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CASE STUDY ON THE MANUFACTURE OF TRANSMISSIONS IN BRAZIL 2/

presented by

Equipamentos Clark S.A.

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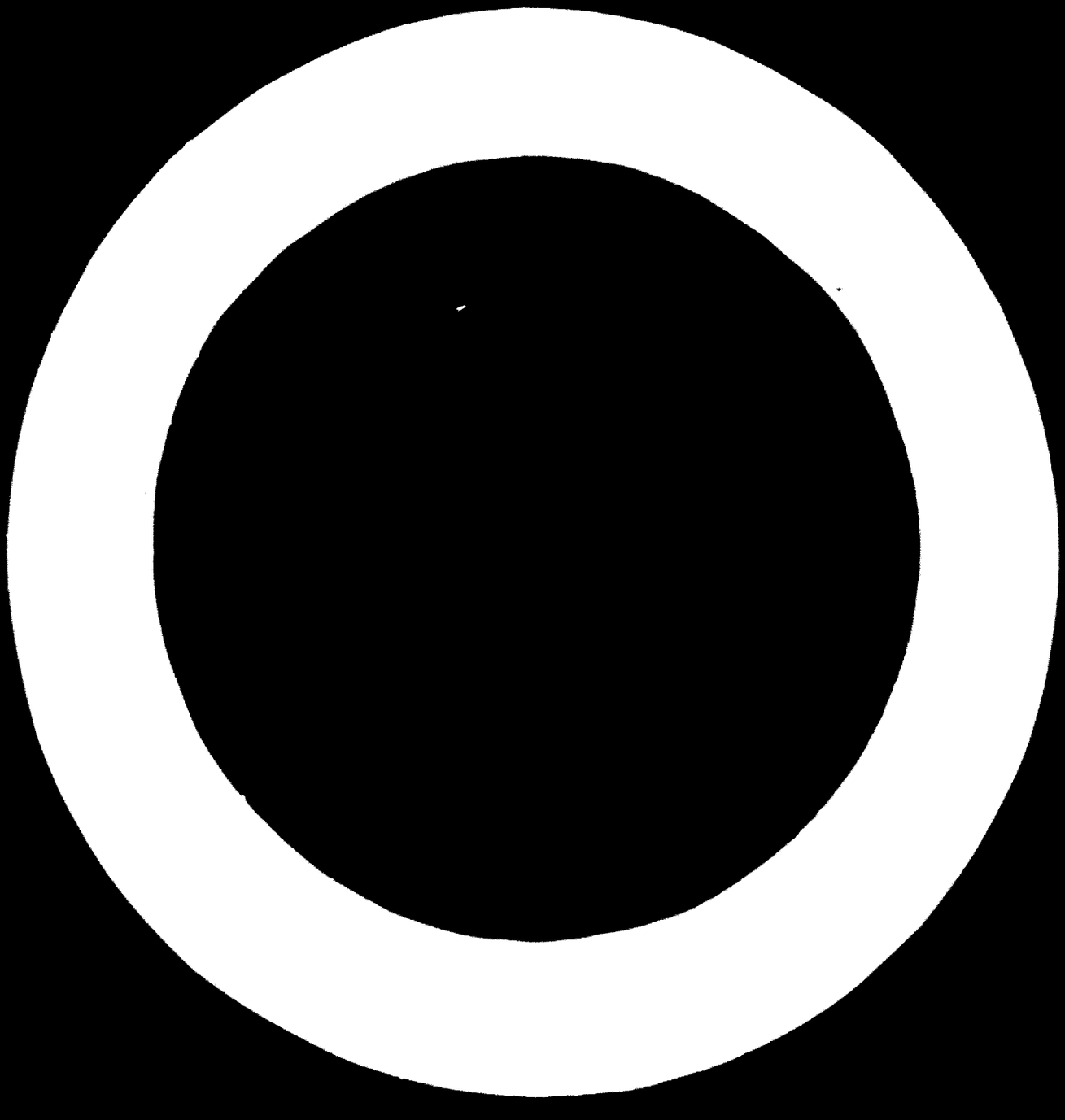
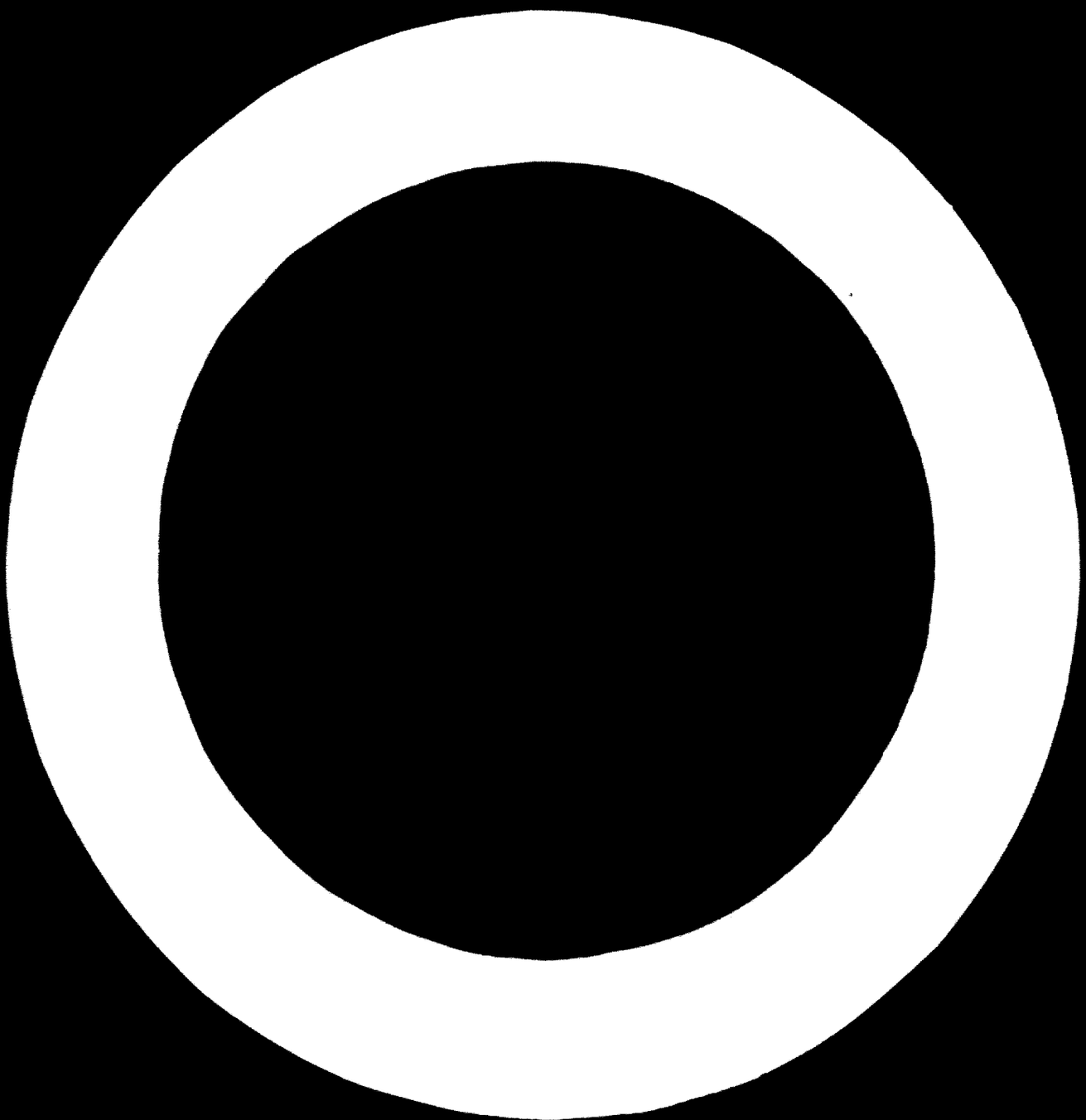
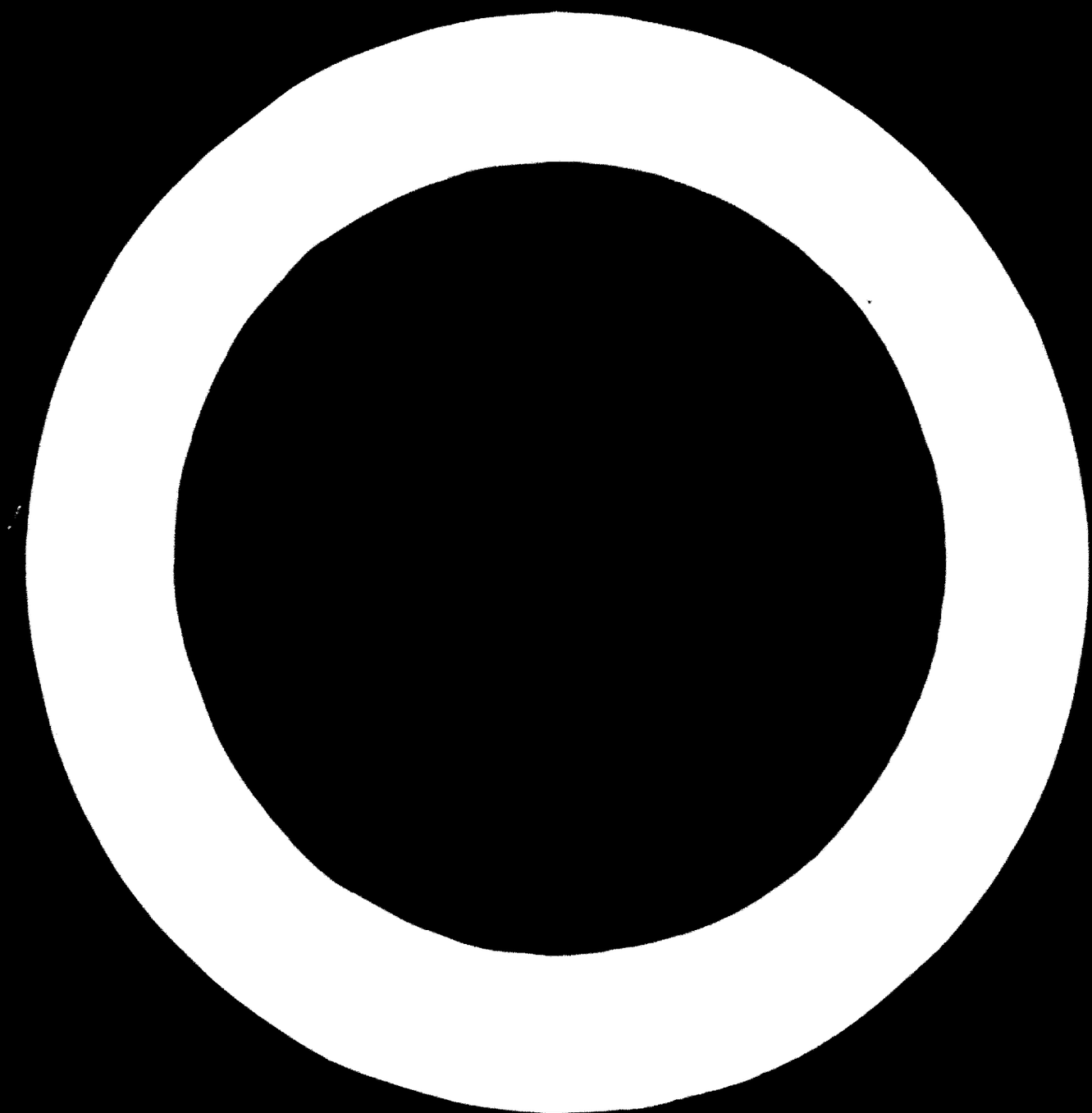




/I. THE CONCEPT



I. THE COMPANY

Equipamentos Clark is a company manufacturing transmissions for passenger cars, trucks, farm tractors, etc., for the Brazilian market as well as other products, like rubber-tired tractors and lift trucks. We are a subsidiary of Clark Equipment Company with home office in Buchanan, Michigan, U.S.A., with seventeen manufacturing plants in the United States and Canada, also eighteen manufacturing operations in which Clark owns between 25 per cent and 100 per cent equity and twenty-five licensees all over the world including several in Latin America. Regarding automotive products in Latin America, Clark has large transmission manufacturing facilities in Brazil and Mexico.

This study is presented by Equipamentos Clark S.A. in Brazil where we manufacture car and tractor transmissions for General Motors, Ford and Chrysler. Also farm tractor transmissions for Massey Ferguson and Valmet as well as a great variety of transmissions, P.T.O.'s and reduced or drop boxes for several OEM manufacturers of special equipment such as cranes, compactors, etc. We furnish all these OEM customers both with original units and spare parts. We also have independent distributors all over the country who buy spare parts from us for resale.

II. THE PRODUCT

The product for the case study is automotive "transmissions". It is an example of a vehicle component which requires a large machine tool investment and, more important for the study, a large tooling investment in dies, jigs, fixtures and cutting tools.

1. Definition and functional position of "transmission"

"Transmission" here will be understood as a mechanism which is part of the power train of the vehicle, that receives power from the internal combustion engine through a friction clutch, fluid coupling or a torque converter coupling and transmits it to a drive (traction) axle at a multiplicity of speed and torque ratios.

/2. Main

2. Main specifications of the transmission

The typical transmission chosen for the case study is a

- "constant mesh countershaft transmission",
- multispeed (3, 4 or 5 speed) forward and reverse with or without overdrive,
- different speed ratios selected for each application.

  Ratio (average) covered:

  1.0 (direct) to 3.00 for a 3-speed transmission,

  0.8 (overdrive) to 7.50 for a 5-speed transmission,
- max. engine input torque range within 120 ft. lb. to 350 ft. lb.

3. Breakdown of the transmission

The typical transmission chosen for the case study can be broken down for economical analysis into three groups of parts:

(a) Castings, comprising mainly the case, cover and retainers.

(b) Gear, shafts, bearings and other quality parts made of steel bars or steel forgings and that require machining and heat treatment for manufacturing.

(c) Stamped parts from sheet metal and other miscellaneous parts of small unit value.

4. Approximate percentual value

We estimate that the approximate percentual value of a transmission referred to the total cost of a vehicle is as follows (taxes and estimated profit for both manufacturer and distributor deducted from selling price of vehicle):

(a) In a passenger car: 4.4 per cent

(b) In a truck: 6.8 per cent

(c) In a tractor 9.0 per cent

This average refers to the Brazilian market.

/III. STANDARDIZATION

III. STANDARDIZATION (NORMALIZATION)

1. The transmission is a highly engineered mechanism whose design is determined by the engine characteristics and pre-established conditions of utilization of the vehicle along with other factors. Thus, the standardization of a transmission depends basically on the standardization of these determinant factors.

This standardization is more easily attained in the truck market. In the Brazilian market, for example, three basic transmissions are used for truck applications as follows:

(a) 3 speed - 120 to 190 ft.lb. max. engine torque for up to 1 ton truck
(b) 4 speed - 180 to 250 ft.lb. max. engine torque for 2½ to 6 ton truck
(c) 5 speed - 280 to 350 ft.lb. max. engine torque for 5 to 8 ton truck.

Within a limited range, each of these three basic models can be offered with different speed ratios by changing one or two sets of mating gears. The speed ratios available are such that they can satisfy most of the Brazilian road, loading, and usage conditions.

2. Standardization of parts and pieces of a transmission

Only a few parts such as ball bearings, needle bearings, oil seals, retainers and fasteners are standardized at the present time.

The gear and shaft designs are a result of complex engineering criteria and calculations and in many cases depend also on available production tooling, so they may not be standardized for universal interchangeability.

Efforts are made by our product engineering people to utilize the same gear and shaft in different transmissions as much as possible. But this may result in far from ideal multipurpose standard gear and shaft designs.

In addition to these basic difficulties we have the incompatibility within metric and inch systems that would require two large groups of non-interchangeable parts.

3. Standards for raw material and purchased parts

Most of steel and castings are specified by AISI and/or SAE standards.
Non-ferrous and non-metalic materials are specified by SAE standards.
Ball and roll bearings are specified by ISO metric standards.
The fasteners are specified by SAE and/or ISO metric standards.

/IV. MANUFACTURING

IV. MANUFACTURING

1. Manufacturing technological operations

The manufacturing of the transmission chosen for case study involves the following operations inside our plant:

Forging
Machining
Heat Treatment
Assembling

(a) Forging

Most gear and shaft are forged parts from carbon and/or alloy steel obtained in impression or upsetting-die.

(b) Machining

Machining can here be defined as a mechanical operation that uses machine tools that remove material in the form of chips to give a piece or part machined specific dimensional tolerances.

The machining operations are usually divided into two groups:

(i) Machining of green parts - steel bars, cast and forged parts without or before heat treatment, such as turning, milling, drilling, boring, tapping, tooth cutting, chamfering and shaving;

(ii) Machining of hard parts, i.e., steel parts after heat treatment, such as grinding and honing.

(c) Heat Treatment

Most steel parts of the transmission that are submitted to stress and/or wear are treated to improve their physical characteristics.

(d) Assembly

As each part of the transmission is machined and controlled within specified dimensional tolerances, all mating parts can be obtained without special selection or adjustment. In other words, all parts are interchangeable.

The final assembly line ends up in a test booth just for checking shift characteristics and the noise level of the running gears.

/2. Material

2. Material

The typical transmission chosen for the case study presents the following raw material breakdown:

Castings	26 per cent	weight
Carbon and alloy steel	71 per cent	
Others	3 per cent	

The material unit average consumption of the transmission is:

Castings	40 kg
Carbon and alloy steel	110 kg
Others	4 kg

V. PRODUCT OBSOLESCENCE

As automotive transmissions have not been really modified during the last years (unless you consider the automatic transmission as a modification which for the purpose of Latin America and particularly for this case study we are considering as a different product), we assume that the basic models are not going to be appreciably modified during the next ten years at least. We constantly introduce improvements in the transmissions manufactured by us, but do not change basic designs. Thus, the product lends itself to standardization throughout Latin America with the possibilities of one plant concentrating on certain models for distribution to motor vehicle manufacturers throughout the region.

VI. LAND, BUILDINGS, AND EQUIPMENT

Description

The transmission plant of Equipamentos Clark S.A. in Valinhos, SP, Brazil, was laid out for an average production of 10,000 assembled transmissions of different model plus spare parts for them per month, in a regular two shift operation.

/The type

The type of layout can be defined by the following distribution of areas:

1. Buildings

Manufacturing:	machining	39.6 per cent	
	forging	7.3 per cent	
	heat treat	10.3 per cent	
	assembly	6.6 per cent	
		Sub-total manufacturing	63.8 per cent
Shipping, receiving, and storage (covered area)			8.3 per cent
Manufacturing services (tool crib, tool room, maintenance, etc.)			10.7 per cent
Employees' facilities			6.3 per cent
Administration offices			10.8 per cent
			100.0 per cent

2. Land

Total property area is 385,000 m^2. From this area only 7 per cent is occupied by transmission manufacturing buildings up to the present time.

New constructions and/or improvements on existing buildings can easily be made on the remaining uncovered land.

Total value of land and buildings can be estimated at US$ 1,500,000.

3. Consumption: electricity, fuel, L.P.G., lubricants, and water

The following figures represent the average monthly consumption:

(a) Electric energy	750,000	Kw. hour
(b) Fuel oil (heat treat and forging)	250,000	litres
(c) Lubricants and cutting oil	24,000	litres
(d) L.P.G. for heat treat	47,000	kg
(e) Water	3,500	m^3

Note:

(i) Electric power supply in the Campinas area will not constitute a problem in the near future thanks to the large hydroelectric plants being built by the Brazilian government throughout the Sao Paulo state (one of the world's largest hydroelectric projects: 2,413,000 kw).

/(ii) Petroleum

(ii) Petroleum refined products and by-products are becoming increasingly available from local production. Thus, we will not have any restriction on increased consumption of these products in the foreseeable future.

(iii) Water consumed in the plant is stored and treated inside our own facilities.

4. Machinery and equipment

To perform the manufacture operations as described above, adequate machinery and equipment are provided in each area as follows:

(a) Machining

Lathes	- automatic, copying, turret, multi-spindle, etc.
Broach	- hole and surface broach (horizontal and vertical)
Drill	- upright, radial, multi-spindle
Boring	- double end
Milling	- horizontal, vertical, universal, duplex, etc.
Grinding	- internal, external, plane surface, centreless
Gear tooth cutting	- shapers and hobbers
Gear shaving	- rotatory type
Gear honing	
Tooth chamfering	
Others	- tool sharpening and grinding, etc.

(b) Forging

2 Upsetters	- (4" and 6")
1 Hydropress	- 2,000 tons
2 Hammers	- 2,500 and 4,000 pounds
1 Coining press	- 600 tons

Furnace, wheelabrator forging cleaner, steam boiler and compressors.

(c) Heat treat

1 Continuous pushing type carburizing furnace

4 Allcase furnaces

1 High frequency induction machine (400,000 c.p.s.)

2 Medium frequency induction machine (10,000 c.p.s.)

/A Straightening

4 Straightening presses

2 Quenching presses

1 Shot peening equipment

1 Wheelabrator (shot blast cleaning)

Note: (i) Most of the machine tools and equipment are universal type of production equipment. Thus they can operate for either long or short job lots.

(ii) Machine tools for the machining of cast iron "box type parts", such as cases and covers, are equipped with jigs and fixtures.

Total value of the machinery and equipment involved can be estimated at US$ 9,500,000. About 50 per cent of this equipment was originally bought as a rebuilt equipment and not less than 95 per cent was imported free of customs duties in accordance with the Brazilian government's nationalization and plant modernization programmes.;

VII. COST OF THE PRODUCT

The following information is based on a real case of a vertical transmission manufactured in our plant. This is a five speed synchronized transmission for trucks designed by Clark Equipment Co. in the United States:

Manufacturing cost		%
(Alloy) steels		16.9
Castings		15.4
BFU parts - local		27.4
BFU parts - imported		0.1
Direct labour		3.1
Indirect labour		3.0
Payroll expenses		4.9
Tooling amortization	9.0%	
Depreciation (equipment and buildings)	7.1%	
Quality control	2.1%	
Fuel and lubricants	2.9%	
Electricity	0.8%	
Maintenance	3.9%	
Others	2.8%	13.1
Manufacturing cost		100.00

/Note: (i) This

Note: (i) This manufacturing cost actually represents approximately 76 per cent of the total cost of the transmission after adding administrative cost which includes processing and designing engineering, purchasing, planning and production control, legal, financial, etc., as well as sales expenses, taxes and technical assistance fees.

(ii) Cost of raw material and some main purchased parts - Local - US$

Alloy steel	0.30/kg
Carbon steel	0.27/kg
Casting	0.40/kg
Maindrive bearing	3.9%
Shift lever	3.27
Rod end clevis	1.5%

Note: (a) Normally we do not import anything as Brazil produces all that we need.

(b) As sales and excise taxes are only paid on the added value, we deduct from the initial cost of the part and consider the total paid on sales as a deduction from gross sales.

VIII. INVESTMENT, DEPRECIATION AND AMORTIZATION

The investment in land, buildings and machinery and equipment was given before. Regarding tooling, we have an investment of around US$ 1,900,000. The depreciation and amortization considered in our plant for equipment are around 15 per cent. Buildings are depreciated at the rate of 2.5 per cent per year based on their life expectancy. Regarding tooling, we amortize as follows: (a) Perishable tools are expenses as soon as they are requisitioned for production; (b) Semi-perishable tooling is amortized on the basis of 1/12 of its cost per month after it is requisitioned for production; and (c) Non-perishable tooling is amortized on the basis of 5 years.

/IX. MANPOWER

IX. MANPOWER COST

Regarding cost of labour in Brazil we can consider that an average hourly cost for production semi-skilled labour is around US$ 0.70 including fringe benefits. From that point on you have highly skilled labour, engineers, supervisors, and managers. The range moves quickly from one bracket to the other until it can reach easily around 1,500 to 2,000 dollars per month, for managers. The total payroll cost is around 25 per cent of the annual sales.

X. WORKING CAPITAL

As manufacturing transmissions in quantities require a long lead time, the working capital needs are relatively high in spite of the fact that sales to OEM customers are normally on short-term basis, we can consider that our needs for working capital are around 3 million dollars. This figure represents approximately 25 per cent of the annual net sales.

SALES EXPENSES

As 95 per cent of our business is carried out with OEM customers, our selling expenses are very nominal since we do not spend much money in distribution, advertising, etc. The same applies to transport and warehousing costs. However, if it were possible to export, transport and warehousing would add up to 10 per cent of the sales price inside Brazil, depending upon destination.

SUMMARY

The main problem that we see in Latin America is the one relative to the actual quantities to be produced during the year. This problem needs to be studied for the purpose of making all efforts in order to produce in each particular plant as many units of the same model as possible. The result would be reduction of the cost per unit, making the Latin American production competitive in the world markets.

/The solution

The solution could be obtained by creating conditions for a plant in a certain country to concentrate on manufacturing certain models for a greater market, say, all Latin America or several countries in Latin America and having other plants in other countries concentrating in other models with the basic idea of interchanging them, thus offering for the vehicle manufacturers standardization in quantity transmission in all countries involved and, of course, at the best possible price inasmuch as the manufacturing facilities in the different countries can be utilized at their maximum efficiency. This production concentration will further allow these manufacturing facilities to modernize the equipment and even to start using more special semi-automatic and sophisticated equipment which today is only used in highly industrialized countries permitting higher production at reduced cost.

The following chart using the actual figures of the transmission chosen for the case study will emphasize the effect of the quantities on the cost:

Units sold/year	Total cost b/	Increment on sales volume (% over preceding figures)	Consequent decrement on cost
1,200 a/	100	....	...
2,400	73	100	27.0
4,200	63	75	13.7
6,000	58	43	8.0
8,400	55	40	5.2
10,800	53	29	3.6
13,800	51,5	28	2.9
14,000 and over c/	...	...	...

a/ The current sales in Brazil of 1,200 units was assumed as the base volume to which corresponds the base cost of 100.

b/ Total cost should be understood as selling price less profit, including G & A, selling, interest, warehousing, and transport expenses.

c/ Over 14,000 units sold per year, the cost reduction would not be significant unless the sales volume increase is in such a way that it would require a revision and reorganization of the production facilities.

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