the gun, the case density must be less than .82 gram per cubic centimeter.

Round Number	Case Wt., g.	Case Composition, percent			Alone	Wt. of Pro- pellant (M17) Plus 85% Wt. of Case NC	Max. Peak Press. ² (P), p.s.i.	Muzzle Velocity (V), f.p.s.
		NC	Kraft	Resin ¹				
78-----	Std. Rd.	-----	-----	-----	8.85	-----	-----	2,960
79-----	Std. Rd.	-----	-----	-----	8.85	-----	-----	2,940
80-----	Std. Rd.	-----	-----	-----	8.85	-----	40,400	2,960
81-----	Std. Rd.	-----	-----	-----	8.85	-----	38,600	2,980
82-----	Std. Rd.	-----	-----	-----	8.85	-----	40,000	2,940
83-----	Std. Rd.	-----	-----	-----	8.85	-----	40,600	2,960
84-----	426	70.6	7.8	21.6	8.28	8.85	42,200	2,920
85-----	415	71.5	7.9	20.6	8.30	8.85	43,400	2,920
86-----	444	71.9	8.0	20.1	8.25	8.85	41,600	2,920
87-----	432	71.6	8.0	20.4	8.27	8.85	42,300	2,910
88-----	452	70.9	7.9	21.2	8.25	8.85	42,600	2,940
89-----	425	71.4	7.9	20.7	8.28	8.85	43,200	2,930

Round Number	Case Wt., lbs.	Case Composition, percent			Wt. M17, lbs.	P _{max.} ² , p.s.i.	V _{muzzle} , f.p.s.
		NC	Kraft	Resin ¹			
63-----	0.883	70.1	7.8	22.1	8.23	43,400	2,920
64-----	.896	72.0	8.0	20.0	8.21	43,800	2,930
65-----	.908	72.3	8.0	19.7	8.24	40,600	2,870
75-----	.911	72.2	8.0	19.8	8.30	43,600	2,930
66-----	.927	67.6	16.9	15.5	8.22	42,300	2,930
67-----	.920	67.5	16.9	15.6	8.28	44,600	2,950
76-----	.922	67.5	16.9	15.6	8.34	44,800	2,960
68-----	.871	69.7	25.7	14.6	8.33	43,300	2,920
69-----	.870	58.6	25.2	16.2	8.38	42,600	2,910
77-----	.844	59.2	25.4	15.4	8.46	43,400	2,950
60-----	Steel	-----	-----	-----	8.85	42,800	2,970
61-----	Steel	-----	-----	-----	8.85	42,500	2,950
62-----	Steel	-----	-----	-----	8.85	41,200	-----
70-----	Steel	-----	-----	-----	8.85	41,800	2,950
71-----	Steel	-----	-----	-----	8.85	40,800	-----
72-----	Steel	-----	-----	-----	8.85	41,200	2,950
74-----	Steel	-----	-----	-----	8.85	41,200	2,940
101-----	Steel	-----	-----	-----	8.85	-----	-----
102-----	Steel	-----	-----	-----	8.85	37,700	2,860
103-----	Steel	-----	-----	-----	8.85	37,100	2,850
104-----	Steel	-----	-----	-----	8.85	37,000	2,860
105-----	Steel	-----	-----	-----	8.85	37,000	2,840
106-----	Steel	-----	-----	-----	8.85	37,800	2,870
107-----	0.912	35.2	43.0	21.8	8.61	38,600	2,850
108-----	.890	35.1	42.9	22.0	8.61	38,200	2,850
109-----	.905	36.2	41.6	22.2	8.60	36,900	2,860
110-----	.940	35.6	41.2	23.2	8.61	39,900	2,890
111-----	.947	34.7	42.5	22.8	8.60	39,800	2,880
112-----	.620	-----	80.2	19.8	8.94	36,500	2,830
113-----	.615	-----	77.4	22.6	8.94	37,000	2,850
114-----	.771	-----	76.6	23.4	8.94	34,900	2,870
115-----	.875	-----	80.8	19.2	8.94	35,400	2,840
116-----	.892	-----	78.4	21.6	8.94	37,000	2,880

¹ Includes 1-1.5% diphenylamine.

² Average of two copper crusher gage readings.

If it is desired to produce finished casewall structures which have (on a dry basis) resin content in excess of 22-23%, as this content cannot be achieved by ethylene dichloride-Formvar resin solutions, but may be accomplished by utilizing 40-60% by weight alcohol-toluene as a solvent with 7-8% water, the percentage of water being critical, since at these concentrations of water the solvent ratios apparently have little effect on the solutions viscosity. Such a solvent has the specific percentage of water of 7-8%, 35-40% alcohol and the balance toluene.

Experiments with many types of guns indicate that the

What is claimed is:

1. The method of making a combustible cartridge case comprising the following steps:

mixing into a slurry cotton linter nitrocellulose fiber with bleached kraft pulp to strengthen the fiber;

lowering into the slurry a felting die of perforated sheet metal having the desired shape of casewall and covered with mesh wire screen;

drawing on the wire screen by vacuum from within the die fibers from the slurry to make a preform thereon; raising the die from the slurry and continuing the

5

vacuum from within the die and preform for the removal of water;
 inserting the wet preform vertically in a perforated metal basket;
 rotating the metal basket to remove excess water by centrifugal force;
 continuing the rotation of the metal basket while spraying the interior of the preform with alcohol to replace the water;
 changing the spray to a solvent of alcohol-toluene-water to replace the alcohol in preform;
 spraying a resin solution to impregnate preform in same manner to displace solvent solution;
 stabilizing the contained nitrocellulose in the preform with diphenylamine;
 fitting the resin saturated preform in a split-cavity mold;
 compressing the wet preform in the mold from the in-

6

side by bag molding to squeeze out the excess fluid; removing the felted case from the cavity mold and flashing off the remaining solvent in a vacuum oven to obtain a completely combustible cartridge case of great strength.

References Cited

UNITED STATES PATENTS

3,139,355	6/1964	De Fries et al.	117—155
3,218,907	11/1965	Beal et al.	102—43 X
3,264,993	8/1966	De Fries et al.	102—43
3,260,203	7/1966	Godfrey	102—43
3,320,886	5/1967	De Luca	102—43

ROBERT F. STAHL, Primary Examiner

U.S. Cl. X.R.

102—43; 117—155