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FRICTION STIMULI STUDIES IN BLENDING OPERATIONS

by

F. L. McIntyre

and

G. L. McKown

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Tests were performed on various pyromixes to determine friction stimuli due to the inducement of foreign objects and metal-to-metal contact during in-process blending. The test results indicated that the frictional energy required to ignite the pyrotechnic compositions was greater than those generated in these experiments. The initiation of pyrotechnics by friction during blending processes may be less hazardous than previously postulated based on reported incidents and accidents.

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PREFACE

The investigation described in this report was authorized under MIPR 8166104601F4W5, Project 5761313. This work was performed at the NASA National Space Technology Laboratories (NSTL) under the direction of the ARRADCOM Resident Operations Office through NASA by the Computer Sciences Corporation as the support contractor. The experimental work was completed April 1977. (It was begun in November 1976.)

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FRICTION STIMULI STUDIES IN BLENDING OPERATIONS

1.0 INTRODUCTION

1.1 Objective. The objective of this study was to determine whether sufficient frictional energy is available from foreign objects or metal to metal contact to stimulate initiation of various colored smoke compositions during in-process blending.

1.2 Authority. The work described in this report was authorized by MIPR 8166104601F4W5 from Edgewood Arsenal to the National Space Technology Laboratories.

1.3 Background. Frictional stimulus has been a suspected source of initiation during the mixing cycle for most types of mixers used in the manufacture of pyrotechnic compositions. Specific types of mixers (e.g., helicone, planetary, ball mills, roller mills double arm, and vertical mixers) inherently have the potential to create friction due to internal moving parts. Other types of mixers (e.g., double cone, jet air mix and static blenders) which have no internal moving parts still are known to have initiated due to foreign objects being introduced into the mixers.

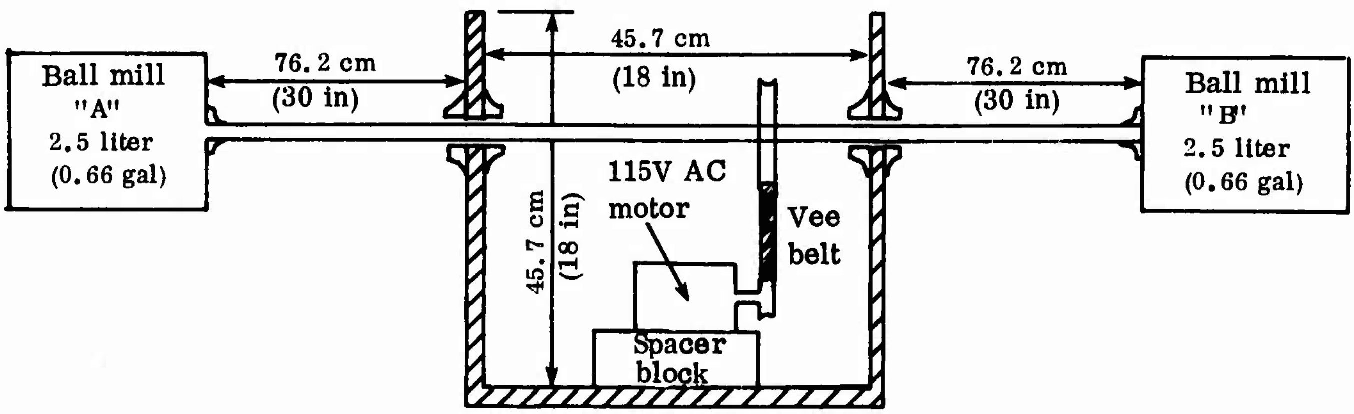
The ARRADCOM Resident Operations Office requested that testing be performed to evaluate the effects of friction due to the introduction of foreign objects into mixers and due to metal-metal contact in the moving parts of several blender configurations.

2.0 EXPERIMENTAL METHODS

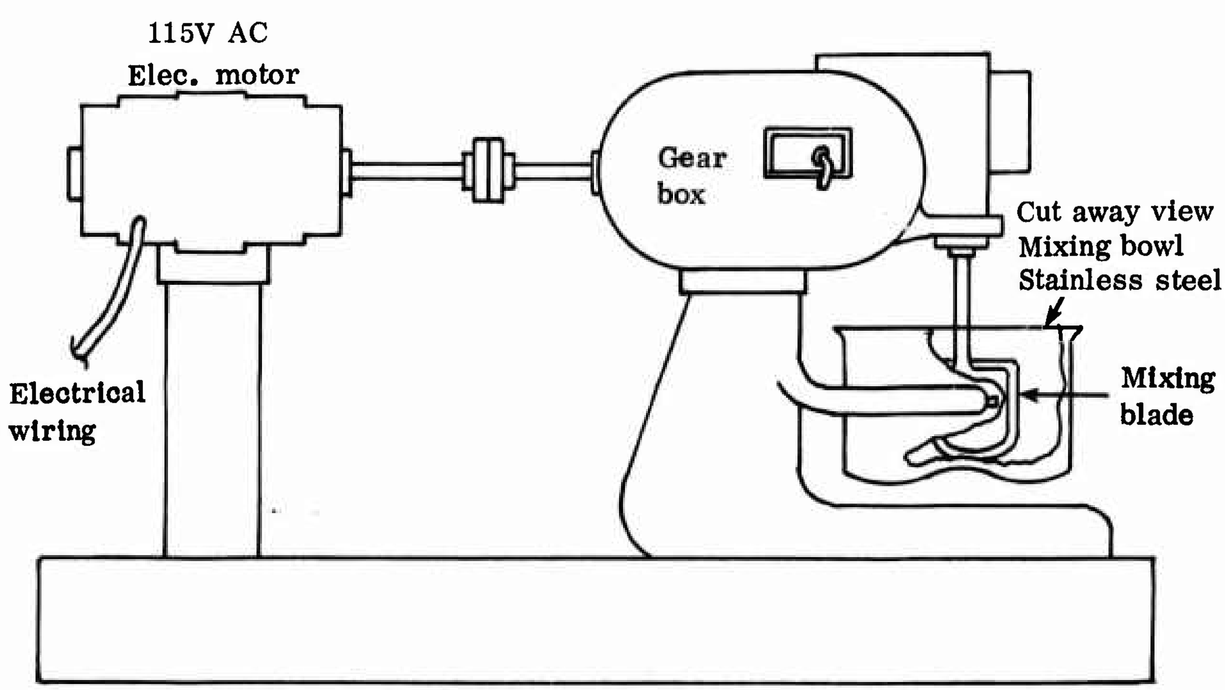
2.1 Test Configuration. Two types of mixing actions were investigated in this study. Figures 1a and 1b show the typical test apparatus used in these experiments.

The first series of experiments were conducted in a 2.5-liter (0.66-gallon) light-metal tumble mill specifically developed by NSTL for these tests. Three types of ball mill containers were used: (1) type "A" which was a standard 2.5-liter (0.66-gallon) container with smooth inside surfaces, (2) type "B" which had 3.5-centimeter (2-inch) wide by 12.7-centimeter (5-inch) long strips of number-80 grit emery cloth glued to the interior of the can approximately 120 degrees apart and, (3) type "C" had two 1.9-cm by 1.9-cm (3/4-in. by 3/4-in.) angle iron strips tack-welded to the inside on opposite sides of the container. Figure 2, parts a, b, and c, show the modifications to the ball mill containers.

Figure 3 shows the typical types of foreign objects used in these experiments. Container "A" had 8 to 10 various size rocks; container "B" had nails, drill bits, nuts and bolts; and container "C" had flint and small pieces of metal bar stock. The containers were then filled approximately one-half full with 500 grams of a preblended pyromix or of components and tumbled for 30 minutes at 30 rpm. The ball mill was stopped and the rotation speed was reduced to 15 rpm and tumbled for an additional 30 minutes. Each pyrotechnic composition was tested in each container for a minimum of three trials.



Tumble Mill Blender Test Configuration



Model N-50-G Hobart Mixer

Figure 1. Typical Test Apparatus Used in Experiments

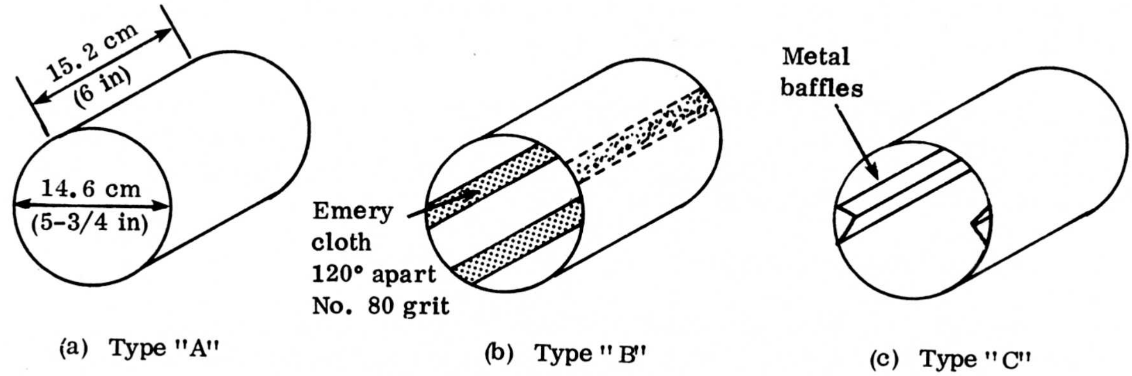


Figure 2. Ball Mill Container Configurations

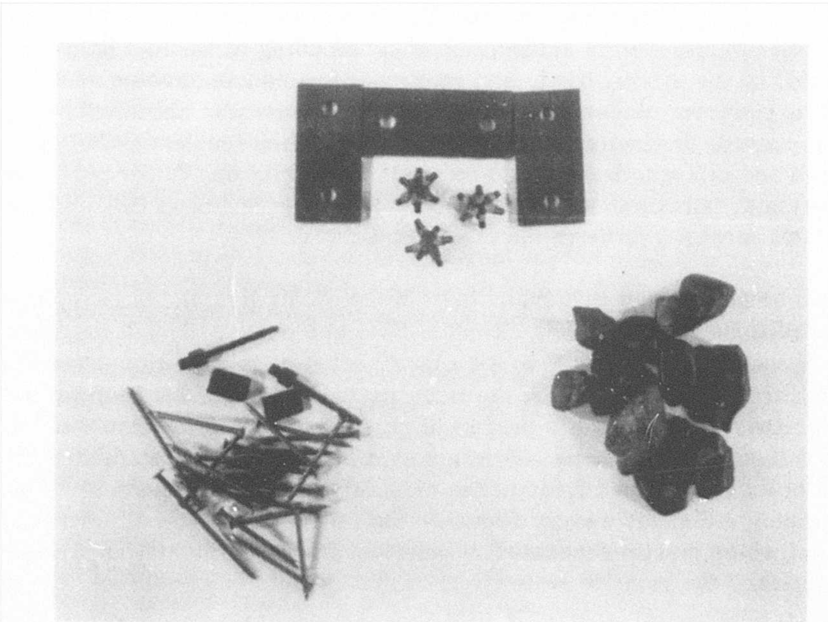


Figure 3. Typical Types of Foreign Objects Used in These Experiments

The second series of tests were conducted in a Model N-50-G Hobart planetary mixer. The mixing bowl was shimmed so that there was metal-to-metal contact between the bowl and the mixing blade. The bowl was filled with 500 grams of pyromix and blended for 30 minutes. Each test was conducted a minimum of three times.

2.2 Test Materials. Preblended sulphur and lactose based colored smokes were used initially in these experiments. Additionally four batches each of Violet Smoke Mix IV dry blend and an illuminant mix consisting of 45 percent magnesium/55 percent sodium nitrate were mixed in the ball mill and planetary mixer.

3.0 RESULTS AND DISCUSSION

3.1 Ball Mill. The tabulated results from these tests are shown in table 1. In no case was there an initiation observed either from friction caused by foreign objects being induced into the mixer or by deliberate roughening of the container walls. These negative results indicated that the frictional forces were insufficient to cause initiation due to either intergranular or granular object-container wall-intergranular effects. Small and King[(1)] have reported that an important consideration in determining whether frictional effect can cause ignition is if the material (in this case pyromix) melts before ignition. If this is the case then the melted material acts as a lubricant and lowers the coefficient of friction. In these tests the pyromix apparently acted as a lubricant, even though melting of the material or components was not obvious.

3.2 Planetary Mixer. The tabulated results are shown in table 2. The actual mixing process in a planetary blender is accomplished by kneading of the mix between the mixing blade and the side of the mixing bowl, and frictional forces can develop at any point between the mixing bowl and blade. In these tests the system was shimmed so that there was metal-to-metal contact to simulate the worst case condition for process blending. There was no initiation and this was believed to be again primarily due to the pyrotechnic material acting as a lubricant. In some cases the fit between blade and bowl was sufficiently tight to cause scoring and scratch marks in the mixer bowl.

It should be pointed out that these tests were qualitative and cursory in nature and were not intended to be a definitive treatment of the subject. Although the various pyrotechnic compositions were subjected to simulated worst case conditions, they failed to ignite. This failure may be caused by the inability to reproduce the head pressure of the pyromix in the mixer and the kinetic energy of objects falling more than 2 meters as might be expected in full-scale operations. Friction as a stimulus has been determined to be a common cause of explosions and fires in the manufacture of pyrotechnics[(2)], but the results of these tests indicate that the energy required for initiation of typical pyromixes may be greater than that which can be generated in small-scale experimental apparatus. It would be valuable to determine the relative sensitivity of pyrotechnic compositions to various frictional

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(1) Small T. and P. V. King, General Electric, Pyrotechnic Hazards Classification and Evaluation Program Contract NAS8-23523, Phase II, Segment 3, Final Report. Test Plan for Determining Hazard Associated with Pyrotechnic Manufacturing Processes, January 1971.
(2) McIntyre, F. L., General Electric, Final Report, Incident/Accident Survey (1950 through 1974). EM-CR-76011, December 1975.

Table 1. TEST RESULTS OF TUMBLE BLENDING IN BALL MILL WITH VARIOUS PYROTECHNIC-COMPOSITION-INDUCING FRICTION STIMULI

Test material	No. of tests	Selected rpm	Ball Mill container "A"	Ball Mill container "B"	Ball Mill container "C"
40-mm Red Smoke, lactose based batch No. 6349-2	3	30	NR	NR	NR
		15	NR	NR	NR
40-mm Red Smoke, lactose based batch No. 6310-2	3	30	NR	NR	NR
		15	NR	NR	NR
40-mm Green Smoke, lactose based, batch No. 6345-1	3	30	NR	NR	NR
		15	NR	NR	NR
40-mm Green Smoke, lactose based, batch No. 6289-1	3	30	NR	NR	NR
		15	NR	NR	NR
M-18 Green Smoke, sulfur based batch No. 6348-1	3	30	NR	NR	NR
		15	NR	NR	NR
M-18 Green Smoke, sulfur based batch No. 6316-2	3	30	NR	NR	NR
		15	NR	NR	NR
M-18 Violet Smoke, sulfur based batch No. 6349-1	3	30	NR	NR	NR
		15	NR	NR	NR
M-18 Violet Smoke, sulfur based batch No. 63C7-1	3	30	NR	NR	NR
		15	NR	NR	NR
NSTL Illuminant Mix batch No. 1607-1	3	30	NR	NR	NR
		15	NR	NR	NR
M-18 Violet Smoke, sulfur based batch NSTL 1607-1	3	30	NR	NR	NR
		15	NR	NR	NR

NR = No Reaction

Table 2. TEST RESULTS OF METAL-TO-METAL CONTACT BLENDING VARIOUS PYROTECHNIC COMPOSITIONS IN A PLANETARY BLENDER

Test material	Number of tests	Results
40-mm Red Smoke, lactose based batch No. 6349-2	3	No Reaction
40-mm Red Smoke, lactose based batch No. 6310-2	3	No Reaction
40-mm Green Smoke, lactose based batch No. 6345-1	3	No Reaction
40-mm Green Smoke, lactose based batch No. 6389-2	3	No Reaction
M-18 Green Smoke, sulfur based batch No. 6348-1	3	No Reaction
M-18 Green Smoke, sulfur based batch No. 6316-2	3	No Reaction
M-18 Violet Smoke, sulfur based batch No. 6349-1	3	No Reaction
M-18 Violet Smoke, sulfur based batch No. 6307-1	3	No Reaction
NSTL Illuminant Mix batch No. 1607-1	3	No Reaction
M-18 Violet Smoke, sulfur based batch No. NSTL 1607-2	3	No Reaction

stimuli in mixing equipment. Such a determination would be useful in evaluating specific manufacturing mixing equipment regarding the potential for initiating pyrotechnic compositions by friction.

4.0 CONCLUSIONS

(1) The frictional energy required to ignite the pyrotechnic materials tested is greater than that produced in these experiments.

(2) The initiation of pyrotechnic materials by friction during blending process may be less hazardous than would be postulated based on reported incidents and accidents.

5.0 RECOMMENDATIONS

The failure to simulate known pyrotechnic incidents caused by friction warrants quantitative testing on particular pyromixes for a given manufacturing process to establish the relative sensitivity of the particular pyromix to various types of frictional stimuli.

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