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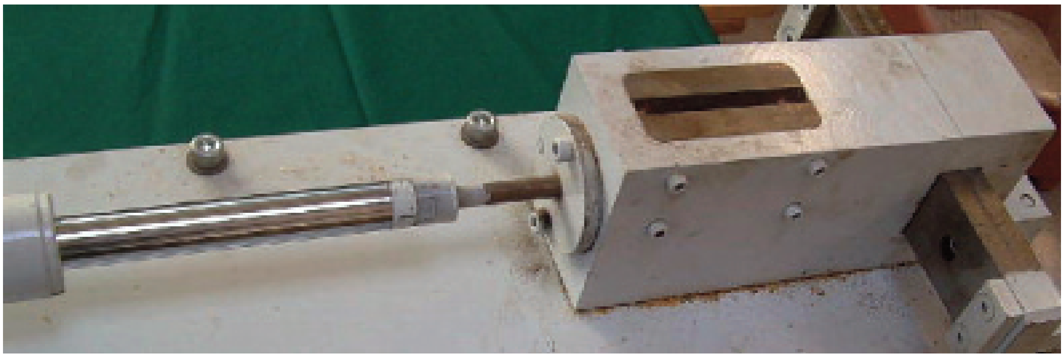
Robinwood



The Robinwood SFMID report:

Development of Small Scale Wood Pelleting Equipment

COED CYMRU
Comisiwn Coedwigaeth Cymru
Forestry Commission Wales
PROJECT PART-FINANCED BY THE EUROPEAN UNION
North East SOUTH West
INTERREG IIIC

Robinwood project: Small scale pelleting

Project aim

The aim of the project was to develop a low cost small scale pellet press suitable for converting sawdust into pellets, tablets or mini briquettes. It should be:

- small enough to match the throughput of a small woodusing workshop
- operate by cold compression alone (standard mills operate by forcing the material through a tapered orifice, thus creating the compression, and considerable heat)
- low cost

This part of the project is to explore the feasibility of making pellets by compaction and to identify equipment that is already on the market and that may be used with or without modification.

Background

The conversion of wood co-products, principally sawdust, into small fuel pellets that can be used in automated stoves and boilers has been developing over the last few decades to the point where it is now a major business in Europe. The pellets, generally 6 – 8 mm in diameter, are formed by extrusion through tapered holes in circular dies in large pellet mills at throughputs of between 1 and 12 tonnes per hour often located at sawmills to produce tens of thousands of tonnes of pellets per year.

In Wales there are many wood using businesses that produce less than a thousand tonnes of timber co-products per annum and such pellet mills are far too large and uneconomical at this scale. There are smaller mills that can process 100 – 500kg/hour, this is still in excess of the supply of many small businesses and these tend to be unable to cope with an inconsistent material (a range of different species of hardwoods and softwoods). Although this could be converted to briquettes, for some reason this market has never developed in the UK whilst there is an increasing demand for pellets.

We postulated that there may be an alternative means of compressing sawdust into fuel pellets and have carried out some studies that would confirm this hypothesis and to determine the specification of suitable equipment. The difficulty with pellet mills is that the compression is created by forcing the sawdust through a tapered die so where a different compression is required due to change in the raw material then a new die is needed. The proposed mill should rely solely on linear compression created by a piston to which the pressure can be varied such as in a pharmaceutical tabletter. In a previous study (part of this current Robinwood project and available from Coed Cymru) we:

- Evaluated sawdust properties to determine volume change/compaction required.
- Carried out trials to test that pellets can be formed from sawdust by direct compaction and determine the pressures required.
- Determined an outline specification for equipment.
- Carried out a review of existing equipment that may be suitable.

A key requirement for such equipment is that it should be low cost.

Design of the test rig pellet mill

The earlier studies (the Coed Cymru report cited above) and the compression study ('Pelletisation of Wood Waste for Fuel: Determining the Compactability of Sawdust and Shavings' M.R. Willis, School of engineering, University of Wales Swansea, May 2004.) showed that the main requirements were:

- The ability to apply a pressure of 40kN or more
- A compaction factor (sawdust:pellet volume) of up to 7 so that even the lightest, 'fluffiest' sawdust could be used to produce a pellet of 1cm or more thickness.

A suitable small scale pellet mill/test rig was constructed to this specification by Dragon Machinery (Dragon Works, New Inn, Pencader, Carmarthenshire SA39 9AY)

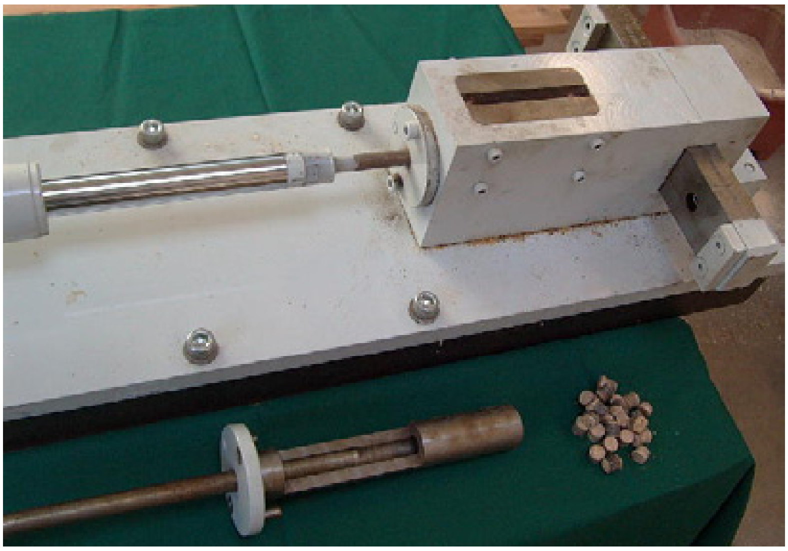


Figure 1: The pellet test rig. The piston used in these trials had a diameter of 12mm.

Operation of the mill.

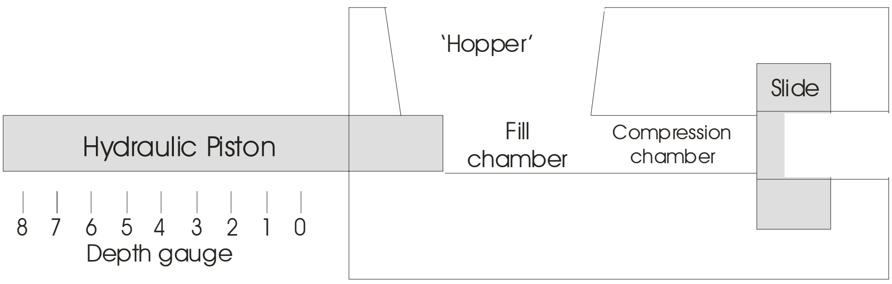


Figure 2: Diagrammatic representation of the rig

Sawdust is first placed in the hopper. When the piston is withdrawn to a selected position on the depth gauge the sawdust drops into the fill chamber. The slide is moved to the closed position. Moving the piston forward pushes the sawdust into the compression chamber where it is compressed to maximum pressure against the slide. The piston is withdrawn slightly, the slide moved to the open position so that the piston can expel the compressed pellet. The process is repeated.

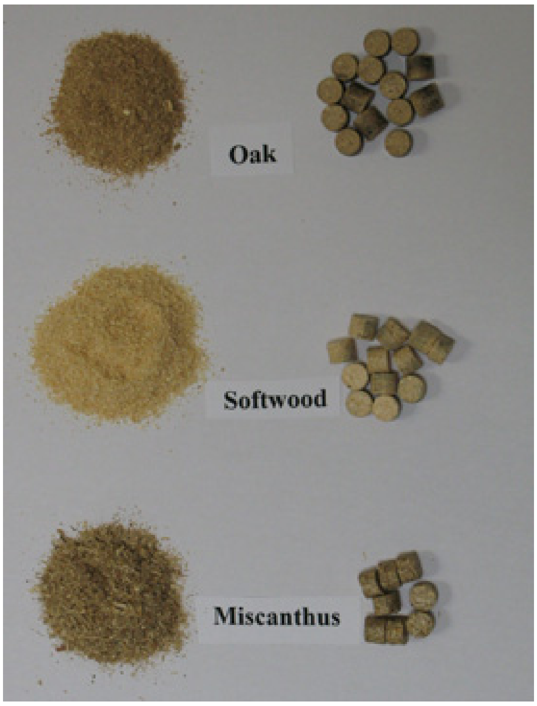
Trial results

The pelleter was tested using a range of different sawdusts (hardwoods, softwoods) as well as a non wood material, miscanthus grass (this is being produced as an energy crop). Different amounts of each were introduced into the fill chamber to produce different sized pellets and the results are shown in Table 1, below.

Material	Density	Moisture content	Fill chamber length	Pellet thickness	Average pellet weight	Average pellet density	Notes
Hardwood Beech	0.2g/cm^3	12%	30mm 50mm 70mm 90mm 120mm (=2x60mm)	5.38mm (4.4 – 5.5) 7.2mm (7.1-8.2) 8.5mm (7.0-9.7) 9.5 (7.9-13.2) (6.0-8.0)	0.62g 0.9g 1.07g 1.2g	1.02g/cm^3 1.11g/cm^3 1.11g/cm^3 1.09g/cm^3	Excellent hard pellets. 50mm+ showing fractures. Split into 7mm pellets
Hardwood Oak	0.29g/ cm^3	11.6%	30mm 60mm 90mm 120mm (3x30mm)	6.65mm (6-7.3) 10.4mm (9-12.1) 11.44mm (9.4-13.3) 6.27mm (6-6.5)	0.86g 1.38g 1.52g 0.83g	1.20g/cm^3 1.18g/cm^3 1.17g/cm^3 1.17g/cm^3	Excellent hard pellets. 60mm+ showing fractures. Split into 6mm pellets
Softwood Pine/spruce	0.21g/ cm^3	14.8%	30mm 60mm 90mm 120mm (3x30mm)*	6.23mm (3.7-7.1) 9.39mm (7.2-10.4) 10.93mm (8.7-12.7) 19.4mm (18.3-20.3)	0.67g 0.99g 1.14g 2g	0.95g/cm^3 0.93g/cm^3 0.92g/cm^3 0.91g/cm^3	Formed pellets, but too light, soft and crumbly Lots of fragmentation
Softwood Pine/spruce (damp)	0.9g/ cm^3	28.4%	30mm				Came through as crumble
Softwood Spruce (coarse)	0.2g/ cm^3	13.2%	60mm	6.88mm (5.3-8.1)	0.84g	1.09g/cm^3	Moderately good, hard pellets. Fragmentation in longer pellets
Miscanthus	0.26g/ cm^3	11.6%	30mm 60mm	6.58mm (5.9-7.3) 8.9mm (8.4-9.6)	0.75g 1.04g	1.00g/cm^3 1.03g/cm^3	Moderate, very flaky

*** The first two lots of 30mm sawdust were pushed into the compression chamber without compression, which was only applied with the final 30mm.**

Figure 3: Various sawdusts and resulting pellets



Pellet formation:

The hardwoods produced very good hard pellets. The absolute densities (as opposed to loose volume densities) are similar to pellets made in a standard pellet mill. There was some sign of fracturing in the longer pellets. The smallest pellets would work in a domestic pellet stove, and probably in a pellet boiler although producing sufficient for a trial in this rig would be rather laborious.
Softwoods did not produce such good pellets, and softwood with a high moisture content did not work. The coarse spruce produced reasonable pellets, and it is just possible that better pellets would be made if the moisture content were as low as that of the hardwoods, although further testing would need to be done. The miscanthus produced moderately good but flaky pellets – miscanthus is currently being grown as an energy crop.

Design of the mill:

The success in making pellets has proved in principle the basic design. However, a working prototype would need to incorporate certain design modifications. It was found the slide was very hard to move after compression and a lever system had to be set up. A production model would need to have a mechanically/hydraulically driven automated arrangement operating in synchrony with the compression piston. Certain lengths of pellets were found to interfere with the operation of the slide. This should easily be rectified by redesigning the slide and exit port.
Variability in pellet length is probably caused by bridging and variable back pressure from material in the compression chamber causing sawdust to push up into the hopper. This could be overcome by pushing several smaller amounts into the compression chamber as illustrated in the softwood, spruce/pine 120mm result.

Sawdust had to be poked into the fill chamber as it did not flow well in such a small hopper and chamber. It also depended on the nature of the sawdust, the finer and drier the better. However, there is a need to design an appropriate feed system that will ensure constant and reliable delivery of sawdust into the fill chamber, as well as a means to prevent it being pushed back upwards if there is any back pressure.

Recommendations

Although good pellets had been made, further work is needed to more precisely determine the types, qualities and optimum moisture contents of sawdust needed for good pellets.

The experience gained from this work is sufficiently encouraging to propose that a prototype pellet mill can now be developed, incorporating the design modifications suggested above.

Summary

There is a perceived need for a small scale pellet mill that is suitable for small wood using businesses. As no such equipment currently exists we have designed and built a trial model that works by cold compression (as opposed to the larger standard mills that operate at high temperature) and tested it with a variety of sawdusts. Very good pellets were produced from dry hardwood sawdust. Softwood sawdust was less encouraging but there may be room for improvement, and the moisture content had to be low. Miscanthus, grown as an energy crop, produced moderate pellets. The success has encouraged us to propose further work to develop a prototype production pellet mill.

Robinwood

This report has been produced as a result of the Robinwood Project, a 45 month European Interreg 111c Regional Framework Operation project – a first for Wales and delivered by Forestry Commission Wales on behalf of the Welsh Assembly Government. It looked at how we should manage our trees and forests to provide solutions to hydrological issues, increase the amount of wood used in heat and energy and the key role they play in helping to regenerate rural communities across Europe.

The Italian project leaders named the project after Robin Hood – a deliberate play on the UK folk hero best known for taking from the rich and giving to the poor. Research carried out by the project now provides valuable new information on how forests can provide all kinds of opportunities for the future.