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ANALYSIS OF THE METHODS FOR ECONOMIC EVALUATION AND FOR THE MATHEMATICAL MODELLING OF AGRICULTURAL MACHINERY IN DEVELOPING COUNTRIES

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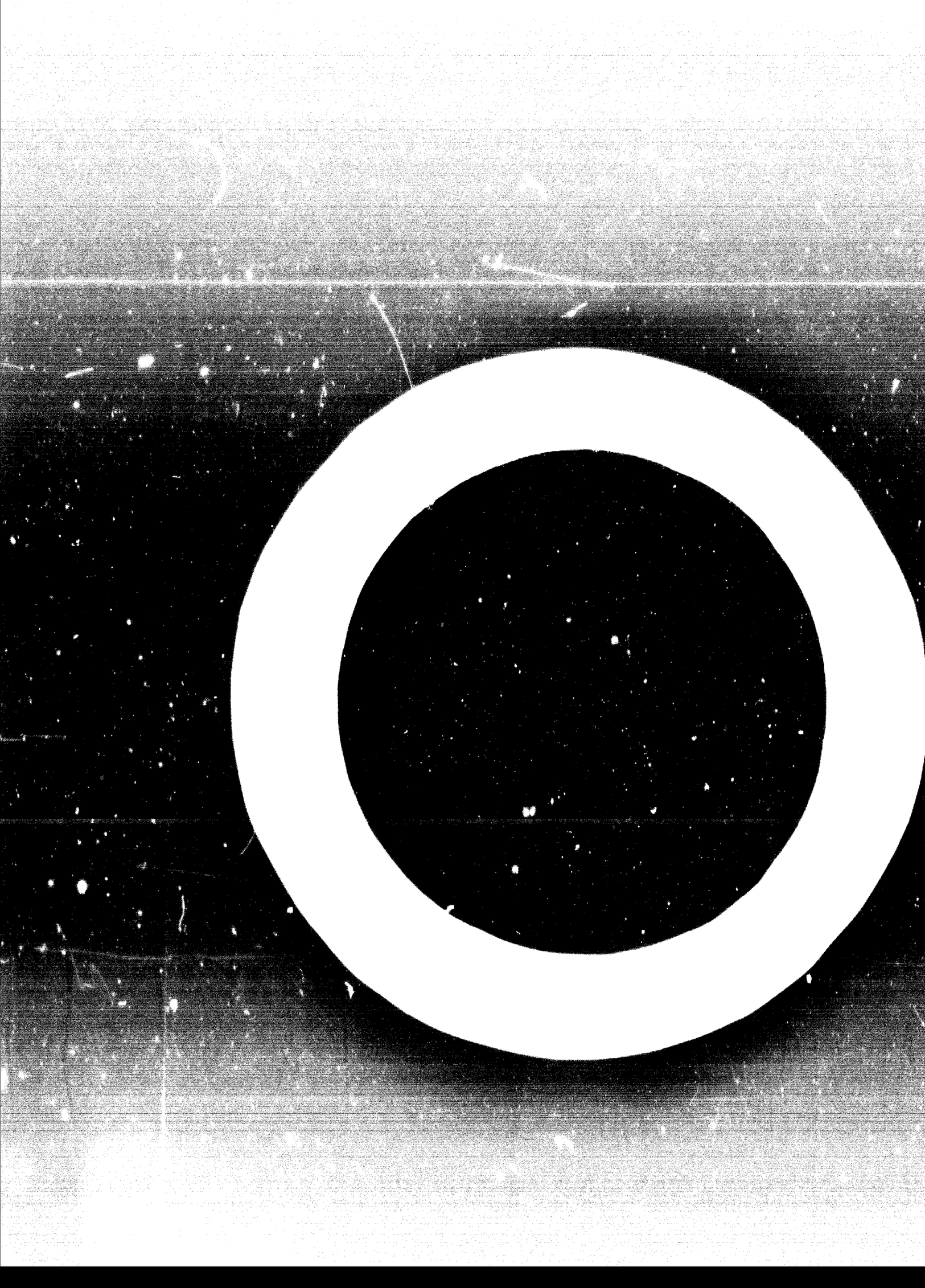

ANALYSIS OF THE CRITERIA FOR FARM MECHANIZATION AND FOR THE MANUFACTURE OF AGRICULTURAL MACHINES AND IMPLEMENTS IN DEVELOPING COUNTRIES

1. Introduction

The problem of the lacking food in developing countries, becoming increasingly urgent with the precipitating growth of population in these regions, has become sufficiently known. It will have to be attended to and solved without much delay. The developed countries can play, and will undoubtedly play, a very important part in technical and financial aspects, in the development of agriculture in these developing countries. In our opinion, however, they can not play a decisive part. They can assist in technical matters, stimulate the development, invest the capital or carry the main burden in the development of technical means for a certain time, but they can not bear a permanent responsibility for the functioning of agriculture, which must be in future self-sufficient for the needs of the increasing population, and which must remove all the lacks which have been critical up to now. It becomes thus evident, that it will be necessary in future for the developing countries to mobilize their own sources, their industry and engineering for the development of agriculture.

The development of the agricultural production is aimed from the extensive to the intensive farming. The main reserves are in fallow land, low yields, insufficient protection of crops

and harvested produce against pest and disease and in the labour, which has not been sufficiently used. Agricultural production can not, however, be intensified, without a development of industry and application of technical means, i.e. chemistry and machinery. Similarly, as the crops can not be efficiently protected without the use of chemicals, it is neither possible to mobilize the land funds and to increase the yields without development of the mechanization. In a certain sense, the mechanization is a key factor, though not the most important for the development of agriculture in the developing countries. In case of a successful agrobiological research and of growing right types and varieties of crops, the mechanization will become one of the main factors of the development. The reason is, that it not only enables an intensive cultivation of soil and production of crops, but that it requires, by itself, a continuous mobilization of the own sources of raw materials and industry, a better organization of labour and skill of those working in agriculture. Such a pressure shall have favourable effects in developing countries, simultaneously with similar pressures in other branches, on a general development of industry, schools, economic organization and thus, in general, on the growth of the national income and productivity. The mutual effects of the different elements of the economy bring into action the economic mechanism, the aim of which should be the self-sufficiency of the developing countries, among others, in the food production. This paper

is to indicate some, but not all, of the possibilities in introducing the mechanization of the developed countries and the possibilities of mobilizing the own sources in the specific conditions of agriculture in the developing countries.

2. The principal conditions of the mechanization of agriculture in the developing countries

One of the mistakes, which can occur when assessing the possibilities of the mechanization and of the manufacture of agricultural machines and implements in the developing countries, may be a thoughtless application of systems which have been successful and which have become traditional in the developed countries. The same mistake used to be frequently committed by the European economists, sociologists etc., as they used to consider the problems of the developing countries from the European viewpoint. It would be of no use to try to import and introduce in the agriculture of the developing countries agricultural machines and implements, which may not be suitable for the specific soil conditions or crops, which would be too expensive for the local farmers, for which tractors of sufficient h.p. are not available or which are not simple enough for the operation and maintenance of the local farmers. When investigating the problem of a suitable manufacture of agricultural machines in the developing countries, it is thus necessary

to make it first clear, which implements and machines can at all be used.

One of the fields, in which the agriculture of the developing countries differs, are the agrotechnical conditiones. The more different geographical position, the fact that the developing countries are mostly in a tropical zone and that their climatic conditions are different, mean that the emphasis is on the different crops and different agrotechnical conditions than in the developed countries. The problem is a broad one and it concerns the subject of this paper in so far, as certain crops require for their cultivation implements, which are specific for the developing countries. Some crops, let us mention from the most important ones for example rice, sorghum or cotton, are not grown in Europe on a sufficient scale to lead to a development of reliable machines and implements. It is true, that these crops have been grown in some of the southern areas of the U.S.A., but the farming is so intensive and the mechanization so progressive (motorization, special harvesting machines, agricultural aircrafts etc.), that the system can not be readily applied in the conditions of the developing countries. There also exist models of a developed agriculture, with methods of crops growing, which appear to be more readily applicable for the developing countries and with crops which are typical for these countries.

This is the case with the Japanese methods of rice growing, using small self-propelled machines. However, neither in this case can a progressive mechanization be applied on a broader scale, as the developing countries are mostly not ready for the application, considering the economic and social aspects, as well as the skill of the labour. For a number of special crops, grown in the developing countries on a large scale, such as for example groundnuts, sisal or tropical fruit, no machines have been developed up to now and approved by practical use, so in this case no application can be considered. It is thus evident, that some of the crops which are typical for the developing countries and which are fully different from the crops grown in the developed countries, make it necessary to develop special new systems of mechanization and specific implements; the experimental testing, investigation, development and, in the final stage, the production of these implements will require a mobilization of the own forces of the developing countries.

We shall reach the same conclusions, if we take into account the different soil conditions of the developing countries. In certain aspects, these conclusions are the more evident, as the tillage, including the ploughing, sowing, planting and cultivation, represent at present and will represent in future, the major share of all field operations in the developing countries. It may thus be

be interesting to pay some more attention to this problem.

The main task in the tillage is to facilitate the biological processes in soil formation and to create adequate soil conditions for seeds germination and growth of the plants. Different implements are used to stir and turn soil to effect the regulation of the soil moisture, of temperature and air in the soil, to kill the weeds and to plough in the rests of plants into the soil. Biological processes are, however, very different in various soil and climatic conditions. Roughly, it can be said, that in warmer climate, the biological processes are more intensive and the effect of heavy ploughing is thus minor. Moderate zones with a long winter or poor soil temperature, with great soil summer rainfalls and with a slow decomposition of the organic matter in soil, require a heavier fundamental tillage and turning of soil, to support the natural biological processes, to plough in the organic matter, to improve the physical structure of the soil and to create the water contents in soil. For this fundamental tillage in moderate zones, the best suitable implements are the traditional bottom ploughs, used in the developed countries.

Other types of implements are needed for fundamental tillage in arid and semi-arid areas, with a high average soil temperature and without summer rains, equally as the areas with constant dry winds, which cause losses of

moisture by evaporation and a quick decomposition of organic matter. These soils require stirring without the turning of the slice, to accumulate and maintain the maximum moisture in soil and to slow down the natural withering of the rests of plants. The roots of weeds are cut off, only cut off, without ploughing in the plants. The ploughs suitable for this purpose, just stir the land without turning it, or turn it only partially. These ploughs have been known in Asia for several thousand years (the first ploughs were used by Sumerians round 3.600 B.C.) and they have been currently used. They do not require much draught and can be thus drawn by animals. They are of a simple design, cheap enough for small farmers, easily manufactured and, consequently suitable for the manufacture in countries with undeveloped industry.

The ploughs for arid areas, not turning the soil, are of course not the only simple implement which is specific for tillage in the agriculture of developing countries. Special bottom ploughs with a broad body, turning the soil, are used for example for the tillage of rice fields with temporary dams to hold the moisture, if leaking of water from the swampy surface under the bottom firm layer of soil is to be prevented. The use of these ploughs is combined with simple implements shaping the temporary dams. In damp tropical regions with a dense vegetation, the soil, shadowed by trees, does not require a profound tillage, as

the shadow prevents the loss of the natural moisture. The fields are usually to be in shadow and the soil is tilled with simple implements in a shallow layer, as a deeper tillage is prevented by the roots of the trees. It seems generally purposeful to use on these small enclosed fields and for shallow tillage only light units, which can be easily and cheaply manufactured, instead of machines that are more complicated and more expensive; there is a danger with the latter machines, that they remove vegetation from large areas and thus impair the balance of the soil vegetation, thus creating conditions for erosion and soil devastation.

Some examples concerning tillage indicate, that the specific agrotechnical and soil conditions in the developing countries require specific and simple implements, which can be manufactured in these countries without any troubles. An important factor in planning the use and manufacture of agricultural implements at present and in future, are the social and economic conditions of the farming. Contrary to the rapid progress of mechanization in the developed countries, it is surprising if we realize, that four fifth of agricultural enterprises in the world still use only implements for animal tillage or animal drawn implements. In the developing countries there exist no industry, most of the people get their living by farming. The maximum part of the agricultural production, partly exported in exchange for some necessary commodities, is

produced in a vast number of tiny agricultural family enterprises, each of which contributes by a very small share only, in the total production. This contribution can bring only a very low living standard to the farmers and can not prevent famine in poor years. The reasons of these conditions are low yields, caused frequently by insufficient rainfalls or occurring at inadequate times, or by lack of seeds of good quality, lack of fertilizers and herbicides or by lack of knowledge in the methods of growing the plants and in the choice as to which crops to grow. Some of the problems were mentioned before in this paper. They are the subjects of the agricultural research but, the endeavoures of the research to increase the production by better knowledge often encounter with the limited output of the primitive means of mechanization, which frequently mean just a hoe. In some cases, a speedy introduction of modern machines and tractors was endeavoured, to overcome the limitations given by the insufficient output of the primitive implements. In most cases, these efforts did not bring the expected success. Apart from the technical problems of tractors and machines, operated in conditions for which they were not designed, (these problems can be overcome by the adaptation of the machines for tropical conditions as described later), there arise social and economic problems, which can not be easily solved. If

a productivity of field operations is to be achieved, it is necessary to reach some of the social conditions enabling joint utilization of tractors and machines, either owned by the contractors or by collective ownership as in case of co-operative farms. Except the big farms, individual ownership of tractors and machines is not practicable, because the economic reasons would force the owner to hire the tractor to his neighbours. This, of course, necessitates the credits, capital mobility and, in general, a functioning economic-financial system and a certain living standard of the farmers.

If the immediate troubles with the introduction of a modern mechanization in the developing countries are of such a scope, there arises a question, whether it is not better to apply the existing mechanization at present and also in the nearest future. A total mechanization with tractors is at present achievable in some areas only, which present just a fraction of the total agriculture in the developing countries. The experience indicates, however, that with a majority of agricultural holdings, the problem of mechanization can be successfully solved by introducing improved manual and animal-drawn implements and machines of simple design and by a more general use of animals for draught. Simple means of mechanization need not be necessarily primitive and, even if they do not differ much from the primitive tools,

they can be purposeful and progressive, if they fulfil their function in the development of agriculture. From the viewpoint of the means of mechanization in the developing countries, the simple implements are important from other aspects: their manufacture does not require a mature industry and it is not difficult to find capacities and material sources complying with the simple or limited technology of this manufacture.

If more ingenious modern machines are to be introduced, some more existing social and economic conditions have to be fulfilled. Some were mentioned before and all can be gathered in several points:

1. Yields and prices obtainable for the crop, the growing of which is to be mechanized, have to be sufficiently high, to cover the costs paid for the mechanization.

2. The machines have to be designed and manufactured for the conditions in which they are to be operated.

3. By the merging of small holdings, sufficiently large areas of fields are to enable the utilization of the machines.

4. All farmers of the particular area should be willing to participate in the new system of farming.

5. The country should have such a level of industry and economy to render possible assembling of machines in the area of their operation, if not their manufacture, the area should have a sufficient supply of spare parts and service.

6. The level of technical education must be sufficient to procure enough skilful labour for the operation and maintenance of machines and implements.

7. Financial system must enable investments, credits and covering of the debts.

It is evident, that consecutive fulfilment of these conditions is a part of the total economic development, in the course of which the country gradually discontinues to be a developing one. A brief analyses of the social and economic conditions of the developing countries makes it thus evident, that for the present time and for the nearest future it is primarily the manufacture of simple implements, such as approved in local practice and improved on hand of the agrotechnical research, which is important for the developing countries. The country's own simple manufacture will, furthermore, be one of the components of the economic development, contributing to create the above mentioned conditions for a modern and progressive mechanization. By no means does it mean, that the developing countries should not receive assistance from the developed countries in the transitional period. This assistance can be, however, only one of the stimulators of the development, the foundation of which should be the development of the country's own sources and capacities for the manufacture of agricultural machines and implements. It would not be reasonable to introduce a modern mechanization precipitately, with no

attention to the conditions mentioned. For a transient period only and as an exception can the government of the developing country assist by subsidies in this speedy introduction of modern machines to achieve an incitement in the natural economic development.

Apart from the specific agrotechnical, economic and social conditions of the mechanization, there exist other factors in the developing countries, which limit the possible application of machines used in the developed countries. One of the factors, important especially for the design and manufacture of more complicated machines, is the effect of tropical climate on the machines. This effect has to be also considered when deciding on the possibilities of utilizing subsidiary industries in the developing countries for the own home production or for the adaptations of imported machines.

The requirement on the climate resistance is much more important with the tractors and agricultural machines than with other machines, for the production of which the local subsidiary industries can be used. The tractors and agricultural machines have been designed in developed countries to meet the requirements and conditions of agriculture in the moderate zone. These conditions, (so far as we have in mind the quality of labour in agriculture), are frequently very strict and difficult to meet, while the working conditions tend to be relatively easy . In the

developing countries, however, the situation is quite different. The requirements on the quality of labour are considerably lower, while the reliability, low requirements of maintenance and repairs are much more valued. The working conditions are, however, much more difficult. Tractors and agricultural machines get devaluated during their life, by a number of unfavourable climatic conditions, the effects of which come apparent not only in operation, but as early as in the manufacturing process (at the surface finish) or before taken over by the customer (during transport and storing). The devaluation may become evident by different means, of which an impaired functional and technical reliability is the most apparent, similarly as an increased consumption of spare parts and increase of requirements on the service and maintenance. The main reasons of deterioration with the agricultural machines and implements are atmospheric corrosion, biological deterioration and wear. Restriction of these deteriorations, to prevent the impairment of the technical characteristics, is the aim of acclimatization (or tropicalization, if the treatment of the imported machines is meant).

The most frequent cause of the deterioration with the materials used is the atmospheric corrosion. It is of an electrochemical nature and it is technically significant with a certain moisture of the environmental atmosphere only, if an electrolytical film sets on the surface of

the metals. The moisture, which is necessary to form this film, is called critical and it is the lower, the more the atmosphere is polluted with gas or solid particles (dust) and the more the surface of the metal is corroded. An important factor is the dew on the surface, which occurs with changes of day and night temperatures. If the temperature of the air reaches the dew point, the moisture would condense as dew on the surface. The frequency and the intensity of this phenomenon are variable. In tropical conditions, it occurs up to 200 times in a year and the daily dew amounts to several millimetres, which is about tenfold compared with the climatic conditions in moderate zone. The dew is condensed not only from the moisture of the atmosphere, but also from the moisture of soil, in which case the acidity of the moisture can be a considerable one. The atmospheric corrosion results in the originating of corrosive products. Their hygroscopicity and small adherence is the most frequent cause of the damage to painted surfaces. The mechanism of the atmospheric corrosion of the non-metallic materials is substantially more complex and depends on the kind of the material. The more important factors comprise, in these cases, the intensity of sun rays (especially of the ultraviolet rays) with plastics and the effects of oxygen and ozone with rubber. The result of this corrosion is the deterioration of the mechanical properties with the materials used. The most frequent results of the atmospheric corrosion with tractors and agricultural

machines is a quick deterioration of the paintings, deterioration or loss of functioning with a number of parts and accessories, such as electrical accessories, springs, bearings, etc. and limited dismantling caused by the corrosion of the connecting parts.

A frequent cause of damage with non-metallic materials is deterioration due to biological factors, i.e. in case of the microbial corrosion due to moulds and bacteria, in case of the macrobiological deterioration by the effects of insects and rodents. Materials, which are most frequently damaged this way, comprise plastics, wood, hide, textiles and rubber, i.e. materials, which are very often used in agricultural implements, notably in the developing countries, where they are the most easily accessible materials used in the manufacture of the auxiliary industries.

From the adverse effects on the agricultural machines, the last which we mention, is the wear, which is a limiting factor in moderate zones as well, but which is especially significant in tropical regions. It is mostly of an abrasive nature and it is very high in tropical conditions, notably in arid areas. It is caused by a high content of sand and dust in the air and by a simultaneous influence of other climatic factors.

The wear has notably adverse effects in moving mechanisms, such as bearings, piston rings, injection pumps, etc., where it decreases the life considerably. These circumstances, too, should be kept in mind, when deciding on the suitability of local auxiliary industries for the manufacture, assembling or maintenance of agricultural machines.

The effects of climatic conditions, as mentioned before, are a very important factor for the technology of agricultural machinery in the developing countries. They are often omitted in connection with the import, assembling or the own manufacture of machines and implements, though it is just them which offer a chance for the prosperity of auxiliary industries (paint shops, plants for the manufacture of spare parts, special store houses etc.), as described in the next chapters.

3. Possibilities in mobilizing the own auxiliary sources and capacities of the developing countries for the manufacture of agricultural machines and their maintenance

The developing countries can obtain tractors and agricultural machines principally by one of the following methods:

(a) purchase or import of assembled and finished machines, notably tractors and more complicated implements and machines; (b) assembling of machines from the imported parts in the local assembly plants; (c) the local industry, manufacturing either simple manual or animal-drawn implements

or more complex machines. Each of these ways brings certain chances for the local auxiliary industry or for other capacities (storing, transport, repairs, etc.).

The import of completed, assembled machines brings the minimum chances for the local production in the developing countries, though it can bring some demands on the auxiliary industries and other capacities. Thus even the transport and storing present a certain problem. If the imported machines are not sufficiently protected, they can get deteriorated (sometimes before they are taken over by the customer), either by adverse conditions in sea transport, or by overloading a long storing in the maritime areas. It is generally duty of the deliverer to protect the machines till delivery by efficient packing and by the means of short-term protection. These means of protection increase the costs of the machines and bring along specific requirements on the development and design of the machine. Thus, for example, a decision whether the machine is to be of a welded or bolted design, has considerable effects on the later costs of packing and sea freight (the volume and not the weight being charged). Thus, for example, Massey-Ferguson deliver their three-bottom ploughs dismantled in packings of 1600 x 810 x 400 mm dimensions. When the machines are taken over, even if not damaged by climatic effects during transport and storing (and the more, if they have been attacked by corrosion), it is

advisable, to apply a new, permanent painting for tropical conditions, be the sale of the machines in the local trade in hands of retailers or a governmental organization or by an agent of the manufacturer, it is important for the success of the machine on the local market, to provide the machine with a sufficiently protecting paint, if the protective coating of the imported machine is not considered satisfactory. This can be done by local auxiliary plants, such as local paint-shops with simple facilities, or paint-shops of the local industry, which may be better equipped and more costly. The tropical climatic conditions bring along the necessity of a very strict compliance with the technologic processes. In smaller and simple plants, the method used would be spraying, while in larger and better equipped plants, which are mostly parts of factories or assembly plants, some more complex technological methods can be used, such as described in the next chapters. Another utilization of local auxiliary facilities in the import of the machines is the assembling of parts, into which the machines were dismantled to reduce the dimensions of the packed machines for transport. This assembling can be mostly done by the final owner of the machine, i.e. the farmer, or it can be done by the importing company, using its own small assembling shops, which do not require high initial costs, nor qualified workers. It is mostly just bolting of larger section of the machine together.

Much more chances for the local auxiliary or subsidiary industries brings along the building up of factories by some big companies of the developed countries, introducing the production of agricultural machines or tractors in the developing countries. When introducing such an industry, it is not only the local assembly, but a supply of a number of home materials and parts, mainly the simple ones, which should be considered, while only more complicated design sections are imported. The developing countries with a partially developed industry can mostly supply from local sources the following materials with the beginning of the manufacture: (a) materials, such as for example rolled carbon steel or refined steel, metal sheets, sectional steel, drawn steel, wires, non-ferrous metals, wood, oils, Diesel oil, graphites, [illegible], etc.; - (b) castings of grey cast iron, of cast steel, malleable cast iron and non-ferrous metals; - (c) simple parts of the local origin, such as for example screws, nuts, plates or washers, split pins, pins, pegs, rivets, springs, bearings, rims, discs, piston rings, etc., - (d) some manufacturing equipments and machine tools, notably universal types of home production. As an example, a scheme could be mentioned, worked out in 196[illegible] by Czechoslovakia, for the building up of a factory for the manufacture of two-wheel tractors and agricultural implements in India. In compliance with the scheme, the plant was to have an annual capacity, with a two-shift production, of 5.000 two-wheel tractors, 5.000 rotary hoes, [illegible].000 disc harrows, 2.500 turn-about ploughs and 1.000 cutter bars. Manufacture of spare parts

was to correspond to 10% of the total annual production. In the final stage, Czechoslovakia was to deliver 12,2% of parts from the total volume of the production in total costs, in the permanent cooperation, while 87,8% were to be supplied by local sources. On the other hand, technological equipment (machines, implements, etc.) was to be supplied by 68 % from the imports, while 32% were to be covered by local sources. It is evident from this example, that local industrial capacities should be made use of in the supply of materials primarily (comprising some simple connecting parts etc.), while most of the more complex technological equipments were to be imported.

As the scheme described was comprising a certain representative range of agricultural machines (one more complicated source of power, two machines driven by this source and two simpler implements), it can serve to demonstrate the composition of the intended range of implements in relation to the composition of requirements on the different capacities of the local subsidiary industry. Of the total consumption of 5.315,1 tons of material for the annual production, Czechoslovakia was to cover under the permanent cooperation agreement 225 tons only, i.e. 4,2%. If we keep apart minor parts, which were to be purchased by the factory also from local sources (to be mentioned in next chapter) and which correspond to 10% of the total consumption of the material, then the remaining 85,8% of the annual consumption, i.e. 4.560,6 tons of material would have to be

supplied by local sources. The requirements on the materials in an average range of agricultural machines are given underneath in a survey as follows:

- Metallurgical materials, comprising th carbon and refined steel (rolled steel, sheets, hoop steel, pipes, iron steel, wires and non-ferrous metals 44,3 %
- Castings of grey cast iron, of malleable cast iron, of cast steel and non-ferrous metals 30,0 %
- Forgings 7,9 %
- Other materials (products of plastics, welding and soldering materials, wood, oils, Diesel oil, graphites, enamels, diluents) 3,6 %

85,8 %

It is evident from the above survey, that the manufacture of agricultural machines brings considerable requirements onto the local sources, notably in semi-products of steel, castings and forgings. A more detailed analyses of the individual items indicates, which of the local subsidiary sources can be especially important for the manufacturers of agricultural machines. With metallurgical materials, which are one of the main groups of the materials, the specification of the steel semi-products in the described case would be as follows:

- Rolled carbon steel ..... 12,0 %
- Carbon steel sheets ..... 10,4 %
- Rolled refined steel ..... 8,9 %

- Pipes of carbon steel ..... 5,2 %
- Sheets of refined steel ..... 3,3 %
- Drawn carbon steel ..... 3,2 %
- Carbon hoop steel, pipes of refined steel, refined drawn steel, steel wires and non-ferrous metals ..... 1,3 %

44,3 %

It is evident from the above pro-forma calculations of the consumption of materials from the local sources for a certain manufacture of a representative range of agricultural implements, that local subsidiary industries in the developing country (in this case India), can participate with deliveries in the following sequence: castings of grey cast iron (in the case described 26,3 % of the total consumption of material), metallurgical rolled material of carbon steel (12 0 %), sheets of carbon steel (10,4 %) and rolled material of refined steel (3,3 %). As evident from the above analyses into the scheme for the manufacture of agricultural machines, it is mostly the grey iron foundries and metallurgical industry with steel rolling mills, especially of carbon steel, which will be needed. Conclusions of an analyses into a certain scheme can be, of course, made generally valid in a very limited range only (though, as emphasised before, the project selected, covers a representative range in the scope of agricultural machines). A distortion may occur due to the fact,

that only weight quantity of the material is taken for calculation and not the consumption of labour, price or other circumstances. In no case, however, can the conclusion be taken for quite erroneous, that the foundries of grey cast iron and the steel rolling mills are very important subsidiary industries for agricultural machinery, similarly as in the developed countries. These plants can be of a technology so far simple, that they could be built up in developing countries, (so far as they do not yet exist). Furthermore, the foundries of grey cast iron, the steel plants and the steel rolling mills are plants of general importance, equally beneficial as subsidiary industries for other branches of machinery.

On hand of similar projects of the manufacture of agricultural machines and power units as the scheme described, it is possible to state roughly the scope of the capacities required by this manufacture from the local subsidiary industry. The project as described in the above, would lay the following requirements on the annual supply of the main materials from the subsidiary industries:

- castings of grey cast iron ..... 1.395,3 tons
- rolled carbon steel ..... 638,4 tons
- sheets of carbon steel ..... 622,5 tons
- forgings ..... 418,0 tons, etc.

The above data of the estimated consumption of material make it possible to plan the capacities when building up

subsidiary industries, or, on the contrary, to plan the manufacture of agricultural machines where these subsidiary industries of corresponding capacities exist. Comprehendably, other important factors have to be considered simultaneously, such as travel distances, costs of transport (comprising the possibilities of utilizing the existing waterways, railways and road network), possibilities of utilizing the capacity of subsidiary industries for other branches of industry, etc.

Similar conclusions can be reached with the project chosen as example, when analysing the requirement of finished parts with local sources. This concerns mainly the connecting parts, i.e. the screws, nuts, washers, pegs, split pins, rivets, etc., as well as antifriction bearings, rims and discs, piston rings, shaft sealings, etc. The more complex is the machine, the more of these parts are needed for the manufacture, as evident from the estimated annual consumption with the individual machines of the projects described:

Machine	Annual production, pieces	Finished parts of local sources in tons	Finished parts of local sources per 1.000 of machines in tons
Two-wheel tractor	5.000	453,0 t	80,6 t
Cutter bar	1.000	18,9 t	18,9 t
Rotary hoe	5.000	51,0 t	10,2 t
Disc harrows	3.000	7,8 t	1,6 t
Turn-about plough	2.500	3,5 t	1,4 t

It is evident, that the requirements of a plant manufacturing agricultural machines on the ancillary industry supplying simple finished parts (screw mills etc.), will be smaller, if the manufactured machines are of a simpler design and if the production is of a smaller scale. On hand of economic calculations, these circumstances (including a number of others, such as the transport etc.) have to be considered and decided, whether the factory is to have its own plants for this ancillary manufacture, whether the parts should be supplied by the existing ancillary industry, or whether this manufacture is to be built up and for which other branches of industry will it serve. The link of these ancillary plants with the manufacture of agricultural machines is not so tight, because the weight quantities considered are considerably smaller and the proximity of ancillary industrial plants is not of such a necessity, due to smaller costs of transport.

This example of a project for establishing a manufacture of a small two-wheel tractor, of two p.t.o. driven implements and of two simple implements has been used to demonstrate the possibilities of utilizing local ancillary industrial sources in a developing country for the supply of the principal materials and of simple parts. Though we think that this example is in certain aspects a typical one, enabling to reach conclusions

as mentioned before, it can be considered of a general validity only so far, as it complies with the local economic conditions. The actual conditions may require, that the share of the home ancillary industry be smaller and that a share of simpler parts (such as for example bearings, sealing rings, etc.) or a part of the material (such as for example rolled refined steel, sheets, etc.) be imported from abroad or vice versa, that also some more complex parts of the design (such as couplings, air cleaners etc.) be manufactured in local plants, so far as they are available. Step by step, as the industry in the developing countries will develop, the manufacture will be more self-dependent and it will be governed by the economic laws valid in the economy of developed countries.

Up to now, we have discussed the possibilities of an ancillary industry of the developing countries in the production of machines and implements of such a design, as used in developed countries and which will be used increasingly in tropical regions by the time. On the other hand, traditional manual labour and operation of animal drawn implements is an important means of mechanization at present and will remain so to a certain extent in future, as pointed out in the introduction of the paper, in connection with the specific, notably social conditions of mechanization in developing countries. In some countries, such as in India and Pakistan, animal-drawn implements have been used for centuries, though the implements are of a primitive design. In India, the

main source of power in agriculture, has still remained a pair of oxen, drawing a wooden plough, which has been the principal implement for cultivation. One of the present problems of the mechanization of agriculture in the developing countries is the research and development of suitable implements for small farmers. This special problem has been paid much too little attention in the developed countries, and most of the machines and implements imported in tropical countries have been too expensive for the small farmers, who are typical for the agricultural population. In the endeavours of making use of the ancillary local industry, there should be taken into account, on a large scale, the manufacture of the present traditional manual and animal-drawn implements, which are being developed from the original traditional designs for the needs of small farmers.

What tools and implements can be considered as traditional ones in the developing countries? The principal traditional implement has been, for centuries, a plough; in Asia and in Middle East, the traditional plough was called Ard, consisting of a wedge-shaped part of wood, connected to a long wooden beam. These ploughs are manufactured by the local village joiners, or by the farmers themselves. The first improvement of this plough has been the addition of an iron nose, or a sort of a share, enabling better piercing into the soil and less wear. From

our viewpoint, the action of the implement is more of a single-share cultivator than of a plough. Nevertheless, it has been suitable for the fundamental tillage without turning of the soil. The disadvantage is a small output, while the advantage is a more less general use, because it can serve not only for the ploughing, but also for the inter-row cultivation or for the sowing, if a pipe and a hopper are attached to the rear part of the implement, the seeds being poured into the pipe in operation. The further development of these ploughs was directed to replace the nose-share by a simple plough body, turning the soil. Thus a type of light animal-drawn ploughs with a universal steel body and with a share of high-carbon steel was developed; the share is wear-resistant and it can be sharpened by any village blacksmith. These improved ploughs lost, however, their universal utilizability and, consequently, new types of ploughs were developed (such as for example the "Pakistan" plough by the Punjub Agricultural College), which can be provided with different bodies and which can also be used as a cultivator or as a drill, with an attached hopper and pipe. Apart from the universal implements for tillage, cultivation and sowing, other traditional implements in the developing countries comprise, for example, peg-tooth harrow, seed harrow, spike-tooth harrow, rotary harrow with wooden or steel times, va-

rious simple drills, threshing machines, and the like.

It is not in scope of this paper to deal in detail with the various types of traditional agricultural implements in the developing countries. From our viewpoint, it is interesting to note, what are the requirements of the manufacture of these implements on the local material sources and on the manufacturing plants. Contrary to the previous case, in which complex design units for the manufacture of more ingenious machines are imported from the developed countries, while the local sources supply some simple parts and materials, in the manufacture of traditional implements, the whole burden is on the local sources and plants. It is thus interesting to note what kinds of materials prevail with the manufacture of traditional implements and what capacities are needed to process the materials and to manufacture the implements. With simple, traditional implements, it is principally the following materials which are used:

- wood (handles of manual implements, beams of the animal-drawn ploughs, tow-bars, handles of ploughs, travel wheels etc.);
- steel (working parts of the implements such as tips, shares, plough bodies, tines of harrows, scythes, frames of the implements , travel wheels or rims, connecting parts, etc.);
- galvanized sheets (hoppers and seed tubes of the drills, various shields, etc.);

- hide (reins and harnesses, straps and belts, etc.).

Timber and wood. This is an old raw material and its supply from home sources presents in most developing countries no problems. The selection of the best suitable woods for different types and parts of agricultural implements depends, of course, on the woods available. The best suitable and universal kinds of wood comprise, for example Hickory (Hicoria alba) and common ash (Fraxinus excelsior L.) for their toughness, elasticity and relatively small weight. The best suitable wood for design is generally obtained from young trees, growing on poor soils. Working of wood is simple and as a rule, does not require special ancillary industries. With the traditional manufacture, the village craftsmen or the farmers themselves are able to manufacture the necessary wooden parts. On a large scale, the manufacture would require plants, equipped to bend wood in steam, polish wood with emery paper, or to finish the surface by flaming or waxing. The profitability of these plants can be, however, hardly estimated. To concentrate simple craftsman jobs into larger plants would be justifiable only in case if it would ensure a cheaper production. This is, however, not probable, so far as the labour of a village craftsman or of the farmer is cheap, as it has been the case up to now. Furthermore, it is difficult to mechanize the technology of working the wood for simple parts of

the traditional implements. Thus it seems, that wood from a not too distant place will remain the material for the manufacture of certain simple parts of the implements and that the manufacture will rest with the village joiners or farmers. The introduction of improved designs of simple implements, developed by means of research methods, would require a system of information service, providing instructions for the manufacture of parts etc., governed by national agricultural organizations, extension service stations and other organizations.

The manufacture of steel parts of traditional implements provides much more chance for the mobilization of ancillary [illegible]. Steel can be obtained from local sources, mentioned before, in connection with the manufacture of parts for more complex machines. This concerns mostly carbon steel of current quality for the manufacture of frames, wheels and similar parts, and high-carbon steel for the manufacture of working tools, i.e. pointed shares, shares to turn the soil, etc. Semi-products are mainly angle irons, hoop steel, steel sheets of different width and material for forgings. Most of the steel plants, so far as existing in the developing countries, are able to supply these materials. An important material is galvanized sheet, used for example for the manufacture of seed tubes and hoppers for the sowing with simple implements.

The manufacture proper of steel parts for simple traditional farm implements, both of the manual and animal-drawn type, is not complicated from the technological viewpoint. The parts to be manufactured are mostly of a smaller size. The technological operations involved are cutting and shearing, bending, forging, pressing, welding and heat treatment, i.e. mostly non-cutting working, which does not require high initial costs for special machines. The main problem of concentrating the manufacture of parts into larger plants is a standardization of the parts, enabling manufacture of larger quantities and thus increase of the labour productivity and decrease of manufacturing costs. It becomes evident, in this connection too, what an importance may have the research and development of universal, simple cultivation implements of standard type, with interchangeable working tools and which can serve as an animal-drawn plough, cultivator, inter-row hoe and a drill. Such an implement was developed for instance at the Punjub Agricultural College in Pakistan as a so called Pakistan plough in two models. An example of a more progressed development is a universal cultivator, which was developed by the Agricultural Development Society at Allahabad in India as a "Wah-Wah", or a "Lucknow Cultivator", developed by the Agricultural College and Government workshops at Lucknow. So far as known, this implement has been manufactured commercially by a manufacturer of agricultural machines in India.

The concentration of the manufacture is important with steel parts of the simplest farm implements as well. The design of the implement has, for this reason, to be standardized in some larger areas, to make it possible for the farmers to buy the parts from the dealers and to mount them on the wooden implements of home manufacture. The dealers and the extension service would have to provide (1) an instruction for the manufacture proper of simple wooden parts of standardized implements and (2) information on the sale of cheap steel working tools, connecting parts, etc. The sale and advertizing of this kind of merchandise could be arranged either by the national organization responsible for the agriculture, or by a manufacturer of steel parts, interested in their sale. Part of the advertizing of the standardized implements should be information on the properties of steel parts, notably of the working parts, as it has to be taken into account, that the farmers or village blacksmiths will themselves sharpen them, forge them, temper or anneal them after they have been worn out. Without this knowledge could an unskillful worker damage the implement when regenerating it.

In the manufacture of simple traditional agricultural implements it is possible to utilize in the developing countries nearly solely the own sources of raw materials and ancillary industries, as evident from the above.

The manufacture of more complex implements of designs corresponding to those in the developed Western countries, in connection with the possibilities it brings for the local ancillary industry, was analyzed in the case preceding. The last case to be discussed, is a complete and finished manufacture of tractors and complex machines in the developing countries by local means. Such a stage of manufacture can be reckoned up in future, but a pre-requisite is a full development of the economic structure and of the level of technology. The auxiliary, subsidiary or ancillary industry gets then changing in its nature and becomes more a cooperation of the primary, secondary and tertiary sections of industry, as it is current in the developed countries.

The study on the possible utilization of the local ancillary industry for the manufacture of agricultural machines in the developing countries would not be complete without the maintenance of the implements and machines, which brings about certain demands on the ancillary industries. As mentioned at the beginning, the specific climatic conditions bring forth heavy demands on the maintenance of agricultural machines in the developing countries. Prevention is an efficient way in the protection of the machines, but it requires carefulness and skill on the part of the farmers, which is not quite current in many developed countries. The least care is required by the simple traditional implements; the more complicated design of the machines or implements, the more important is the prevention and the maintenance

for its operation and life. Consequently, the introduction of tractors and more complicated machines in the agriculture of the developing countries would not be possible without a good organization of the education of users and operators and without an efficient advisory service. Interested in the education and in the advisory service would be the manufacturers of the machines (be it foreign or local companies) and the national agricultural organizations. The organization of education requires a technical service, if it is to be efective. Thus, the education in the agricultural mechanization, comprises a broad field of requirements. It requires a cooperation of engineers, instructors, research workers and manufacturers. Furthermore, workers who are able to demonstrate modern applications of the agricultural machines and technologies to the farmers, are also very important. Such an education of the workers is, of course, a relatively slow process, as it comprises a large number of persons who are to be instructed and informed. The experience in many countries indicates, that the most efficient method of educating a large number of workers in technical service and in the agricultural practice, is to educate leading instructors, who are able to carry on the education in the farming practice, wherever it turns out to be necessary. The education of the workers has no direct requirements on the ancillary industry, but it is so far important, that it should be mertioned here, however briefly. Without a skilled ope-

ration and maintenance of agricultural machines and implements great values, produced by the industry, can be destroyed.

Service, with a supply of spare parts, brings forth direct requirements on the ancillary industry. With all the auxiliary material sources and plants, serving for the production of agricultural machines and implements, it will be necessary, to reserve a certain capacity for the production of spare parts. About 10 % of the total production capacity tends to be reserved for the purpose, generally speaking. The consumption is not, of course, the same with all the spare parts and it is directly proportional to the life of the parts. Consequently, it is necessary to determine an increase in the production of the different parts in per cents, to cover the demands on the spare parts. Of the total manufacturing program a group of parts is usually selected, with which the maximumwear is expected (working parts, shares, moving parts of the driving mechanisms, etc.) and in which a higher increase of the spare parts production is envisaged. Sometimes these spare parts are delivered with the machine and are included in the price of the machine.

This arrangement facilitates the service, which would have to supply the spare parts for the machines within a relatively short time anyway. In the range of semi-products it will be mainly steel parts manufactured from sheets

and plates (shares etc.), forgings (tines of the harrows) etc., that will have to be reckoned with. Less of the spare parts will concern castings of grey cast iron, except special parts of some machines of a more complicated design, such as for example cutter bars. The broadest range of spare parts occurs with complicated machines, such as e.g. with tractors. Equally as in case of the manufacture of the machines and implements, it is also in case of the manufacture and supply of spare parts, that the standardization plays an important role, if possibly coupled with a small assortment of the machines used. The less models of machines and implements are used in the farming practice, the cheaper is the manufacture of spare parts and the simpler their distribution. Furthermore, the spare parts are then cheaper and better available for the farmers, which is very important in the developing countries, where the purchasing power of the farming population is relatively low.

Contrary to the technical education of the workers in agriculture, in which national organizations are primarily interested, the service and supply of spare parts is more less solely in hands of the manufacturers of machines and implements. The specific conditions of service in the developing countries are notably long transport distances and a thin network of transport and haulage facilities, with a relatively low qualification and skill of the

farming population. The organization of the service network will have to be adapted to local conditions, though it seems, that transportable small workshops with a store of the more important parts, i.e. service vehicles, will be a generally applicable system. It enables the service in comparatively vast areas, with customers, who are unable to deliver their machines at long distances for repair or maintenance. The profitability of such service vehicles depends on the prices of the manufactures, on the purchasing power of the machine owners and on many other circumstances. It can be combined with an advisory or instruction service and with training of operators. Principally, it can be applied with success more easily with modern and more ingenious, i.e. more expensive machines, in areas with a comparatively higher level of agricultural production and mechanization. With simple, traditional animal-drawn implements, an expensive service would not pay and these implements do not require any service proper. The repairs can be made by the farmers themselves or by the village craftsmen and the necessary spare parts (shares, connecting parts, etc.) can be supplied through the usual commercial channels.

Summary

The utilization of the ancillary material sources and of the local industry for the manufacture of agricultural machines and implements in the developing countries is closely linked with the specific conditions of the agri-

cultural mechanization in tropical regions. These conditions differ from those in the developed countries notably by adverse climatic conditions, by the general economic level and by the social structure.

The climatic conditions bring forth higher demands on the machines (higher effects of the corrosion) and, apart from that, make necessary the use of machines and implements quite different from those currently used in the developed countries. Consequently, the supply of machines and implements for the developing countries must be re-valuated from a new angle. Up to now, the main attention has been paid to a direct industrial help of the developed countries, i.e. the import of finished machines. These machines may not be always suitable for the climatic conditions of the developing countries. Furthermore, they have been always too expensive for a developing economy, with a low purchasing power and unskilled labour. The imported machines are thus utilized in certain areas only and their life is much shorter than would be in normal conditions. A new approach to the problem of availability of machines and implements for the developing countries may be in (a) a development of traditional and standardized manual or animal-drawn implements of simple design, manufactured from the local sources, (b) utilization of local sources of materials and local industry

for the manufacture of simple parts of some more ingenious modern machines, adapted to local agrotechnical conditions; the manufacture of these machines and of design sections or parts of a more complicated design would have to be effected by a cooperation with developed countries.

Ancillary industries and sources for the manufacture of agricultural machines can be defined more accurately in actual conditions only. A Czechoslovak project for establishing manufacture of a representative line of machines and implements in India, comprising a more complicated power machine, several p.t.o. driven machines and some implements of simple design indicates, that the manufacture brings forth a demand for foundry materials (carbon steel), castings of grey cast iron and simple finished parts, notably connecting parts.

With regard to a low purchasing power of the broad agricultural population and to other different conditions of the developing countries, it seems reasonable, to count for present and for the near future with the manufacture and utilization of the simplest traditional implements manufactured by the farmers themselves or by the village craftsmen. The projects of modernization of some simple multi-purpose implements in some developing countries (for example in Pakistan and in India) indicate, that

a certain standardization would enable a concentrated manufacture of steel parts of these machines (shares etc.) in ancillary industries, while some parts of the implements (wooden handles etc.) could be manufactured in agriculture directly, if this way were the least costly, due to cheap labour in agriculture. Future manufacture will aim towards a higher technological level, towards more efficient utilization of ancillary industries and, at last, towards a manufacturing structure similar to the pattern in the developed countries. The utilization of the ancillary industry will gradually get the characteristics of a cooperation of equal industrial branches in a more or less independent economy. This trend will help to improve the system of raising the technical know-how in agriculture and the service, with one of its main tasks, i.e. the supply of spare parts. The system of mobile service workshops , which seems to be the best suitable at the present, will be gradually replaced by a network of service similar to the one in the developed countries.


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