# GENERAL PURPOSE TWO-WHEEL TRACTOR

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## Introduction

Self-sufficiency in food is still a central theme in discussions relating to national development. It has over the past years received the attention of the State and other national organizations as well as the general public. Several reports published during the past few years stressed the need for mechanical aid for farmers. A recent World Bank report indicates that about 4000 tractors will be needed in the next three years if the country were to achieve greater agricultural productivity and expansion. The import of two-wheel tractors for the purpose requires an initial investment of about Rs. 30 million and a further expense of well over Rs. 30 million for the purchase of spare parts during the nominal life period of the tractors.

The past few years saw several attempts at manufacturing two-wheel tractors locally. State sector organizations, as well as private sector organizations were involved in these attempts which proved to be rather unsuccessful. The failure can be attributed to two key factors:

(a) Some of the attempts were no more than merely duplicating some foreign design. The cost of the product was high while the quality was poor. This is not surprising in view of the fact the foreign designs were meant for advanced manufacturing systems and the production facilities available locally were not suitable for their production.

(b) The designs which were produced at comparably reasonable cost lacked some important facilities (such as gears, wheel releasing clutches etc.).

It can be clearly seen that the attempts at manufacturing the tractors were made without due consideration to the objective realities of the local situation such as,

(a) The available facilities for the manufacture of machine elements like gear wheels, splined shafts etc.
(b) Cost of producing the necessary components locally.
(c) Availability of material (steels and non-ferrous metals).
(d) Market conditions.

The local consumer who has got used to good quality tractors with elaborate facilities was naturally reluctant to changeover to an inferior rival whose price was in any case high. It is therefore necessary for a successful designer to take full account of the aspects mentioned above and ensure that his product was competitive with the imported one in quality as well as cost. The present two-wheel tractor gearbox and transmission system successfully designed and trial-produced at the Faculty of Engineering, Peradeniya Campus was based on a careful study of the various aspects referred to.

## 1. The design criteria

The design criteria were based on the following observations about conditions prevalent in Sri Lanka.

### 1.1 Production facilities available

Production facilities in Sri Lanka for the manufacture of machines are rather backward compared to that of developed countries. The developed countries employ highly sophisticated manufacturing systems such as computer-controlled systems using advanced machine tools such as numerically controlled machines, automatic lathes, electro-chemical machines, electro-discharge machines etc. The local manufacturing facilities are mainly individual types such as centre lathes, general purpose milling machines, low power presses and so on.

### 1.2 Availability of materials

Sri Lanka has no metal extraction industry, this makes the problem of raw materials somewhat serious. However, the availability of scrap steel in large quantities locally has at least for the next few years eased the problem in relation to cast iron. Also mild steel is easily available in the local market.

### 1.3 Availability of skilled labour

The average skilled workers of this country has not been trained to think in terms of optimisation, product quality and strict tolerances. The lack of training makes it not possible for the vast majority to produce a work from a somewhat complex working drawing.

### 1.4 Cost

The imported two-wheel tractor is available in the market for a price ranging from Rs. 8000 - 12000.

It is important that the locally produced tractor cost no more than the imported one; has facilities such as large numbers of forward gears and wheel releasing mechanisms; is easy to handle and versatile in application. The manufacture should be possible on medium size machines; permit large tolerances in order that even semi-skilled machinists can handle production; use cast iron and mild steel to the fullest possible extent.

## 2. The design of the prototype

The components designed and developed in the present work include a friction clutch at the input side, a gearbox and a transmission unit incorporating a wheel release clutch. (See Appendix 1 for the specifications of the unit).

Two-wheel tractors commonly use jockey pulley type clutches at the input side. These tend to get heated up during power transmission and suffer further disadvantages of belt slip during engagement and disengagement. Owing to frequent idling and engaging, the life of the belt is adversely affected. This made it preferable to use a friction type clutch in the present design. (Figure 1). The clutch has the advantage of smooth engagement and disengagement and incorporates a locking action while engaged. The clutch is operated by a push and pull type cable mechanism and is subject to easy adjustment by changing the cable position.

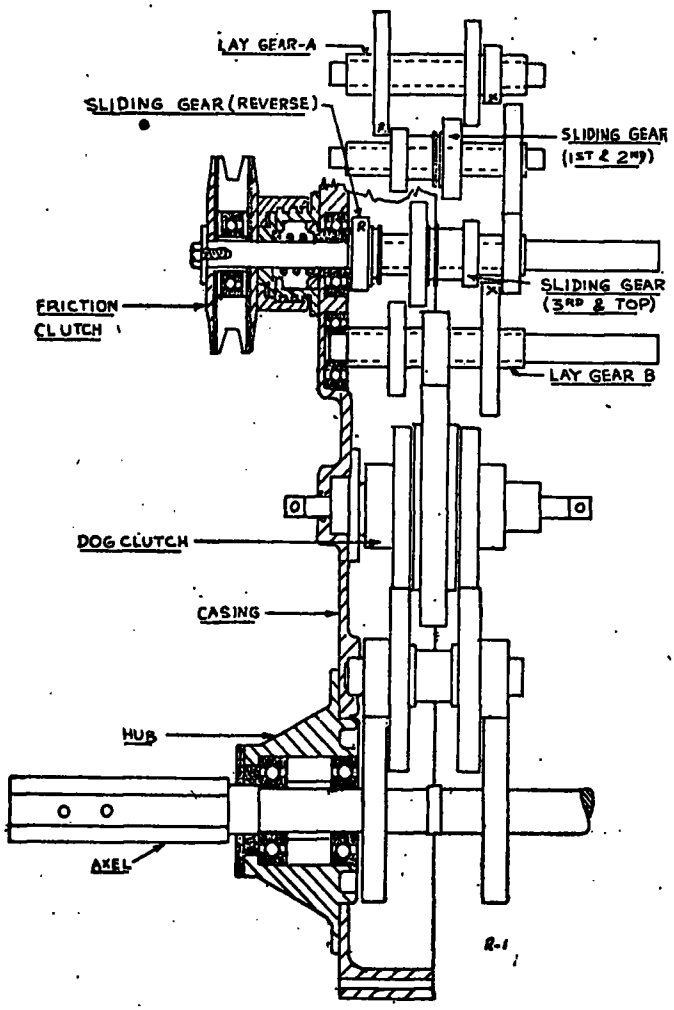


**Fig. 1. Gear Box & Transmission**

The gear box used on the prototype is shown in Figure 1. It has four forward gears and one reverse gear. The first two of the forward gears are for working the land and the other two for transport. The gear box use simple spur gears and no internal type gear wheels were employed. This ensured that the gear wheels were easy to manufacture with the only internal machining done being spline cutting which in turn was done by broaching. The design of the sliding gears (carrying two gears on each) was such that they could be cut on a general purpose milling machine using standard gear cutters. The lay gear clusters A and B were built from individual gears, force fitted to a splined shaft in order that the following problems were overcome.

(a) Inadequate facility for preparing blanks and cutting wheels of the lay gear type.
(b) The need to have very few critical tolerances in view of the lack of adequately skilled labour.
(c) Wastage of material in machining and the problems of rejects.

The splines of the shafts were machined on a general purpose milling machine using a splined cutter designed and manufactured at the faculty workshop. The broaches required for splining the wheels were also manufactured at the faculty with medium carbon steel.

A survey of the two-wheel tractors in local use revealed that no locally manufactured two-wheel tractor had a wheel releasing mechanism. Some of the earlier imported tractors too lack this facility. The absence of wheel releasing mechanism makes the handling of the tractor in the field rather fatiguing.

Although some recent models of imported tractors possess this facility, users have complained about axle failure in some models. The axle failure in most of the models was most probably due to the type of dog clutch used and its location. The dog clutches are placed at the final stage of the transmission where the torques are very high and nearly all dog clutches appear to have no shock absorbing facility.

The present design overcame these problems by placing the dog clutch at an intermediate stage of transmission, where torques are relatively lower and by using a shock absorbing mechanism (see Figures 2 & 3). The present clutch while having the usual components of a dog clutch has the torque transmitted through springs thus reducing the shock load imposed on engagement. The clutch operating mechanism was designed in order to minimise the number of components required and also to provide positive action. The mechanism is operated by two cables and two handles.

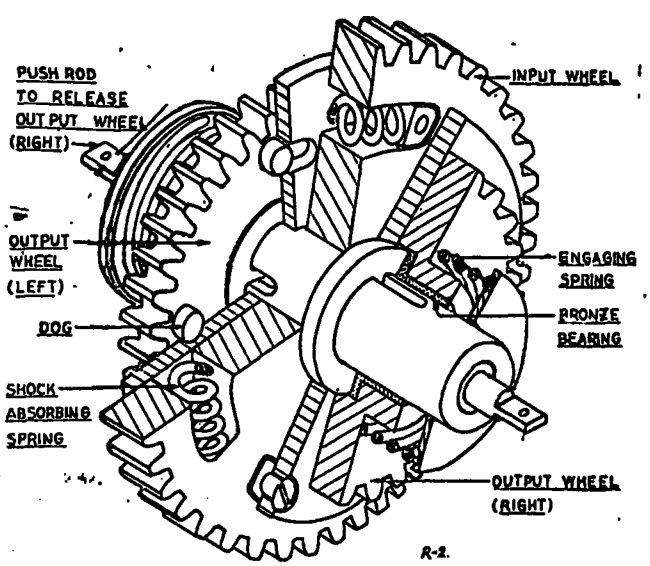


**Fig. 2. Dog Clutch**

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The two stages of the transmission employ two simple spur gear drives. The double gear at the intermediate stage was designed and manufactured in two parts. These were subsequently force fitted and welded together after inserting load carrying pins. This eliminated the need to use a gear shaper to machine this item.

The final stage of the transmission was designed so that it along with hub and axle could be easily removed from the casing thus facilitating easy assembly and convenient repair. The axles and gear wheels were fitted together on splines with each of the axles mounted on the hub on two ball bearings. The axles were splined with a common gear cutter and the gear wheels were broached with a broach manufactured in the Engineering Faculty workshop.

A simple design was used for housing the gear box and transmission. Problems in casting and machining were taken full account of in the design. The gear casing was cast in a sand mould with an aluminium-copper alloy. The machining operation for bearing, housings and drilling for fastening bolts was done on a simple vertical miller, using the co-ordinates of the centres with respect to the locating pins.

The design of the case and the handle for the tractor permits it to be manufactured with facilities available at a blacksmith's shop with little or no additional equipment. The design consists of a sheet metal case and steel tube handles. The gear lever was mounted on the sheet metal case with a ball joint coupled to the gear changing mechanism, through a simple universal joint. Ergonomic considerations determined the location of all handles and levers.

All mild steel components were case hardened using a powder developed at the Faculty of Engineering.* The depth of the case selected is as follows:

| | |
|---|---|
| Gear wheels | 0.6 mm. for all 10 D.P. gear wheels<br>0.8 mm. for all 8 D.P. gear wheels |
| Shafts | 0.4 mm. |
| Gear forks<br>Pins | 0.2 mm. |

## 4. Present state of the project

The prototype has been tested for power and strength; further texts for wear characteristics of components are in progress. The load tests on the machine showed successful results. Five thousand hours of testing revealed no signs of wear except for a initial sign of polish (the gear wheels were not ground initially).

The tests proved to be satisfactory and an initial batch of ten two-wheel tractors are now under production for the purpose of further field tests and investigation of interchangeability and other problems of mass production. They are expected to be completed in the very near future.

The estimated cost (including labour, depreciation of machinery etc.) is about Rs. 6,000/-. It is estimated that mass production can cut this down to as low as Rs. 5,000/-.

## Reference


* Maliyasena, H. P., *Unpublished Work at the Faculty of Engineering, Peradeniya Campus.*


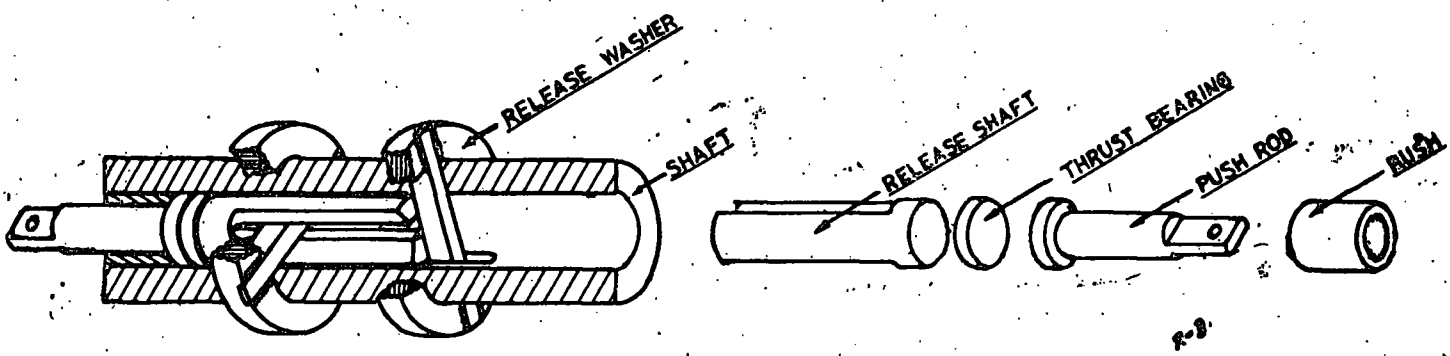


**Fig 3. Dog Clutch Shaft**

The engine which was imported (Shibuwa, petrol/kerosene 75 ml) was mounted on an angle iron frame fixed to the casing. This frame also could be manufactured in a blacksmith's shop.

## 5. Materials used

The following schedule gives the materials used in the prototype.

| | *Components* | *Materials* |
|---|---|---|
| 1. | All gear wheels, shafts (except main axle), dog clutch, gear forks. | Mild steel |
| 2. | Main axle | Jumper steel |
| 3. | Gear casing | Al. - cu. alloy |
| 4. | Bush bearings | Bronze |
| 5. | Springs | Spring steel |


## Acknowledgements

Dr. H. B. Maliyasena in aiding and carrying out the case hardening of components etc.; Prof. A. Thurairajah for allowing this project to be carried out in the Faculty Workshop: Final year students in the Department of Production Engineering and all members in the Workshop in the manufacture of the prototype.


## Appendix 1

**Specifications of the gear box and transmission unit:**

Coupling to engine — Belt driven through a friction clutch.

Gear box and transmission — All spur gears with a spring loaded dog clutch for wheel release.

**Gear box reduction**

| | |
|---|---|
| First— | 1 : 0.159 |
| Second | 1 : 0.253 |
| Thied— | 1 : 0.485 |
| Fourth— | 1 : 1.13 |
| Reverse— | 1 : 0.279 |

Reduction in the transmission— 1 : 0.101.
Design horsepower of the gearbox and transmission = 7 h.p.
Maximum road speed on top gear— 25 m.p.h.

## පොදු කාර්ය රෝද දෙකේ ට්‍රැක්ටරයක්

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ගොවියනට කාර්මික සහාය ලබාදීම වගා ව්‍යාපාරයේ පුළුල් වීමත් සමග ඇතිවූ අවශ්‍යතාවයක් වූ අතර මේ සඳහා අප රටේ අවශ්‍යතාවයන්ට රෝද දෙකේ ට්‍රැක්ටර් හොඳින් ගැලපෙන බව පැහැදිලි විය. මේ නිසා රජයේ සහ පුද්ගලික ආයතන කිහිපයක් ම රෝද දෙකේ ට්‍රැක්ටර් අප රටටම නිෂ්පාදනය කර ගැනීම සඳහා ප්‍රයත්න දරුහ. මේ ප්‍රයත්න ඉතාමත් සාර්ථක නොවූ අතර එයට ප්‍රධාන හේතු දෙකක් දක්විය හැකිය. මෙයින් පළමුවැන්න නම් සමහර නිෂ්පාදනය කල ට්‍රැක්ටර් පිටරට ඒවායේ පිටපත් වීමය. සමහර නිෂ්පාදිත ට්‍රැක්ටර් වල පිටරදින් දුනට ගෙන්වන ඒවායේ තරම් පහසුකම් සහ අවශ්‍යතාවයන් නැතිවීම දෙවැනි හේතුව ලෙස පෙන්වා දිය හැකිය.

ක්‍රම සම්පාදන සහ ආර්ථික කටයුතු පිළිබඳ අමාත්‍යාංශයේ (ප්‍රාදේශීය සංවර්ධන අංශයේ) ආධාර ඇතිව පේරාදෙණිය මණ්ඩපයේ ඉංජිනේරු පීඨයේ දුනට රෝද දෙකේ ට්‍රැක්ටරයක් නිර්මාණය කොට නිපදවා ඇත. මෙම ප්‍රථම ප්‍රයත්නය පරීක්ෂණවලදී ඉතා සාර්ථක ප්‍රතිඵල දක්වා ඇත. මෙය නිර්මාණය කිරීමේ දී දුනට ලංකාවේ පවතින කාර්මික ඥාණයත්, පහසුවෙන් ලබාගතහැකි ද්‍රව්‍ය සම්බන්ධවත්, නිෂ්පාදන වියදම් ආදී දේ ගැනත් සලකා බලා ඇත. මෙම ට්‍රැක්ටරය බහුනිෂ්පාදනයේදී රුපියල් 6000/- පමණ වෙයයි ගණන් බලා ඇත. ඉදිරියට ගියර හතරකුත් පස්සට ගියරයකුත් සපයා ඇති මෙම ට්‍රැක්ටරයෙහි ඉදිරියට ඇති ගියර දෙකක් බඩු ගෙනයාමේ කාර්යයන් සඳහාත්, අනිත් ගියර දෙක අනිකුත් ගොවිතැන් කටයුතු සඳහාත් වේ.

මෙම ට්‍රැක්ටරයේ ඇති ඉතාමත් වැදගත් සහ අලුත් කොටස රෝද නිදහස් කිරීමේ ක්ලචය වේ. මෙම කොටස මගින් රෝද දෙකින් ඕනෑම එකක් හෝ එකවර දෙකම නවත්වා නැවත ක්‍රියා කරවිය හැක. මෙය කේබල් සහ ලීවරයන් දෙකක් මගින් ක්‍රියා කරවිය හැකි අතර රෝද නවත්වා නැවත ක්‍රියා කරවීමේදී ඇතිවන අධික තෙරපීම අඩු කිරීම සඳහා විශේෂ ක්‍රමයක් යොදවා ඇත.

මේ ට්‍රැක්ටරය නිෂ්පාදනය සඳහා අවශ්‍ය ලෝහවලින් වැඩි කොටසක් ලංකාවේ පහසුවෙන් ලබාගත හැකි ඇලුමිනියම්, වාත්තුයකඩ, සහ පිත්තල වැනි ලෝහ වලින් නිෂ්පාදනය කලහැකි අතර දැනි රෝද මෘදු වානේ වලින් සාදා මතුපිට පන්නරය තබා ඇත. මතුපිට පන්නරය සඳහා යොදගෙන ඇත්තේ පොල්කටු අඟුරු වලින. පේරාදෙණිය මණ්ඩපයේ ඉංජිනේරු පීඨයේදී සොයා ගත් කුඩු මිශ්‍රණයකිනි. ට්‍රැක්ටරයට අවශ්‍ය රාමුව සහ අනිකුත් කොටස් ඉතාම සුළු කම්හලක වුවත් නිෂ්පාදනය කළහැකි ලෙස නිර්මාණය කොට ඇත.

මෙම ප්‍රථම නිෂ්පාදනයේ කොටස් පැය 5000 ක් ධාවනයෙන් පසුව සැලකියයුතු ගෙවීමකට ගොදුරුවී නැති බව පෙනී ගොස් ඇත. තවදුරටත් පරීක්ෂණ කිරීම සඳහාත්, බහු නිෂ්පාදනයේදී ඇතිවිය හැකි ප්‍රශ්න නිරාකරණය කිරීම සඳහාත් දුනට ට්‍රැක්ටර් 10 ක් මෙම පීඨයේ නිෂ්පාදනය වෙමින් පවතී.

## பொதுநோக்கு இரு-சில்லு இழுப்பூர்தி

ஆர். ஜே. கே. ஏஸ்.ரணத்துங்க

உணவு உற்பத்தி இயக்கத்தின் விரிவாயனுக விவசாயிகட்கு பொறிமுறை உதவிச் சாதனங்களை வழங்கல் அவசியமாயிற்று. இரு-சில்லு இழுப்பூர்திகள் நாட்டின் தேவைக்கு நன்கு பொருந்தின. இது பொதுத்துறை, தனியார்துறை இரண்டினையும் உள்நாட்டில் இரு-சில்லு இழுப்பூர்திகள் உற்பத்தி செய்யத் தூண்டியது. இரு-சில்லு இழுப்பூர்திகளை உற்பத்தி செய்யும் முயற்சிகள் அனேத்தும், இரு காரணங்களால், வெற்றி காணத் தவறின. முதலாவதாகச் சில முயற்சிகள் அயல் நாட்டினவற்றின் நேரடிச் பிரதிகளாய் அமைந்தன. இரண்டாவதாகச் சில உள்ளூர் உற்பத்திகள் இறக்குமதி செய்தவற்றின் கியர், சில்லை விடுவிக்கும் வசதி போன்றவற்றைக் கொண்டிருக்கவில்லை.

ஒரு முதன்வகை இழுப்பூர்தி கியர்ப் பெட்டியும், செலுத்து முறையும் திட்டமிடல் - பொருளாதார அலுவல்கள் அமைச்சின் (பிராந்திய அபிவிருத்திப் பிரிவு) ஆதரவுடன் பேராதனை வளாக எந்திரவியற் பீடத்தில் விதானமிடப்பட்டு உற்பத்தி செய்யப்பட்டன. பாவனைப் பரிசோதனைகள் மிகத் திருப்திகரமாகக் காணப்பட்டன. இதனை விதானமிடுதலில் இலங்கையில் உள்ள நிலவரங்கள் (திரவியங்கள் கிடைக்கும் தன்மை, நம் தொழிலாளரது தொழில் நுட்பத் திறன், உற்பத்திச் செலவு போன்றன) கணிப்பில் எடுக்கப்பட்டன. இவ்விழுப்பூர்தியின் மதிப்பீட்டு விலை ரூ. 6000/-. இது வீதிப் பாவனை கட்கு இரு வேகமான முன்னேக்கு கியர்களையும், வயற் பாவனைகட்கு இரு மெதுவான முன்னேக்கு கியர்களையும், ஒரு பின்னேக்கு கியரையும் உடையது.

இவ் விதானத்தின் ஒரு அதிமுக்கிய, நவீன உறுப்பு அதிர்ச்சி - தாங்கும், சில்லை விடுவிக்கும் கிளச்சு ஆகும். இக் கிளச்சு கம்பிக் குழாய்கள் மூலம் இரு கைநெம்புகளால் இயக்கப்பட்டு இரு சிற்களிலும் ஏதேன் ஒன்றையோ அன்றி இரண்டையுமோ நிறுத்த வல்லது.

உற்பத்தியில் பாவிக்கப்பட்ட திரவியத்திற் பெரும் பகுதி அலுமினியம், வார்ப்பிரும்பு, பித்தளை போன்ற கழிவுத் திரவியங்களாலானது. கியர்ச் சிற்கள் மெல்லுருக்கால் ஆனவை. எந்திரவியற் பீடத்தில் உற்பத்தி செய்யப்பட்ட பெட்டிக் கடினமாக்கு துகள் பாவித்துப் பெட்டிக் கடினமாக்கப்பட்டவை. கைப்பிடி, சட்டம் ஆகியன உள்ளூர்க் கொல்லர் கம்மாலைகளில் உற்பத்தி செய்ய உகந்தவாறு விதானமிடப்பட்டுள்ளன.

முதன் வகை 5000 மணி ஓட்டத்தின் பின்னரும் கணிசமான தேய்வைக் காட்டவில்லை. தற்போது எந்திரவியற்பீடம் 10 இழுப்பூர்திகளை மேலும் சோதனைகட்காக உற்பத்தி செய்வதிலும் பெருவாரி உற்பத்தியில் பிரச்சினைகளை அறிவதிலும் ஈடுபட்டுள்ளது.

**Library** (*Continued from Page 29*)

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