TECHNICAL NOTE

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Forest Research
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THE ADAPTATION OF AGRICULTURAL TRACTORS FOR FORESTRY

Summary

Many agricultural tractors can be adapted for forest use and some of these are purpose made for a dual farm/ forestry role. Agricultural tractors are cheaper to buy and operate than purpose-built forest machines, although they cannot achieve such large programmes or high outputs.

Careful selection of the correct tractor and correct modification for forest conditions are important.

Introduction

This Technical Note identifies adaptations required for differing forest conditions and operations. Information on suppliers and indications of cost are given wherever possible.

The modified farm tractor was extensively used in the UK forest industry before purpose-built forestry tractors became increasingly available in the 1970s. At that time, building on Scandinavian experience, the Forestry Commission led research and development into the modifications required to match tractors to UK forest conditions. Standard agricultural tractors, modified to such designs, are available today from a relatively limited number of manufacturers and specialist engineers (Plate 1).

Machine Selection

Essential forestry requirements can differ widely according to the job.

Plate 1

Modified Agricultural Tractor and Processor

Considerations include:

- Power required.
- Terrainability required.
- Ergonomic factors.
- Guarding and protection.
- Special demands made by forestry accessory equipment.

Power requirements in forestry can range from 20 hp for a small linkage winch working part time in easy terrain to 120 hp for more difficult conditions with a respacing/mulching attachment. Given several job requirements, power will be dictated by the most demanding application. High power alone is of no use if it cannot be fully used by the attached equipment or translated effectively into drawbar pull in the operating conditions. Excessive power can, for example, give rise to machine control mistakes or can overload the attached equipment.

Terrain limits are determined by a number of factors. A careful assessment of the likely terrain conditions the adapted agricultural tractor will encounter should be made. For example, in flat heathland pine and mixed broadleaf forest conditions, a standard tyred 2 wheel drive tractor is suitable. In wet upland conditions, often with very variable terrain, a 4 wheel drive tractor is essential. This may also have to be augmented by wide tyres of special 'forestry' construction. Tyre chains are required in wet and steep conditions to ensure wheel grip. The 'ring' type have proven to be best but ordinary tyre chains can produce a smoother 'ride' and help significantly in moderate conditions.

Certain factors are determined by the choice of tractor itself. **Ground clearance** on agricultural tractors is usually only 35 to 40 cm, compared with the 50 cm or more on purpose built forest machinery. Removal of the swinging drawbar, or use of a higher profile pick-up hitch can often increase ground clearances sufficiently to prevent a tractor being repeatedly 'hung up' on tree stumps. Wider section standard tyres can often minimise sinking on soft forest surfaces, for example 18.4 inch instead of 16.9 inch widths.

Machine **weight distribution** is important. Most agricultural tractors have a rear axle weight bias of *c*. 60% to assist farm operations such as ploughing. Forestry equipment such as winches and processors can greatly increase this and may significantly reduce the load on the front wheels. This results in steering difficulties and can be dangerous. Four wheel drive tractors have a heavier front axle, which is helpful. The addition of front-end weights, about 45 kg (100 lbs) for every 7.5 kW (10 hp), is also recommended[1]. Some agricultural tractors either have a front axle weight bias or are designed to carry equipment so that resultant loading is carried more evenly. Examples are the M-B Trac, Massey Ferguson 1200, Forward Control Ford County and Fendt 380GTA (Plate 2).

Plate 2

Massey Ferguson 1200 with 5.6m Loader and Harvester

Purpose built forestry machinery usually has 'frame-steered' **construction**, whilst traditional agricultural design is mostly 'rigid frame'. Frame steered machines have a central pivot joint that is designed to accommodate horizontal steering and vertical twisting movements. Rigid frame machines usually have asteerable front axle that also pivots vertically to accommodate ground roughness, the rest of the tractor being 'rigid'. Laden weight distribution is improved by having all the heavy components in the front. The 'framing' action gives the driver a better combination of manoeuvrability, grip and climbing ability. Examples of agricultural tractors with frame steering are the Massey Ferguson 1200 and Holder models. Others include the 'Vineyard' tractors, although these may be unsuitable for modification because the addition of forestry attachments and guarding affects basic stability characteristics.

Frame steered agricultural tractors are not well suited to towing forestry trailers.

Very **basic criteria** can affect tractor terrainability:

- Wheel track (spacing across the machine) should be wide for stability. Exact distances will depend on individual machines and conditions.
- Tyre pressures can have a remarkable effect in difficult conditions and as a rule-of-thumb should generally be the lowest setting the tyre and machine manufacturers recommend.
- Radial tyres are **not** recommended for forestry use. Their flexible side wall construction renders them liable to earlycarcase damage from stumps.

1 Folkema MP, (1986). *Logging Winches for Farm Tractors*, Technical Note TN-90, Forest Engineering Research Institute of Canada.

- Small diameter tyres, especially those on the front steering wheels of 2 wheel drive tractors, can easily become bogged or unsealed from the wheel rim by obstacles on anything other than easy terrain.

- For making tight turns at slow speeds, the simple addition of a steering wheel knob (such as often fitted to combine harvesters) improves ease of control. Good power steering is also desirable to aid manoeuvrability.

- Independent braking must be more frequently maintained and used with care in soft, wet or sloping conditions.

A number of **ergonomic** factors should be considered:

- A comfortable cab environment is a prime consideration, especially if the operator spends a significant amount of time in it.

- Layout of attachment controls at the rear of the cab imply the need for a reversible seating position to avoid an awkward operating position.
- A seat belt option should be requested if available, as it will increase safety in difficult conditions. Most manufacturers now fit seat belts as standard.

- Ease of cab access and egress is especially important when a tractor is used for skidding rather than forwarding.

- Rear facing ability is not only useful for good ergonomic reasons but also for higher productivity. This optional feature is available from many tractor manufacturers including Valmet, Massey Ferguson, John Deere and Same. Some manufacturers also give the options of driving the unit when in this position.

- Good visibility is most important. Ability to see the wheels and how attachments such as winches, processors and loaders are performing is desirable. However, this may not be easy to accomplish in all weather conditions or because of tractor guarding.

- Window shading, by means of translucent retractable blinds or extended roof overhang, can be essential for certain operations in bright sunlight.

- Good, powerful lighting will almost certainly be required for in-wood operations in the winter. This may need to be augmented by extra lighting for attachments, such as a forwarding trailer and loader.

Guarding and Protecting

There is a range of mandatory operational requirements:

- The machine must have a roll over protection structure (ROPS). This has been incorporated into all standard agricultural tractors for some time.

- A falling object protection structure (FOPS) is also required if the forest work type produces that risk.

Other cab protection may also be required. For example:

- Correctly installed polycarbonate glazing to protect from penetrating objects and chain 'shot' from broken processor saw chains. Even within a safe cab environment the operator may need extra protection.

- Certain spraying operations may require a higher standard of cab air filtration.

- Cab noise levels should be comfortably low and wherever possible, the need to supply the operator with hearing protection should be avoided.

- Any cab safety framework must not be affected by tractor modifications.

Guarding and protection for vulnerable tractor areas is also essential for forestry use:

- A 10 mm thick steel belly pan should be fitted to protect the vulnerable underside. Curving designs will be stronger and less liable to be hung up on stumps and stones. Provision should also be made for easy maintenance access and for regular cleaning to prevent fire risk.

- The radiator (Plate 3) and vulnerable tractor engine side components (Plate 4) should be protected from puncture and impact by branches and logging debris.

- If the tractor is to be worked within the crop, the front window, exhausts and intake pipes will need protection by means of deflector bars running from the bonnet front to the cabtop sides.

- Metal mesh or other window guarding will be needed, depending on the risk caused by different work equipment . For example, the rear window should be guarded if a winch is fitted. Such guarding needs to be easily removed for window cleaning.

- Tyres are especially vulnerable to damage in the forest. Tyre valves must be protected. Special agricultural/forestry tyres are made by most manufacturers. These are characterised by puncture resistant side walls and especially by wheel rim reinforcement. This special moulding prevents debris from poking between tyre and wheel rim, a common occurrence in forestry conditions.

Plate 3

Massey Ferguson 290 Front Guarding

Plate 4

Massey Ferguson 290 Side Guarding

Other Accessory Requirements

Except for ROPS, FOPS and special cab filtration, most tractor protection can be made and fitted by a competent workshop. Several specialist forestry engineers and suppliers can undertake such work. A few tractor manufacturers can supply tractors with a degree of forest guarding, such as MB Trac and Massey Ferguson. Valmet tractors have, to date, the most comprehensive standard range of machinery suitable for forestry.

The special demands made by forestry implements can also have a significant effect on the choice of, or adaptation to, the agricultural tractor. Probably the most common requirement is the ability for the operator to face rearwards in the cab to give the best control of mounted or trailed attachments.

Optional 'creeper' gearing may be an advantage if the work type demands it, for example rotary drainage ploughing, heavy duty mulching and brush cutting.

Hydraulic services differ between tractor makes. Some are more easily adapted for the extra hydraulic pumps and reservoirs often required by modern forestry attachments.

Special protective polycarbonate windows, required when harvester/processor attachments are fitted, are more easily attached to some tractors than others Similarly, special wheel traction/flotation equipment, such as half or three-quarter tracks, are fitted more readily to some models than others.

Safety

Having selected a suitable tractor and decided upon the forestry adaptations required for a particular use, it is essential to have any modification carried out by competent personnel.

Adaptations for forestry use should not lessen safety features already built into the tractor, nor create new risks (Plate 5). For example, belly guards should be easy to clean as they can present a fire hazard from accumulated debris.

Under the Supply of Machinery (Safety) Regulations[2] it is the responsibility of the designer to produce a safe design for the stated purposes, usage and expected life of a machine. The Provision and Use of Work Equipment Regulations[3] cover the maintenance (or improvement) of safety standards, with employers and employees having responsibility to uphold them.

[2] Machinery Safety Regulations (1995).

[3] PUWER 98, (see HSE document (AIS27).

Plate 5

Poorly Designed Foot Step

The safe design of forestry attachments such as loaders, processors or timber trailers are the responsibility of their designer and manufacturer. Recommendations for fitting and use should always be followed.

Working practices are safest when machines are suited to their work and are well maintained. Operators must be well trained and familiar with the work. Forestry driving techniques can be very different from those in agriculture.

Cost Indications

The cost of properly adapting an existing agricultural tractor for forestry purposes (1995) can vary from *c*. £700 for a 2 WD 35 hp machine to *c*. £3000 for a 4 WD 90 hp machine modified for forwarding. The cost of purchasing a new medium range agricultural 4 WD tractor incorporating forestry specifications and protection may vary from *c*. £22 000 for a 49 kW (67 hp) standard machine to *c*. £34 000 for a 62 kW (85 hp) machine with creeper gears and a full reverse-facing-drive capability.

Conclusions

A wide range of agricultural tractors can be successfully used in forestry. Different work will require different levels of specification or adaptation. A prime advantage is the flexibility of such machinery for use on the farm and in the forest.

As more agricultural tractors than specialist forest machines are built, they have a distinct capital cost advantage. In the right circumstances this can translate into operational cost advantages. In recent years there have been some significant design developments in farm tractor manufacture which better suit the demands of forestry.

Valmet gives the option to specify a fairly wide range of forestry modifications before the machine is built. However, even such developed agricultural machinery cannot emulate the high output, large annual programme achievements of purpose-built forestry forwarders, harvesters and skidders.

Recommendations

Agricultural tractors used in forestry should be carefully selected for the work intended. They should have adequate power and be suitably modified to include guarding for the machine and operator.

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