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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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THE IMPACT OF ECONOMICS UPON THE DESIGN OF MACHINERY AT IRRI

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ABSTRACT

Research has shown the need for mechanization to optimize the production of the small farmer. However, serious constraints face the designer of farm machinery in developing machines that are economical for the farmer and can be produced by the small entrepreneur in the developing country.

Machines provide the farmer the means to produce beyond his own needs. However, there are severe restrictions on the designer to develop effective, easy to operate, easy to maintain machines which will provide a return on his investment. The economic constraints extend to the design of the machine elements. The result is a large number of individual design decisions, all of which have an economic element, culminating in a machine which will do the task effectively yet at a low cost.

The designers decisions also determine whether or not a machine can be economically produced by the manufacturer who may be limited in his production capabilities but must also reap a reasonable return on his investment.

INTRODUCTION

Research over the last twenty-one years has developed new varieties of crops for the tropics, fertilizers for increased production, new cropping practices, and new chemical for weed and insect control. However, the benefits from these new inputs cannot be fully realized without the use of mechanization. Mechanization makes it possible to plow, plant, cultivate, and harvest at the optimum time to obtain maximum yield. In addition, the more rapid completion of the various needed activities permits the production of two and often three crops per year. As a consequence the total production and income of the farmer is increased.

The need for mechanization in any agricultural enterprise should be apparent. If one considers the laws of nature, it is obvious that a man working alone, with a hand tool, can produce very little beyond his own needs. The simple hand tool is, in fact, the small degree of mechanization that helps him produce a little more than he could without it. If he has the energy of a couple of oxen available to him, he can produce enough for his family and somewhat more to sell. However, because of the slow rate of animal power, he is also subject to losses as a result of untimely operations. In addition he must utilize some of his crop as a feed for his animal power.

Machines powered by an engine provide the farmer with a means of performing the required tasks in a timely manner and at a more rapid rate than he can with hand tools or with animal powered machines. However, he is dependent upon a fuel resource and that is usually off the farm and often imported and heavily taxed. There are economic costs to the use of such machines. A farmer must be able to justify this additional cost of input against the potential benefits.

The designer of farm machines is thus faced with the task of developing machines which will provide the farmer with his needs without being excessively high in cost.

It has been said that the field of farm machinery design presents a greater challenge to an engineer's ability than any other field of engineering endeavor (Skromme, 1). Farm machines must perform satisfactorily over wide ranges in a considerable number of variables. They must be designed to handle wide variations in crop and soil conditions. Operators are often relatively unskilled, partly because of the limited usage of the machines.

In addition to the difficult environmental conditions, farm machines are subject to stringent economic limitations. Manufacturing costs must be kept to an absolute minimum so that the limited amount of operation will not put the cost per hour into a prohibitive range. Therefore, farm machinery designs must be as simple as possible, must utilize the lowest-cost materials that are available and satisfactory for the job, and must permit the widest manufacturing tolerances that are consistent with good performance.

GENERAL OBJECTIVES OF THE DESIGN OF AGRICULTURAL MACHINES

There are broad functional requirements that are true for any successful design effort whether it is for a highly industrialized country or an underdeveloped nation; and which are true regardless of the political, social, or economic systems that may prevail.

1. The machine must do the particular task in a manner acceptable to the farmer. This may mean that:

a) The machine does the task as well as, or better than existing methods. Examples of this are a tractor powered plow replacing an animal drawn plow; or, an IRRI designed axial flow thresher compared to the flail, or animals walking on the grain on a threshing floor.

b) The use of a machine may result in a lower quality end product but the benefits outweigh the loss in quality. An example is the use of early corn pickers which resulted in increased field losses and left more husks on the ear than when the crop was picked by hand; however, the machine enabled the farmer to cultivate more cropland, saved a tremendous amount of labor, and enabled him to harvest his crop in a more timely manner. The poor quality of work resulting from the use of a machine is often characteristic of a new machine; however, in time, as designs are improved, the machine is often capable of performing work of higher quality than that of the human labor.

c) The machine reduces the labor input to the task or reduces the drudgery involved and results in more pleasant work. This principal is basic to machinery utilization; i.e., the purpose of most machines is to increase the productivity of the individual and to relieve man of drudgery. The IRRI manual transplanter, as an example, increases the energy expenditure of the individual but since the operator works in an upright position, his total output is increased three or four times that of the individual transplanting by hand.

d) The machine must perform the task in a more timely manner than can man with his hand tools. Thus, when the land needs to be plowed and prepared for planting, it must be done immediately; when the crop is ready for harvest, it must be cut and threshed before the crop is lodged, eaten by birds or rats, or losses are increased due to shattering. In most countries, weather patterns institute constraints of timeliness upon the farmer for most operations. Thus, there are usually a limited amount of days available to accomplish a given task or a reduction in yield will result.

2) The use of the machine must result in economic benefit to the farmer.

Economicconstraints are present in every area of design of farm machinery and in most instances they are the factors that govern most design decisions. A machine purchased by a farmer should be economically justifiable as a financial investment. Farmers, as a group, are very astute with respect to the economics of a farm machine purchase. Few farmers will buy a machine unless they are convinced their decision is economically sound. When farmers first began utilizing machines in developed countries, many scientists found it difficult to justify the investment. However, farmers intuitively understood the timeliness factor which made it more economical to use the machines. We now recognize the wisdom of their decisions.

The farmer may not purchase a machine even though he desires to purchase it and it would be a sound investment. He may not have the capital to purchase the machine unless some type of credit is extended to him.

A farmer is also subject to the vagaries of nature. A storm may ruin his crop and he will have no means of recovering his investment in a machine. In such a situation the farmer in a developing country usually has more to lose than one in a developed country. Thus, it is important that his machine costs are as low as possible and still accomplish the task. For the designer this means the development of low cost machines.

ECONOMIC CONSTRAINTS IN DESIGN

Perhaps the most persistent constraint for the designer of farm machinery, and especially farm machinery for the small farmer are those related to the economics of design. Before a machine can be put on the market at a reasonable cost, the designer is faced with a multitude of decisions which are wholly or in part economic in nature.

The designer must select low cost materials such as wood or light gage metal. He must select the lightest steel but still maintain a factor of safety which will insure against undue failure.

An exercise in selecting a bearing for a particular machine element will illustrate some of the economic decisions involved:

1. First cost

a) If there is no wear problem a low quality bearing may be used, such as for lever pivots, hitch pivots, or very slow moving parts. In this case a sleeve bearing can be used such as a steel shaft running in steel, cast iron, or wood. This would be less costly than a precision-made, anti-friction bearing.

b) If a medium speed and load are to be encountered, the material costs usually favor a sleeve bearing but the manufacturing costs may be higher because of the better shaft finish and hardness required.

c) If a high speed or load is to be encountered, a precision-manufactured bearing must be used.

2. Maintenance and repair

a) Most sleeve bearings require periodic lubrication while a sealed anti-friction bearing does not. An anti-friction bearing can be replaced as a unit while the sleeve bearing may entail replacing an entire shaft or assembly. Thus, training of the operator on proper maintenance is more important when using low-cost bearings. On the other hand, if sealed bearings are used, they may not be easily available in some villages.

Where farmers are limited in available capital or credit, it may be more beneficial to design machines for the custom operator who will do the work for several farmers. In this way the cost per hour of use will be reduced while a higher quality machine can be produced. Examples of such machines are the power tiller, the axial flow thresher (TH-8), and the IRRI designed reaper.

Component costs are always a challenge for decisions. Some precision parts such as anti-friction bearings, roller chains, and sprockets are inexpensive and easily available in most areas of the world. Component parts such as gears, special alloy steels, heat treated parts and special precision parts are expensive and often not available unless imported. When designing the reaper adaptation for the Philippines, gears were needed for the knife drive assembly. New stock gears were not available unless imported at high cost. Custom made gears were unreasonably expensive. A gear set used in the construction of the jeepneys was available everywhere in the country at a reasonable price and satisfied the economic requirements of the design.

The capabilities of the indigenous shops and manufacturers is an important consideration in the design of the machine. What kind of tools do the machine shops have and what are the capabilities of the workers? Most of the shops that produce farm machinery designed by IRRI have few highly skilled laborers, a limited number of machine tools but an abundance of unskilled laborers. Consequently, designs must be such that the farm machinery can be constructed with the use of simple, basic machine tools such as lathe, drill press, and welder plus a considerable amount of hardwork.

Generally, a farm machine is operated a relatively low number of hours per year. A tractor usually operates no more than 600 to 700 hours per year unless it belongs to a custom operator. A machine such as a mechanical transplanter may operate no more than 200 hours or less per year. Thus the cost of a machine must be as low as possible to make it economical for the farmer to own.

The number of units of a machine that a farm equipment manufacturer produces is small compared to many other industries. Thus, the designer must work toward the lowest cost at the probable volume of the machine to be produced. Few manufacturers can survive if only one type of machine is produced. They must produce a number of different machines and diversify their output in order to be an economically viable firm.

CONCLUSION

The farm equipment designer has always been challenged by the economic facets of his work. This is increasingly true when designing machines for a small farmer when those farmers are entering the first phases of mechanization. Machines developed at IRRI must meet all tests of acceptability by the small farmer and be of economic benefit to him.

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