

# JUICE SCALE MODIFICATION FROM CONVENTIONAL TO BUTTERFLY VALVE ACTUATION

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## Abstract

Recently, new Servo-balans scales have been equipped with butterfly valves rather than the conventional linkage and plug valve actuation. There are advantages in using butterfly valves and AK was one of the first South African mills to successfully convert a conventional scale to the use of butterfly valves.

## Introduction

In 1974, AK underwent an expansion, which included the installation of a 400 ton per hour cane diffuser. Besides the increased juice tonnages that the juice scales had to contend with, they were also getting hot juice. This juice gave off a considerable amount of steam which in turn washed out any lubrication that might have been present in the bushed eyes of the linkage mechanism.

Severe wear of pins and bushes resulted, causing the whole linkage mechanism on the scale to be rebushed and pinned twice a season. AK has two juice scales of 7 and 4 ton capacity. The receiving hoppers are linked by large diameter piping so that juice can flow to either of the two scales. For those who are unfamiliar with juice scales, it should be pointed out that there are two sets of linkages per scale. One set is for the plug valve in the receiving hopper and one set for the plug valve in the weighing hopper. Figure 1 shows a general arrangement of a juice scale.

## The Mechanism

Figure 2 shows details of the components of the linkage mechanism. A motion from the weighing head causes shaft A to turn, say, anticlockwise. This movement is transferred via the lever B to the connecting rod C. This rod then transfers the motion via shaft D and arm E to lever F. Lever F is connected via a rod to the plug valve in the bottom of the hopper. If shaft A was rotating anticlockwise, looking from the left, then lever F is raised and the plug valve to that hopper is opened.

Points 1 to 4 show where the mechanism is bushed and pinned. If the scale has to weigh hot juice, bearing points 2, 3 and 4 are particularly vulnerable to the steam being released from the juice. As the bushes and pins wear, the resulting slack has to be taken up at each point before any motion is transferred to the lever F from shaft A. Shaft A only moves a finite amount so that, with wear, lever F moves less and less until the time could arise where no movement took place at all.

The smaller movement of lever F means that the plug valve lifts less making the juice take longer to pass the valve. After a while, the juice trying to get through the valve is exceeded by the quantity of juice entering the hopper. The result — the hopper overflows. This state of affairs motivated the Amatikulu staff to find a solution to the problem.

## New Scales and Triangle

At about this time new Servo-balans scales were entering the country equipped with butterfly valves instead of plug valves. These valves seemed to work very well although the method of their actuation needed some revision. Added to this AK was advised that Triangle had converted their juice scales to butterfly actuation and that the capacity of the scales had been substantially increased by the conversion.

AK therefore asked the scale agents if a conversion could not be undertaken on AK scales. They agreed that the wear in the linkages was a problem with hot milling but they felt that a conversion could not be undertaken as :—

- the relevant Government department would not approve. Rhodesia had no such department.
- the butterfly valve used on the new scales was very expensive.

However, after a year of discussion, the department of Trade Inspection sanctioned the conversion to butterfly valves. AK decided, with the agents' blessing, to undertake the conversion themselves.

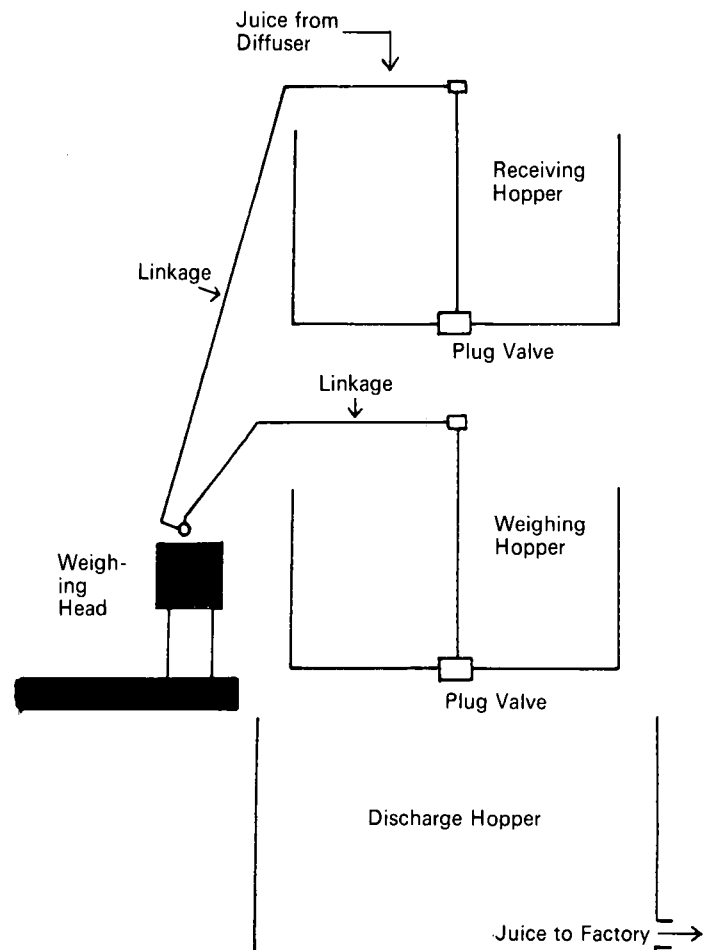


FIGURE 1 Schematic arrangement of servo-balans juice scale.

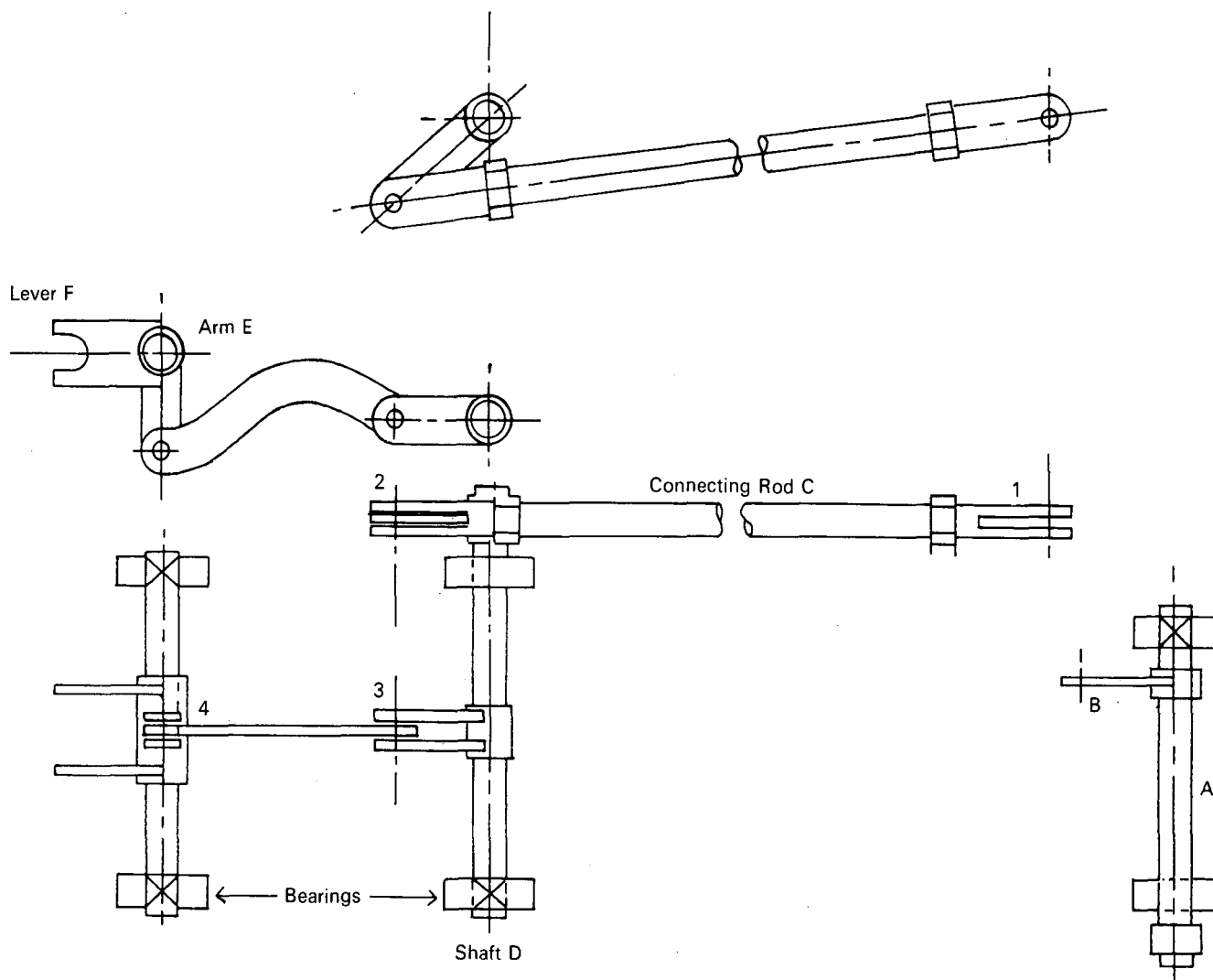


FIGURE 2 Juice scale linkage.

### The Butterfly Valve

#### The Specification :

There were a number of considerations that it was felt the valve should be capable of, to perform adequately in a juice scale application. They were :—

1. **Bubble tight shut off :** The valve must be capable of shutting off tight every time the valve closes. Added to this it must be capable of performing this shut off approximately 700 000 times a season.
2. **Robust construction :** The valve must be of robust construction and not likely to fail as this would cause a mill stop.
3. **Heat and corrosion :** The valve material must be able to withstand temperatures from the juice not in excess of 90°C. Also the valve material must tolerate the corrosive elements of the juice.
4. **Cost and origin :** The valve must be relatively cheap, maintenance free and, if possible, made in this country.

#### The Choice :

There were basically two types of butterfly valves available. One type had a removable liner or seat, and one had a bonded liner. The bonded liner butterfly valve is locally manufactured and is cheaper than the removable liner type. Triangle mill had used the bonded liner type for a number of years and had experienced no problems.

The valve could be relined but only by the valve manufacturers. However, this was not a problem as it could be done during offcrop. The cost of relining was about the same

as the cost of the replaceable liner in the other type.

It was decided to use the bonded liner butterfly valve following the experience of Triangle mill. The valve worked well during the first year of operation but at the end of the season it was found that the valves had to be relined, and this was not done very successfully, so in retrospect, the better choice would have been the replaceable liner butterfly valve.

There are two makes of butterfly valve that use replaceable liners in the size of valve required for a juice scale. An example of such a valve is shown in Figure 3. This particular make of valve is well engineered and designed for easy maintenance. It comes with a totally enclosed pneumatic actuator that is connected directly to the butterfly shaft. At least 5 mills that have recently converted their scales to butterfly actuation have purchased this type of valve complete with actuator. One reservation about this kind of valve is that there is no means of correcting the valve should the actuator overclose or underclose the flap.

However, the makers have guaranteed that the valve can only close square to the liner. Added to this, the design of the liner has ensured that the valve is sealed tight 5° before the flap is square to the liner. Only the experience of the mills using this valve will verify this argument.

### The Actuator

#### Valve Actuator by Pneumatic Cylinder.

As AK purchased a bonded liner butterfly valve without an actuator attached to the shaft, a method of actuation had to be designed.

Firstly, the torque required by the butterfly valve was calculated and the cylinder sized accordingly. It was found that a 100 mm diameter cylinder with a 152 mm stroke was required using air at a pressure of 600 KPa.

Secondly, it was decided that the cylinder should be situated as far as possible away from the steam and the hot juice. As a result the receiving hopper cylinders were mounted outside the top lip of the weighing hopper whereas the weighing hopper cylinders were mounted at the extreme edge of the underside of the hoppers. The cylinders on the weighing hoppers had to be placed here for thrust reasons.

Thirdly, a lever mechanism was used to connect the cylinder to the valve shaft. The whole assembly is illustrated in Figure 4, with the relevant dimensions. Note that the air

cylinder is centre trunion mounted to allow for linkage movement. The mechanism is arranged so that the cylinder spindle is retracted when the valve is closed, to save it from the corrosion and the heat of the steam.

Note also that a rigging screw is installed on the mechanism to allow for adjustments to be made to the valve to make sure that the flap closes properly.

*The Pneumatic Circuit :*

This circuit is shown in Figure 5. It consists of a pilot operated spring return control valve connected to the cylinder as shown. The control valve is actuated by a plunger operated spring return valve, whose plunger is depressed by the movement on lever B on shaft A on the old linkage mechanism (Figure 2). Shaft A together with lever B is situated on top of the weighing head of the juice scale. An adjustable dog is welded to the side of lever B to actuate the plunger. It is important to enclose the plunger valve and lever B in a dust proof cover. This is due to the fact that sugar dust in the air could stop the plunger from working. For the same reason, this plunger must be regularly greased. Finally, this plunger operated valve must be so positioned in relation to lever arm B that the butterfly valve closes immediately the weighing hopper reaches its tip weight.

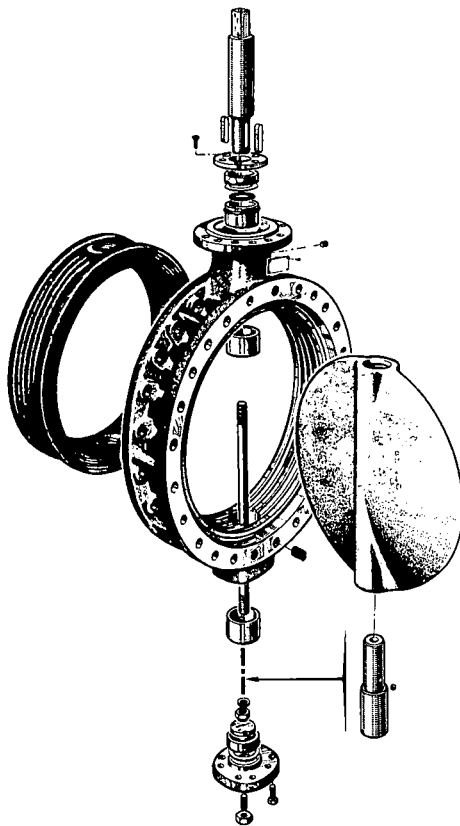
A push button valve is also shown in the circuit in Figure 5. This valve is not essential for the automatic operation of the scale. Its function is to manually open the butterfly valve, for inspection purposes. If this push button valve is situated at the approach to the juice scale station, then it could be very useful in an emergency when, for instance, the scales are overflowing.

Only 4 mm tubing is necessary for the pilot lines whereas 8 mm tubing is required between the control valve and the cylinder. The control valve must also be as close as possible to the cylinder so that a quick response can be obtained.

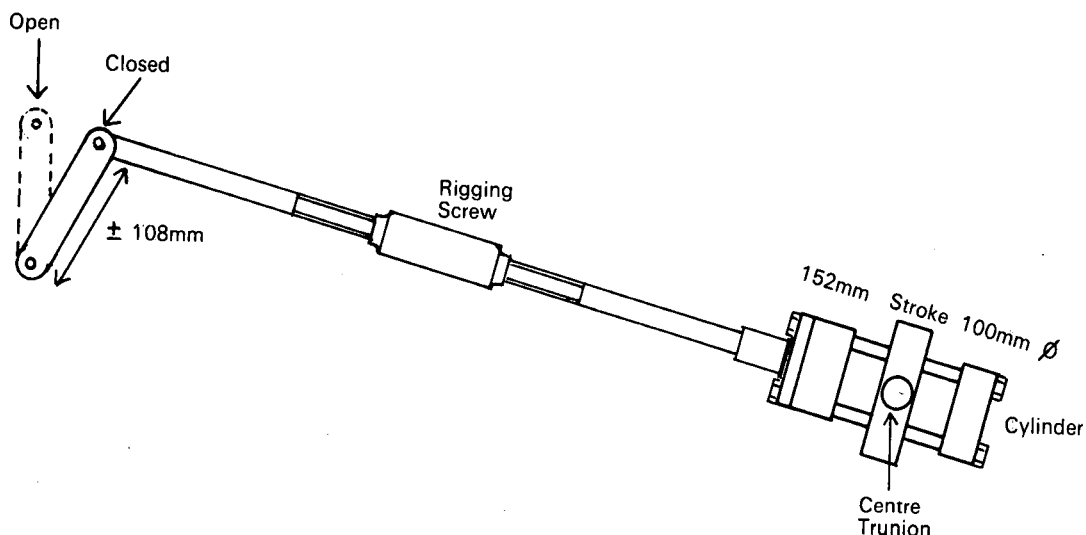
**Scale Performance**

Scale performance improved radically after the conversion. Before the conversion the scales were performing at their best with newly bushed linkage at 60 tips/hour.

After the conversion this increased to 80 tips an hour. As has been mentioned in the introduction, the scale capacities are 7 and 4 tons but they usually operate at 6,5 and 3,5 tons respectively. At 80 tips an hour the big scale can accommo-



**FIGURE 3** Removable liner butterfly valve.



**FIGURE 4** Valve actuation by air cylinder.

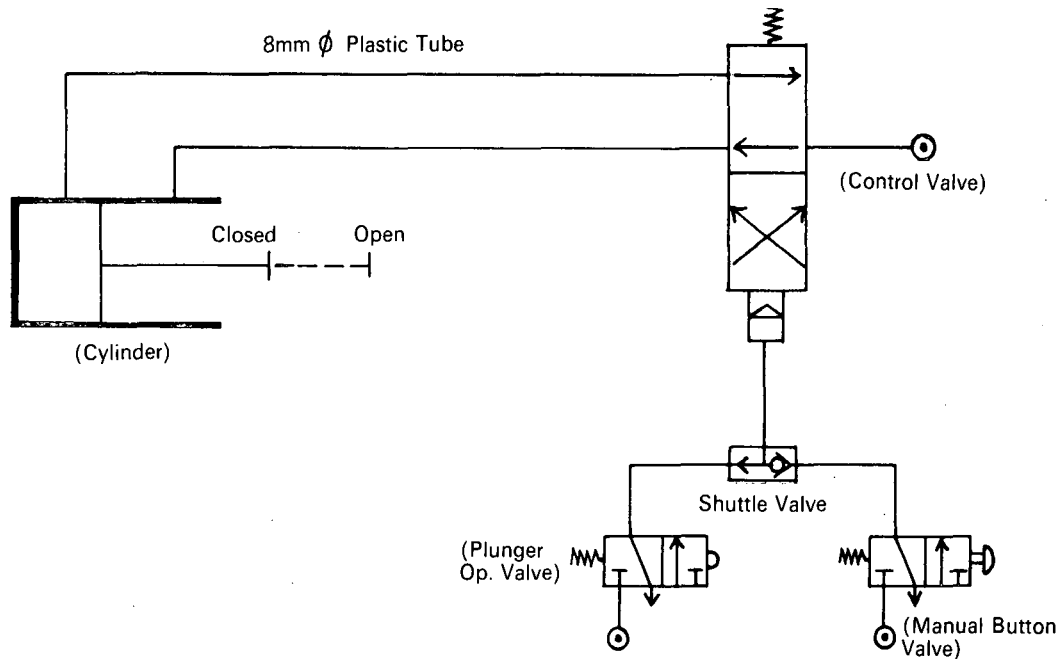


FIGURE 5 The pneumatic circuit.

date the total juice capacity from the diffuser under normal running conditions. This capacity is approximately 500 t/h.

When AK's scales were converted to butterfly actuation the wrong size butterfly valves were ordered by mistake. They were 450 mm diameter whereas the scales could have accommodated 600 mm valves. When the opportunity presents itself the valves will be changed to 600 mm. By so doing it is hoped to increase the tip rate to 100 + tips/hour. At this rate the big scale will be able to weigh all the juice that is pumped from the diffuser including any surges that might arise.

#### Project Costs

The costs of converting one scale are as follows :

Pneumatic valves, cylinders and air line equipment	R1 000
2 only rubber lined butterfly valves	R2 500
Piping, flanges and accessories	R100
Sundry stores	R250
Labour	R500
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	R4,350

The costs of converting one scale therefore are about R4,500.

#### Benefits and Conclusion

1. There is no multi-pin linkage mechanism that gets worn out as the season progresses causing the scale to perform more and more inefficiently.

2. Butterfly valves open wide whereas plug valves do not. Butterfly valves therefore allow more juice through at any given moment than plug valves.
3. Butterfly valves open and close more rapidly than plug valves.
4. Maintenance on the scales has been substantially reduced.
5. Scale capacity has increased mainly due to points 1 to 3 above.

AK was one of the first South African mills to convert juice scales to butterfly actuation and has since received many interested visitors. It is hoped to further increase the number of tips a scale can perform per hour. Besides increasing the size of the butterfly valve, mentioned above, the delay between valves opening and closing should be reduced. This will have to be done in consultation with the scale agents as part of the head works of the scale will be changed. Should this alteration be done the scale would perform 140 tips/hour and process 910 tons of juice/hour. This will be a worthwhile objective.

#### Acknowledgements

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