USA CRREL

Special Report 53

PERFORMANCE TESTING OF A MODIFIED FIELD PLANER ON PROCESSED SNOW

U. S. ARMY

COLD REGIONS RESEARCH AND ENGINEERING LABORATORY

PREFACE

This paper describes the performance testing and modification of a Gurries Field Planer, Model GP-50, for leveling processed snow. The work was performed at the Keweenaw Field Station, Houghton, Michigan during 1960 and 1961 under SIPRE tasks 022.02.006 and 5010.02205 (now 5010.22210). The testing was conducted by Mr. A. F. Wuori, project leader, Applied Research Branch, assisted by Mr. Gunars Abele, civil engineer. The testing during the 1960 season was under the general supervision of Mr. W. K. Boyd, then Chief, Applied Research Branch, and the 1961 tests were under the general supervision of Dr. A. Assur, the present Chief.

Any use of the material presented in this report for promotion or advertising purposes by any commercial interest is prohibited.

This report has been reviewed and approved for publication by the Commanding General, U. S. Army Materiel Command.

W. L. NUNGESSER
Colonel, CE
Commanding
USA CRREL

Manuscript received 30 January 1962

Department of the Army Project 8S66-02-001

CONTENTS

ILLUSTRATIONS

SUMMARY

A Gurries field planer was tested at Houghton, Michigan as a means of leveling processed snow to produce a trafficable surface. The unit was a tow-type, hydraulically controlled, automatic leveler, used normally as a finish planer for airfield and highway construction work. It was modified to include skis for work in snow.

The initial tests indicated the need for several modifications. They included a manual cross-slope and blade-height control, ski adjustment, and an adjustable hydraulic valve.

After these modifications were made, the planer was again tested and found to be a satisfactory implement for leveling processed snow.

PERFORMANCE TESTING OF A MODIFIED FIELD PLANER ON PROCESSED SNOW

by

Albert F. Wuori

INTRODUCTION

This paper describes the use of a Gurries field planer for leveling processed snow. The testing and modification were performed during 1960 and 1961 at Houghton, Michigan.

Experiments conducted by USA SIPRE during the past few years have led to the development of methods of processing snow for the construction of snow roadways and runways. Leveling of the snow to create a surface smooth enough for landing aircraft has always been a problem. It must be done immediately after the snow is processed, before it hardens. Because the snow surface created by the processing unit is quite rough, a considerable amount of snow must be moved. A crawler tractor equipped with a hydraulically operated blade is quite effective in rough leveling; however, additional fine leveling is required. Ski-equipped, tow-type road graders with standard moldboards have produced fair to poor results. The moldboard cannot carry enough snow, and the manual blade control is not adequate for producing a smooth surface in one or two passes.

On the basis of these experiments it was decided that a snow planer should be procured having the following general characteristics. The planer should be ski-equipped and be light enough to be towed by either the processing unit or a crawler tractor. It should have a sufficient snow storage capacity in its leveling bowl so that a considerable amount of snow could be moved. The leveling action should be automatic and accurate enough to produce a level surface in one or two passes.

Estimates revealed that a specially designed and constructed snow planer would be very expensive. A commercially available grader or planer already having the required design features would be less costly. It was found that a planer manufactured by the Gurries Manufacturing Co. for road and airfield work had most of the required features. A standard model was procured with only two modifications which included replacing the standard wheels with skis and extending the drawbar so that it could be towed by a snow processing unit, a rotary snow plow.

GENERAL DESCRIPTION

The Gurries field planer, Model GP-50, is a tow-type planer, specially designed for leveling the base-course surface of an airfield or road to a high degree of accuracy. It is normally towed by a crawler tractor.

The major components of the planer include the main frame, leveling bowl, tail boom, and a power unit. The leveling bowl is attached rigidly to the main frame, and the cutting depth of the bowl is controlled by hydraulic cylinders attached to the bowl wheels or skis. The power unit is a small Wisconsin Model AEN, single-cylinder, air-cooled engine which operates a hydraulic pump to furnish hydraulic power to operate the planer. The tail boom, mounted on a rear caster, controls a hydraulic actuator valve which in turn controls the bowl hydraulic cylinders. The width of the bowl is 12 ft, and it has a storage capacity of 4 yd^3. The true planing length of the unit is 50 ft, while the overall length is 58 ft 3 in. (See Figure 1 and Appendix.)

The planing action is automatic and therefore no operator is required. The principle of operation involves the use of live hydraulic power to achieve almost complete rigidity in a 50-ft span. The bowl wheels or skis are operated up or down to support the frame and bowl in a fixed line relationship with the two end points of the machine. The cutting edge of the bowl is controlled to lay in the same plane as the ground contact point of the front skis and the tail boom caster ski. However, the hydraulic system is designed so as not to respond to small surface irregularities but to adjust itself for the average contour of ground and maintain a smooth cut or fill.

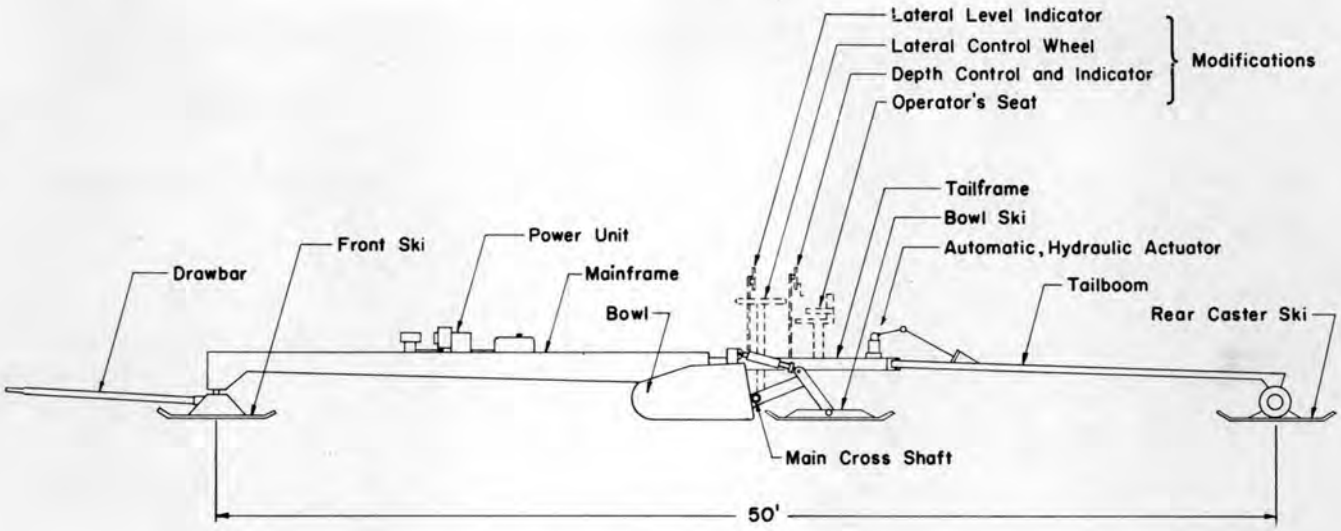

Figure 1. Gurries field planer, Model GP-50, ski equipped.

The hydraulic actuator valve which controls the cutting depth of the bowl can be adjusted manually to hold the cutting edge in exactly the same plane as the front and rear skis, or above or below this level depending on the amount of cut desired. Each graduation on the actuator dial represents a 1/16-in. vertical setting of the cutting edge.

To adapt this planer for work in snow, the bowl wheels and the front wheels were removed, and skis were fabricated and mounted in their place. Another ski was mounted beneath the tail boom caster wheel. The skis were constructed of $\frac{1}{4}$-in. steel, reinforced at $9\frac{1}{2}$-in. widths. The two main bowl skis were 37 in. wide and 78 in. long. The two front skis were 18 in. wide and 78 in. long. The rear ski was 9 in. by 78 in. These sizes were selected to keep the ground contact pressure of the skis below 1.5 psi. Brackets were fabricated for mounting the skis so that their ground contact point would be in the same position as the previous contact point of the tires.

The only other modification made before the first tests was to extend the drawbar by 5 ft and fabricate a bracket so that the planer could be towed by the snow processing unit, a rotary plow.

PERFORMANCE TESTING, 1960

Performance testing of the Gurries planer began in January, 1960 and continued through March. The planer was used to level the surface of a number of snow runway and roadway test sections (Figs 2, 3).

In constructing the test lanes, a rotary snow miller such as the Snowblast plow or the Peter miller* was used to process the snow and deposit it behind the plow with the use of backcasting chutes. The resulting snow surface was quite rough and uneven. This was due mainly to two factors: (1) the undisturbed snow surface before plowing was uneven, and (2) the backcasting chutes did not distribute the snow evenly behind the plow.

The first few tests indicated that the original processed surface was too uneven to be leveled with the planer alone. The storage capacity of the planer bowl (4 ft^3) was not great enough to cut and carry sufficient snow for removing the high spots and filling the depressions. Also, the planer did not have a lateral leveling control. Whenever either

*Wuori, A. F. (1961) Supporting capacity of processed snow runways, U. S. Army Cold Regions Research and Engineering Laboratory, Technical Report 82, 16p.

Figure 2. Planer, front view.

Figure 3. Rear view of planer.

of the bowl skis settled into a soft spot or depression not completely filled by snow, the bowl would begin cutting lower on that side. The lack of a lateral leveling control made it impossible to correct the situation and produce a level surface.

This difficulty was expected somewhat when the planer was procured, but it was decided to test the standard planer first without this feature and provide for this special control later if the tests warranted it.

When the planer began cutting on a level surface, it would normally continue a laterally level cut if the cut and fill could be balanced; that is, a level cut would be maintained until one side of the bowl became empty before a depression was completely filled.

More desirable results were obtained in subsequent testing when a tractor with blade was used to roughly level the surface before the planer was used. It was found during the remainder of the testing season that one forward blading pass and one back-blading pass with the tractor was desirable before towing the planer over the surface. It was then necessary to make about three coverages with the planer to produce a suitably level surface. In some cases, however, additional coverages had to be made.

Several attempts were made to tow the planer immediately behind the Snowblast rotary plow. The same difficulties were encountered as before. The planer could not handle such a great volume of snow and the lateral position of the bowl could not be corrected.

Another observation made was that, in many cases, the leveling action in the direction of travel was not satisfactory. A Gurries representative, present for one of the trials, explained the cause of the difficulty. The hydraulic system of the planer has a built-in restriction to retard the leveling action so that the bowl is not immediately responsive to small, fast vertical movements of the front skis over rough terrain, but maintains an even cut and fill corresponding to the average contour of the surface. This restriction was designed for a forward planer speed of about 3 to 5 mph. However, the forward speed of these trials varied from only 20 ft/min with the rotary plow to about 90 ft/min with the tractor, averaging less than 1 mph. Thus, the leveling action of the bowl was too rapid for this slow forward speed. The installation of an adjustable metering valve in the hydraulic system to further retard the leveling action was suggested.

When making a rough cut, the bowl would at times become overloaded, and at times become empty because of its limited capacity. It would therefore be desirable to have a manual blade-height control so that, when making a rough cut, an operator could raise the bowl when accumulation of an excessive amount of snow was anticipated. Also the blade could be lowered when insufficient material was being accumulated to fill in depressions.

It was also observed that the front skis of the planer could not follow the crawler tracks because their spacing was too narrow. This would cause the front of the planer to shift to one side.

On several occasions it was noted that the hydraulic bowl cylinders reached the end of their travel. A resetting of the bowl ski fittings to give about two inches more cylinder extension was indicated.

Despite the difficulties encountered, the planer performed much more satisfactorily than any method of leveling used previously. The results showed that, if the observed difficulties could be eliminated, the planer would become a more useful tool for leveling operations. It was decided that several modifications could be made which would eliminate these difficulties.

MODIFICATIONS

The performance of the planer and the need for modifications were discussed with the Gurries Manufacturing Company and their local dealer, the Brebner Machinery Company. It was decided that the following modifications should be made:

1. Manual cross slope control. A manual cross slope control would be fabricated and installed, consisting of cutting the main cross shaft, installing a flange on each cut end of the shaft, and bolting the two flanges vertically with an Acme thread screw. A shaft with universal joints would lead to the operator's platform where it could be controlled by a handwheel with chain drive and an indicator dial. A reduction gear box would be included to make it easier to turn the handwheel. A level bubble would also be included to indicate the bowl position. Turning of the handwheel would then control the lateral position of the blade, and a 2 to 3-inch lateral correction could then be made.

2. Blade height control. The blade height control would consist of a hand-operated unit with a double worm reduction box with pointer and calibrated dial and a sealed adjuster gear box to be mounted to the tail boom. A universal joint shaft would lead to the operator's platform. This would permit the operator to raise or lower the cutting bowl rapidly.

3. Metering valve. An adjustable metering valve would be installed in the cylinder hydraulic line at the rear of the bowl to restrict the flow of oil and cause a slower action on the bowl cylinders.

4. Front skis. The front skis would be spread farther apart to track with a D7 or D8 Caterpillar tractor.

5. Bowl ski fittings. The bowl ski fittings would be reset to give about two inches more hydraulic cylinder extension when the bowl is at ground level.

6. Operator's platform. An operator's platform and seat would be installed above and to the rear of the bowl. All controls would be located here.

The mechanical design of the modifications and some of the component parts were made by the Gurries Manufacturing Company, and the Brebner Machinery Company performed the modifications during the fall of 1960. The planer was again ready for operation by January 1961.

PERFORMANCE TESTING AFTER MODIFICATIONS, 1961

Performance testing of the planer, after the modifications were made, was carried out during February and March 1961. (See Fig. 4.)

The planer was used to level the surface of processed snow test lanes as explained before. However, during this test season only the Peter plow was used as a processing unit, and it was equipped with a set of backcasting chutes which distributed the snow quite well behind the plow, producing a more level surface than during the previous winter. A number of test lanes were constructed and leveled with the planer.

The planer in general performed very satisfactorily, and it was observed that the modifications were quite effective in eliminating the previous difficulties. It was no longer necessary to level the processed snow surface with a tractor blade before planing. Normally, three planer coverages were necessary to level the surface. The first coverage was a rough cut, during which the operator controlled the blade height manually to prevent excessive accumulation of snow in the bowl and also to prevent the bowl from becoming empty. The operator also kept the bowl approximately level. The remaining two coverages were finishing cuts during which the operator kept the bowl level laterally and allowed the automatic control to regulate blade height.

The metering valve was set to retard the bowl cylinder speed from about 48 in./min to a speed of about 12 in./min. This retarding of the cylinder speed seemed to be effective in producing a more level surface.

Figure 4. Planer after modification.

The front skis which were now spread farther apart tracked very well with the towing tractor. The adjusted bowl ski fittings were effective in providing for the desired hydraulic cylinder extension with the bowl at ground level. The cylinders seldom came to the end of their travel during operation.

However, it was apparent that a larger bowl capacity would still be desirable. Quite frequently the bowl would become over-filled before a high area was removed, and in other cases the bowl would become empty before a low area was filled in. Also one side of the bowl would occasionally become empty while the other side was still filled with snow. This situation could be remedied by having a spreader to keep the snow spread evenly in the bowl.

Another difficulty experienced was that in some cases the lateral level control was not adequate for making a quick correction. One reason for this was that retarding the speed of the bowl hydraulic cylinders, to produce a more level surface in the direction of travel, also retarded the lateral level control reaction. This difficulty was partly eliminated by opening the metering valve during the rough cut to provide a faster leveling action and then partially closing it to retard the leveling action during the finish cuts. Another possible improvement would be to change the gear ratio of the lateral level control so that each turn of the handwheel would effect a greater correction. However, the handwheel would then become somewhat more difficult to turn.

It was also noted that the total lateral level correction (2-3 in.) was not large enough in some cases and therefore the bowl could not be returned to a level position as quickly as desired.

Mechanically, the planer's performance was highly satisfactory. No trouble was experienced with the power unit, hydraulic system, or other operating components of the planer, even during operation at temperatures as low as -10F.

DISCUSSION

The tests performed with the modified Gurries planer indicate that it is a very promising tool for leveling processed snow sufficiently smooth for landing aircraft. Its performance was far superior to that of implements used previously to level processed snow, such as bulldozers and other tow-type graders. Because of the feature of automatic leveling, the required operator control is held to a minimum. It is light enough to be towed with a rotary plow, if necessary. Its mechanical performance at low temperatures is very satisfactory.

The Gurries planer is essentially a finishing tool. Its performance on a previously rough-leveled surface is excellent. However, it is not a very good rough-leveling implement. A rough processed snow surface should be first leveled with a bulldozer.

Further improvements could now be made in the design of a new snow planer. Additional desirable features would include a bowl having a larger storage capacity, a powered spreader in front of the bowl which would continually spread the material laterally in the bowl, and an automatic lateral leveling control, as well as the automatic control in the direction of travel. This snow planer would then function as a combination rough and finish grader and would possibly produce a finished surface in one coverage.