THE ECONOMICS OF FERTILIZER MANUFACTURE IN SOUTH AFRICA

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Introduction

As a background to this talk on the economics of fertilizer manufacture in South Africa I wish to present a techno-economic history of its development.

In the early days of mining in South Africa, up until the mid-1940's, fertilizer manufacture was closely coupled to, and entirely dependent on, the production of explosives because diluted, or spent, sulphuric acid arose in fairly large quantities, as a waste product, of nitroglycerine manufacturing.

This acid was used to convert relatively insoluble phosphate ores (or rock phosphates) into more soluble forms available for use by plants; the so-called superphosphates.

The operation was a simple batch process and required no sophisticated machinery or technically skilled supervision. The economics of the whole proposition was straightforward and pricing quite simple. The only requirements were that the revenue earned from fertilizer sales would more than offset the cost of production to an extent where it was more profitable to produce fertilizer than to concentrate the spent sulphuric acid for re-use in the dynamite works.

The sulphur for acid and the rock phosphates were imported, consequently fertilizer plants were situated at the coast. To assist inland farmers railage on finished products was subsidised.

In the early 1950's two significant changes took place, viz

(i) the exploitation of local phosphate deposits, discovered at Phalaborwa, started and

(ii) the uranium market collapsed, leaving large inland sulphuric acid plants idle.

The Viljoen commission of enquiry, which investigated the matter in 1962, recommended a withdrawal of the rail subsidies thereby forcing manufacturers to move a large part of their production inland and to concentrate their activity in the area of consumption. The availability of concentrated acid, the use of local phosphates and the higher rail rates made major technological changes absolutely necessary and eventually resulted in the manufacturing of phosphoric acid and double superphosphate. Production plants became far more sophisticated, requiring greater technical skills, more rigid controls and larger capital investment.

Running parallel to the history of phosphatic fertilizer development we see the development of nitrogenous fertilizer. For about 40 years, up uptil the mid-1950's, ammonium sulphate, imported or derived as a by-product of coke manufacture, was about the only bulk source of nitrogen. The local production process was simple and the product one of minor importance to the manufacturers, who were mainly concerned with steel making (ISCOR). Similarly, as a minor product, locally made ammonium sulphate and ammonium nitrate became available from SASOL and AE & CI in the mid-1950's. Pricing was also simple and the economic consequences of changing demand or fluctation in manufacturing of no vital concern to the manufacturer. I specially mention this point, and the similar point made with regard to early phosphatic fertilizer pricing because these simple situations still, to a certain extent, form the basis for out present price control formula. This will be dealt with later in a more detailed analysis of the fixed and variable costs of fertilizer production.

During the 1960's tremendous changes took place in the use and manufacture of fertilizers. Usage increased as indicated in Table 1.

Table 1. *Fertilizer usage in metric tons × 1 000*

Year	N	P	K
1950	10	39	5
1960	46	65	29
1970	181	123	80

This clearly indicates a very rapid increase in demand.

With regard to manufacturing, where by-product and imported ammonium sulphate and ammonium nitrate was the major source of fertilizer nitrogen in the 50's, locally produced ammonium nitrate, urea and LAN became the main source of supply in the 60's. These products are all based on ammonia which is specially manufactured for this purpose.

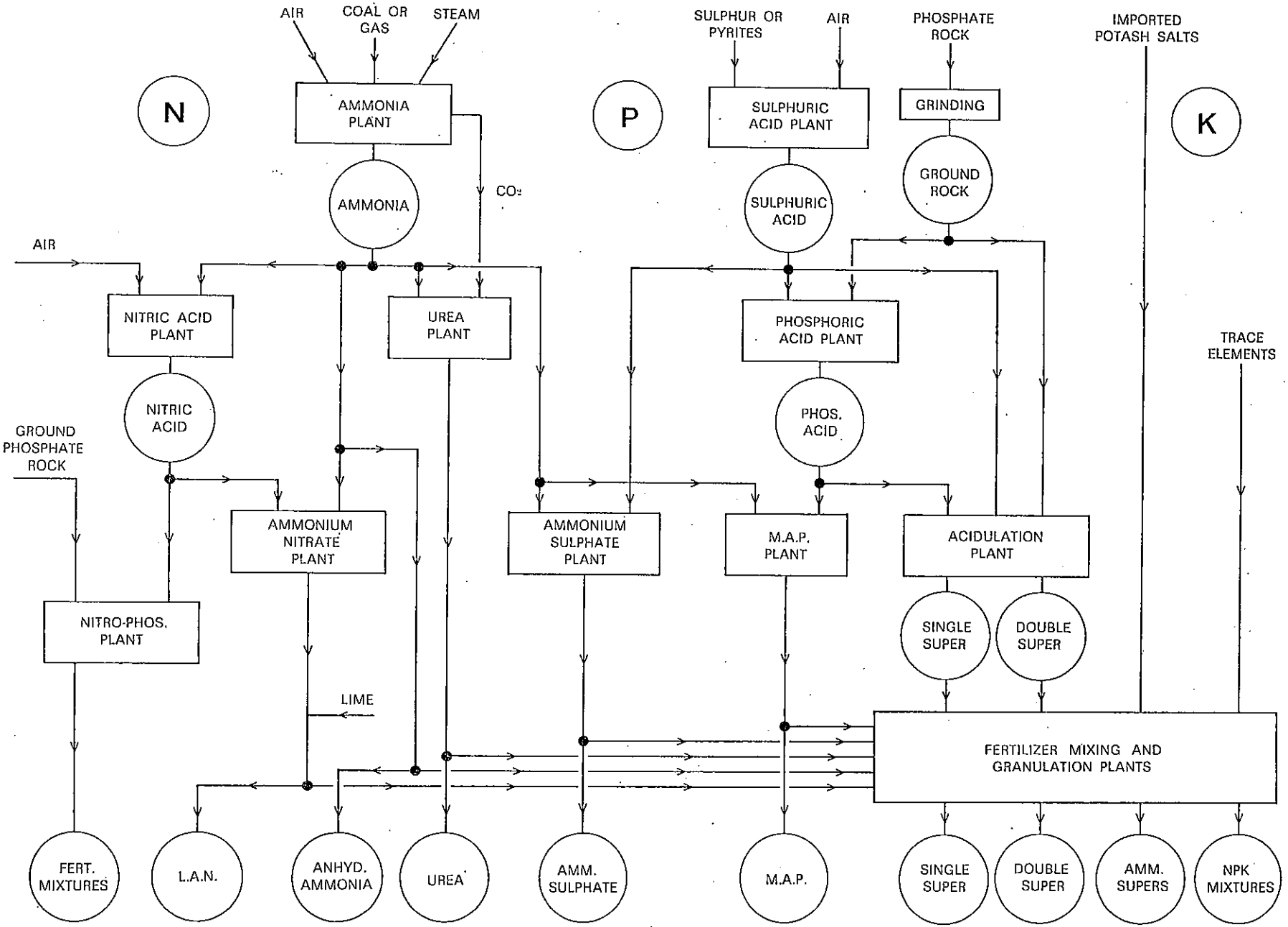
The significant switch is therefore away from by-products and imports to the purposeful production of ammonia for fertilizer in modern, large-scale and very capital intensive production complexes where one manufacturing unit is closely coupled to, and entirely dependent on, others. The complexity of modern manufacturing is shown in Figure 1.

Technologically and managerially these complexes are difficult to build and operate successfully hence they require the backing of large teams of engineers, scientists and well trained businessmen, giving rise to large fixed annual costs. It is well known that the larger the production unit the higher the thermal and chemical efficiencies, and from an operational point of view, the lower the total unit cost of production for a given plant utilisation. This is the so-called phenomenon of the economy of scale, and it explains why South African manufacturers in almost every field of industry are at a distinct disadvantage vis-a-vis overseas competitors, who operate in markets many times larger than ours.

As larger and larger plants are used to achieve this economy of scale, the capital required for a single production unit increases. In an attempt to contain these huge capital investments, technology was directed towards the development of the so-called single stream plants and in 1967 typical units of this kind were commissioned at Milnerton and Umbogintwini. The significant features of these single stream plants are that there is no duplication of any of their major components. This saves capital investment but increases the overall business risk because, if one component breaks down, or requires servicing, the whole plant is stopped and no product is made by the specific plant or even by others in the complex. The economic consequences of the higher risk will also be touched on later.

As a result of all these technological and economic developments the economics of fertilizer manufacturing, and especially the manufacture of the primary ingredients, ammonia, nitric acid, ammonium nitrate, urea, LAN, sulphuric acid and phosphoric acid now centres around the relationships of fixed and variable costs of production against the output achieved. This will be analysed in detail

Fig. 1


AIR
COAL OR GAS
STEAM
N
AMMONIA PLANT
AMMONIA
CO₂
AIR
NITRIC ACID PLANT
NITRIC ACID
UREA PLANT
GROUND PHOSPHATE ROCK
NITRO-PHOS. PLANT
AMMONIUM NITRATE PLANT
LIME
FERT. MIXTURES
L.A.N.
ANHYD. AMMONIA
UREA
SULPHUR OR PYRITES
AIR
P
SULPHURIC ACID PLANT
SULPHURIC ACID
PHOSPHORIC ACID PLANT
PHOS. ACID
AMMONIUM SULPHATE PLANT
M.A.P. PLANT
AMM. SULPHATE
M.A.P.
PHOSPHATE ROCK
GRINDING
GROUND ROCK
ACIDULATION PLANT
SINGLE SUPER
DOUBLE SUPER
IMPORTED POTASH SALTS
K
TRACE ELEMENTS
FERTILIZER MIXING AND GRANULATION PLANTS
SINGLE SUPER
DOUBLE SUPER
AMM. SUPERS
NPK MIXTURES

below but before this let me introduce two other techno-economic features which could affect the fertilizer business of the 1970's.

One must assume a steady growth in demand of about 10 per cent per anum for nitrogenous fertilizer plus 6 per cent to phosphates, but superimposed on this, significant fluctuations will also occur as a result of variation in weather conditions. In the 1970's technology will advance further and therefore possible new plants will be bigger and more efficient. The industry will therefore continue to be capital hungry and will swallow huge sums of money. In the next ten years this may well reach a figure of R150-million, which is almost a doubling of the total assets of the present business. Inflation will probably remain at a level which will cause fixed operating costs to increase at about 5 per cent per annum while the cost of capital will remain high although it may drop a little from the present rate of about 9½ per cent per annum to about 8½ per cent per annum. Furthermore, the costs of erecting new plants will also be much greater as a result of inflation. The interactions of these economic forces will also be dealt with below.

Alvorens ek nou verder gaan met hierdie analise wil ek eers nog, as algemene agtergrond, 'n aanduiding gee van die kostestruktuur van vier tipiese kunsmisstowwe.

Die kostestruktuur van vier tipiese kunsmisstowwe

A *AMMONIAK* (Rand per ton teen 300 000 ton per jaar)

Grondstowwe	Rand	%	
Steenkool, water, krag, katalisator	12,1	17	
Dienste en Administrasie			
Instandhouding, fabrieksadministrasie salarisse en lone	13,6	20	
Kapitaalkoste			
Waardeverindering (7½%)*	13,6	20	63
Rente op belegging (13½%)*	29,4	43	
TOTAAL	68,7	100	

B *UREUM in 50kg SAKKE* (Rand per ton teen 150 000 ton per jaar)

Grondstowwe	Rand	%	
Ammoniak, stoom, krag en sakke	55,0	71	
Dienste en Administrasie			
Instandhouding, fabrieksadministrasie, verpakking, salarisse en lone	8,1	11	
Kapitaalkoste			
Waardevermindering (7½%)*	4,9	6	18
Rente op belegging (13½%)*	9,2	12	
TOTAAL	77,2	100	

* Ek beskou hierdie persentasies as laag en sou eerder meer realistiese syfers sien. (Sien paragraaf Plant replacement bl 14)

C. *ENKELSUPERFOSFAAT* (Rand per ton)

Grondstowwe	Rand	%
Rots en swawelsuur	16,1	78
Vervaardigingskoste		
(Broadfield den)	1,7	8
Administrasie	0,7	3
Rendement en waardevermindering	2,2	11
TOTAAL	20,7	100

D *2:3:2 (22) MENGSEL* (Rand per ton)

Grondstowwe	Rand	%
Stikstof, enkelsuur, dubbelsuur, fosforsuur, kaliumsoute, sakke, ens.	42,2	70
Vervaardigingskoste		
Meng en verkorrel, verpak en laai	7,7	13
Administrasie	4,3	7
Rendement en waardevermindering	6,1	10
TOTAAL	60,3	100

Hierdie vier voorbeelde het betrekking op vier tipiese produkte van die kunsmisbedryf. Ammoniak (voorbeeld A) is 'n ‚moedergrondstof' en word gebruik om ureum en baie ander grondstowwe te maak. Die kapitaalkoste beloop 63 persent van die totale koste. In voorbeeld B, ureum in sakke, is die kapitaalkoste van ammoniak ingesluit in die grondstofkoste en kom daar weer 18 persent kapitaalkoste by.

Op hierdie wyse word kapitaalkoste steeds opgebou tot die uiteindelike totale koste van 'n mengsel verkry word.

In elke stap, van ‚moedergrondstof' tot finale produk, speel kapitaalkoste elke keer, in daardie stap, 'n kleiner rol.

Hieruit kan ons dus sien wat 'n geweldige rol kapitaalkoste speel in die kunsmisbedryf as die hele vervaardigingskolom beskou word. Verder toon dit ook hoe maklik kapitaalkoste onderskat en verkeerdelik gehanteer kan word.

The relationship between fixed and variable costs and plant utilisation

The economics of modern fertilizer manufacture is dominated by the achievement of high plant utilisation. To illustrate this I present below a typical case based on a real-life situation. It illustrates how, notwithstanding the fact that all costs of owning and operating a plant are kept constant, the return on capital earned can vary from 5 per cent to 30 per cent before tax as a result of a change from 50 per cent to 100 percent in plant utilisation. This means that by doubling output, return on capital is increased sixfold or by 600 per cent.

Typical base case

Investment in factory : R1-million
Plant capacity : 20 000 tons per annum
Costs
Fixed annual costs
Depreciation 10% R100 000
Supervision etc R100 000
Total fixed R200 000 per annum
Variable costs
Raw materials R11 per ton
Services etc R 4 per ton
Total variable R15 per ton

Cases	1	2	3
Sales (ton per annum)	10 000	15 000	20 000
Plant utilisation	50%	75%	100%
Costs Fixed	R200 000	R200 000	R200 000
Variable	R150 000	R225 000	R300 000
Total costs	R350 000	R425 000	R500 000
Price R40 per ton			
Revenue	R400 000	R600 000	R800 000
Profit	R 50 000	R175 000	R300 000
Return on capital	5%	17,5%	30%

Fig. 1

This is the most outstanding economic feature of modern chemical production and yet the fertilizer price-control formula does not recognise this adequately. Let us examine this effect further by analysing

(a) what effect production volume variation in a particular period would have on the controlled price applicable to a following period and consequently on profitability during that period,
(b) what effect the limited recognition of volume variation has on investment policy in the industry,
(c) how the present price-fixing formula tends to lead to a monopolistic situation in this industry.

Price determination and its effect on profitability in a future period

The fertilizer price for a given period is based on the average cost of production in some previous period. Using the base case again and allowing 13½ per cent return before tax on capital it is shown that three different prices for the coming period are obtained ranging from R48,5 to R31,8 per ton, corresponding to the three levels of production shown.

Using the highest and lowest prices thus obtained, but keeping all other cost and capital investments constant, a further analysis shows that when a low-volume period of one or more seasons follows a high-volume one, a manufacturer can make a substantial loss or, if the sequence of the seasonal change is reversed, he can have a return on capital of some 47,0 per cent before tax.

PRICE DETERMINATION FOR NEXT PERIOD (Rand)

Case	1	2	3
Total cost	350 000	425 000	500 000
Average cost per ton	35	28	25
Allow profit @ 13½% on capital	13 500	13 500	13 500
Profit per ton	13,50	9,00	6,80
Price fixed for next period per ton	48,50	37,00	31,80

SALES VOLUME TO PROFIT RELATIONSHIP DURING NEXT PERIOD

PRICE FIXED AT R48,50 PER TON

Case	1	2	3
Sales in tons	10 000	15 000	20 000
Total costs (R)	350 000	425 000	500 000
Revenue (R)	485 000	727 500	970 000
Profit (R)	135 000	302 500	470 000
Return on capital	13,5%	30,3%	47,0%

PRICE FIXED AT R31,80 PER TON

Case	1	2	3
Sales in tons	10 000	15 000	20 000
Total costs (R)	350 000	425 000	500 000
Revenue (R)	318 000	477 000	636 000
Profit (R) (Loss)	(32 000)	55 000	136 000
Return on capital	Loss	5,5%	13,6%

The actual figures are not significant but the principle is. As long as the price-fixing formula takes only limited account of volume variations the price for the future season bears only partial relation to production costs. It also amplifies the effect of volume variations on future profitability by amplifying the effects of changes in climate from year to year. This increases business risk to manufacturers.

As the industry develops, this influence will of course become greater as fixed costs become a greater proportion of total cost for any given volume of production. Furthermore, as the industry is a capital-hungry one, and not a dying trade, it will be more and more difficult for private enterprise to find the capital required to sustain steady long-term growth in a field of high investment risk.

Investment risk is of course only significant when related to return on capital. The high risk in this case arises firstly from the use of single-stream plants which increase operating risk, and secondly from fluctuations in demand arising from changes in climatic conditions and amplified by the present price-fixing formula. This of course largely explains why overseas manufacturers no longer wish to invest in fertilizer production in this country. This is sharply contrasted by the massive flow of foreign capital into South Africa during the past decade. A substantial part of this capital is being invested in industry where reasonable profits are made, leaving the relatively lower return/higher risk fertilizer business to South African entrepreneurs.

The effect of the limited recognition of volume variations on the investment policy in the industry

The base case presented above clearly indicates the sensitivity of capital-intensive production plants to variations in product demand. For larger units, where investment is not a mere R1 million as in the base case but several tens of millions, as contemplated for the new Modderfontein complex, the effect is of course still greater.

The price-control formula recognises no lower utilisation than 80 per cent of plant capacity. It therefore makes no concessions for the very low plant utilisations which are a typical feature of operation during the early life of a modern chemical complex. The effect on investment policy is therefore for manufacturers not to erect plant of a given size before a higher than 80 per cent plant utilisation can be expected. In effect this means that the erection of large economical plants of world class is continually being postponed for many years during which South Africa has to import fertilizers or basic ingredients like ammonia, *or*, when a certain demand level is reached a small uneconomical plant, which is not competitive by world standards, is erected to fill a temporary local demand gap.

This may not appear important from the narrow and parochial point of view of a price controller but from the long-term national point of view it either allows opportunity gaps to appear when supply is insufficient for demand or it forces the country to live indefinitely with small uneconomical plants and therefore high fertilizer costs.

The present price-fixing formula tends to lead to a monopolistic situation in industry

The interaction of the fixed and variable cost relations of manufacturing and the present basis of price fixing, viz on the average cost of production of a certain group of production units in a given period, has yet another undesirable economic influence on fertilizer manufacture in the short term from a producer's point of view and in the long run from a national point of view. The base case above is typical of a chemical plant but, with expanding markets,

new technology, higher cost of construction and more expensive capital, a future unit will be larger but more efficient and therefore more capital intensive.

For a given sales volume, the new unit will, after the initial high-cost period when plant utilisation is poor, produce at a lower overall cost per unit. This will apply to all possible new plants, and from time to time one or more of these will come on stream.

For a short period, while the controlled price is still based on smaller plants (and lesser manufacturers) the larger plants (and larger manufacturers) have a better profit opportunity or, conversely, as soon as the price is based on the cost of production of the larger and more efficient plants, working at high utilisation, the smaller plants are at a distinct disadvantage. This will inevitably lead to the formation of larger and larger manufacturing companies and eventually to a monopolistic situation.

I will now deal with plant replacement policy and that all-important economic feature — inflation.

Economic effect of future trends

Plant replacement

I have already touched on the effects of technological changes in so far as these give rise to larger and more efficient machines but there is a different and even more important economic aspect of technological change to be dealt with, viz its influence on plant relpacement.

Op die gebied van die tegnologie — en in letterlik elke vertakking daarvan, van hartoorplanting tot by 'n maanwandeling — versnel die tempo van ontwikkeling en word die kanse op belangrike vordering, op enige gebied, en dit sluit die vervaardiging van kunsmis in, by die dag groter. Die direkte ekonomiese gevolg hiervan is dat, sodra 'n nuwe proses, of 'n meer doeltreffende manier om 'n bestaande proses te laat verloop ontwikkel word, die bestaande proses, en dus ook die bestaande aanleg, nie meer in staat is om weens sy laer rentabiliteit, genoegsame winste te lewer om teen 'n nuwe aanleg die stryd, in 'n vrye marksituasie vol te hou nie.

Die individuele ondernemer wat dus nog glo dat sy aanleg 'n ekonomiese lewe van 15 tot 20 jaar het, en wat dus 'n verkeerde afskrywingsbeleid volg, sal, deur sy foutiewe kosprysberekening oënskynlik 'n gunstiger mededingende posisie in die mark beklee. 'n Té konserwatiewe afskrywingsbeleid en dus 'n té mededingende prysbeleid, sal egter op die langtermyn tot 'n tekort aan fondse vir aanlegvernuwing lei. Ons betree snel die era waarin die ekonomiese lewensduur van 'n aanleg in die kunsmisbedryf beslis nie hoër as 10 jaar geskat moet word nie. Dit wat betref die gevolge van die sneller tempo van tegnologiese ontwikkeling, maar meer nog, die nuwe aanleg wat die oue sal moet vervang sal ten eerste weens sy grote en kompleksiteit veel meer kapitaal eis, maar dit sal ten tweede ook veel meer kos as gevolg van inflasie.

Dit is dus nie voldoende om, selfs met 'n baie kort lewensduur voorsiening vir afskrywing van batewaarde te maak nie, daar moet voorsiening vir aanlegvervanging gemaak word. 'n Positiewe en dinamiese beleid in hierdie rigting sal op die korttermyn miskien effens hoër pryse ten gevolge hê, maar dit sal verseker dat, wanneer tegnologiese ontwikkeling, of 'n veranderde ekonomiese toestand, die geleentheid skep vir meer doeltreffende produksie die fondse vir die nuwe belegging beskikbaar sal wees.

Die individuele maatskappy wat hierdie beginsel in sy prysberekening miskyk volg 'n korttermynbeleid wat uiteindelik sal lei tot 'n kapitulasie aan sy mededingers. As hierdie korttermynbeleid in 'n vrye marksituasie deur alle vervaardigers gevolg word, of as hulle deur 'n prysbeheerformule daartoe gedwing word, tree algehele stagnasie uiteindelik in en word die hele bedryfstak deur buitelandse konkurrensie bedreig. Hiervan is daar al die eerste duidelike tekens en word daar al om tariefbeskerming op ammoniak gevra.

Hierdie toestand van sake kan gedeeltelik aan die huidige prysbeheerformule ten laste gelê word omdat rentabiliteit slegs of afgeskrewe boekwaarde bereken word en gevolglik is daar geen voorsiening vir die toekomstige vervanging van toerusting nie.

Dit is dan 'n toekomsblik wat die ontwikkeling van die nywerheid betref. Laat ons nou kyk na die belangrikste ekonomiese vraagstuk van die sewentigerjare, naamlik inflasie.

Inflasie in die sewentigerjare

Daar is geen rede om te glo dat inflasie in die sewentigerjarie enigsins stadiger sal voortwoed as in die laat sestigerjare nie; inteendeel, daar kan 'n hoër inflasiekoers verwag word. Alle koste van vervaardiging, en nie net die prys van grondstowwe, sal dus styg, en hierdie tempo in die kunsmisbedryf sal sekerlik, oor 'n hele dekade geneem, nie laer as vier persent per jaar wees nie.

Die huidige prysbeheerformule maak geen voorsiening vir kostestygings anders as dié van grondstowwe nie, terwyl daar 'n volle twee jaar tydsverloop is tussen die prysbepaling en die toepassing daarvan. Fabrikante moet dus alle ander kosteverhogings dra. Die formule is dus in beginsel foutief.

Inflasie sal ook die vervangingskoste van 'n produksieaanleg aansienlik opstoot, gevolglik moet fabrikante die geleentheid gebied word om ruimskoots genoegsaam vir toekomstige uitbreiding voorsiening te maak deur 'n redelike rentabiliteit op kapitaal te toon. Laat ons nou kyk na wat 'n redelike rentabiliteit is.

Gestel ons wil, onder inflasionistiese omstandighede, voorsiening maak vir die vervanging van 'n aanleg wat tans R100 gekos het en wat 'n lewe van 10 jaar het. Die koste van vervanging teen die aangetoonde inflasiekoerse sal as volg wees

4 persent per jaar inflasie	R148
5 persent per jaar inflasie	R163
6 persent per jaar inflasie	R179

Vir 'n ekonomiese lewe van tien jaar, dit wil sê, 10 persent per jaar waardevermindering, op 'n reguit lyn basis bereken, en met die rentabiliteite hieronder aangetoon, sal die totale kontant wat oor die lewe van die aanleg beskikbaar gestel word as volg wees

Rentabiliteit	*Kontant beskikbaar*
17½ persent op afgeskrewe kapitaal	117
20 persent op afgeskrewe kapitaal	125
25 persent op afgeskrewe kapitaal	143
17½ persent op oorspronklike belegging	175

As inflasie teen 'n koers van 4 persent per jaar of meer voortwoed, dan is in geen geval, behalwe die laaste, genoegsame fondse beskikbaar vir die vervanging van toerusting nie. Die huidige prysbeheerformule laat slegs 7½ persent toe op waardevermindering en 13½ persent op afgeskrewe kapitaal. Die beskikbare kontant is onder hierdie formule slegs R25.

Slotopmerkings

'n Analise van die ekonomie van kunsmisvervaardiging lei direk en onwillekeurig tot die gevolgtrekking dat die huidige prysbeheerformule so onrealisties is dat 'n haas arbitrêre keuse van prys (natuurlik binne perke) nie 'n minder bevredigende situasie ten gevolge kan hê nie. Op die korttermyn en veral gedurende 'n periode van pragtige opeenvolgende reënseisoene soos wat ons tans ervaar, lyk dinge reg, maar as langtermyn kan die huidige prysbeheerformule slegs tot monopolistiese toestande en uiteindelike tegnologiese stagnasie lei. Hierdie stelling bly waar ongeag wie die bedryfstak besit, bestuur, of beheer en op die langtermyn sal, óf die prysbeheerformule opgehef of verander moet word, óf sal die Suid-Afrikaanse boere in die voorsiening van hul kunsmis by die res van die wêreld agterbly.

Daar is dus by uitstek drie belangrike ekonomiese elemente wat enige prysbeheerformule moet omvat, naamlik

(i) Die verouderde en passiewe begrip van waardevermindering op batewaarde moet vervang word deur die moderne en dinamiese begrip van voorsiening vir vervanging van toerusting; en dit moet op so 'n manier geskied dat daar vir die nywerheid as geheel die geleentheid geskep word, om, in sy vervangingsbeleid, die beste gebruik van tegnologiese ontwikkeling te kan maak. Die voorgestelde vervangingsbeleid sal ook voorsiening moet maak vir die hoër koste van toekomstige toerusting wat voortspruit uit inflasie;

(ii) Die prysbeheerformule moet voorsiening maak vir die vermeerdering van alle koste as gevolg van inflasie en nie net van grondstowwe nie;

(iii) Die variasie in vraag na kunsmis het 'n té belangrike invloed op enige prysbepaling en op die langtermynwinsgewendheid van die hele bedryfstak dat hierdie belangrike element volledig en noukeurig in die prysbeheerformule opgeneem behoort te word. As daar sprake is van 'n té hoë prys vir kunsmis op die korttermyn dan moet boere deur 'n subsidie of op 'n ander manier gehelp word terwille van die langtermynvoorde!e wat 'n realistiese pryskontrole sal meebring.