Process Technology in the Third Reich: The Case of IG Farben and Buna

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Why This Topic?

The issue of science and technology in the Third Reich is of continuing interest to historians from the Mehrtens & Richter volume of 1980 to the Szollosi-Janze volume of 2001.

At the same time, synthetic rubber was of crucial importance to the Third Reich especially after the invasion of the Soviet Union in 1941.

Furthermore, it is a technology that links one of the major German firms, IG Farben with the extermination camp at Auschwitz.

What are the Themes Here?

On the whole I have not found the secondary literature on science and technology in the Third Reich very useful.

However it does raise two themes which arise with any totalitarian regime—the degree of autonomy enjoyed by the technologists (or as here, the firm) and the degree of cooperation with the ruling regime.

These are not two sides of the same coin, although a high degree of co-operation does render autonomy largely meaningless.

Technology and the State

In short, the central question here is “who shapes the technology, the firm or the state?”. And if the state shapes the technology, in what way does it do so?

Having established this, we are then in a position to ask if there was anything specifically Nazi about the Third Reich’s influence on this technology or would any state—totalitarian or democratic—have acted in the same way to maximise the production of synthetic rubber?

But we are in danger of getting ahead of ourselves…..

The Basic Process

Synthetic rubber is made by polymerising a monomer with two conjugated double bonds, such as isoprene or butadiene, using a catalyst. The monomer itself is made from a suitable organic chemical feedstock such as coal, carbohydrates or petroleum.

Like natural rubber, the synthetic rubber is then compounded and converted into the desired product, most often tyres.

Beginning of Synthetic Rubber

In the second half of the 19th century, chemists discovered that isoprene (from the dry distillation of rubber) could be converted into rubbery lumps.

The key breakthrough was made by William Tilden in 1884, when he produced a rubbery mass from isoprene obtained from turpentine.

In 1906, Fritz Hofmann at Bayer took up the industrial synthesis of rubber thanks to a speech by Sir Wyndham Dunstan which backfired. Research on synthetic rubber was also carried out by the firm of Matthews & Strange and W. H. Perkin Jnr; they discovered sodium polymerisation in 1910.

Methyl Rubber and Buna

During the First World War, Bayer and BASF produced methyl rubber from acetone via methyl isoprene. The spontaneous polymerisation took several weeks and produced a cauliflower-like rubber. By the end of the war, the Germans had produced 2,500 tonnes.

In late 1925, the German dye industry—including BASF, Bayer and Hoechst—merged to form IG Farben. Within a few months, IG had resumed research on synthetic rubber.

The rubber produced was a polybutadiene rubber. The polymerisation was catalysed by sodium metal, hence Buna.

It was all Churchill's Fault

The price of natural rubber fell by 76 per cent between February 1920 and March 1922, threatening to bankrupt the rubber plantations in British Malaya.

In 1922, Winston Churchill as Colonial Secretary introduced a plan (the so-called Stevenson scheme) to restrict rubber exports from Malaya to force up the price and protect the infant industry.

The rubber price suddenly accelerated to 4s 5d (22p) per pound in July 1925.

To calm the situation, the British raised the exportable percentage in November 1925, but the damage, internationally, was done.

World's 1st Synthetic Rubber Industry

As a result of the Stevenson scheme, Stalin was determined that the Soviet Union would have the first synthetic rubber industry, seemingly driven by a desire to success where Ford and Edison had failed.

A competition was held in 1926 to find a process. It was won by the Lebedev alcohol process and the Byzov petroleum process and a pilot plant was set up in 1930.

The rubber used was a sodium-polymerised polybutadiene similar to IG's original Buna.

World's 1st Synthetic Rubber Industry

The first factory was at Yaroslavl' north of Moscow—production began in July 1932.

Second factory, at Voronezh south of Moscow, followed in October 1932 and third one at Yefremov, between Moscow and Voronezh, in July 1933.

The ethanol for the Lebedev process was fermented from potatoes grown in the surrounding countryside when there was mass starvation in the Soviet Union.

The output of the Russian industry in 1938 was 53,000 tonnes.

The Discovery of Buna S

In July 1929, IG chemists using an incorrect theory produced Buna S, a copolymer of butadiene and styrene. This turned out to have superior wear resistance to natural rubber and as such the first synthetic rubber to surpass natural rubber in any way.

Other IG chemists then discovered Buna N, a copolymer of butadiene and acrylonitrile. No other copolymer has ever been of any value.

IG considered building a factory to make Buna in 1929, but the Depression prevented any further progress…

The Neoprene Thunderbolt

In November 1931, Du Pont announced that it had succeeded in making a synthetic rubber from acetylene which was oil-resistant unlike natural rubber.

Neoprene (aka Duprene) was a thunderbolt to IG. Du Pont was not then a firm associated with new polymers. Furthermore it used a completely new acetylene chemistry.

On the other hand, neoprene showed that a synthetic rubber with specific advantages could sell for more than natural rubber, a strategy not hitherto considered by IG.

Nazi Seizure of Power

Just over a year after the neoprene shock, on 30 January 1933, Hitler became Chancellor of Germany. Within a few months, the new Nazi regime became interested in the production of synthetic rubber, Hitler being an admirer of methyl rubber.

Having just discovered that Buna N was also oil-resistant and seeing a glimmer of commercial opportunity, IG now had to take political factors into account.

I will now consider the various aspect of IG's synthetic rubber technology and show how the advent of the Third Reich changed the situation.

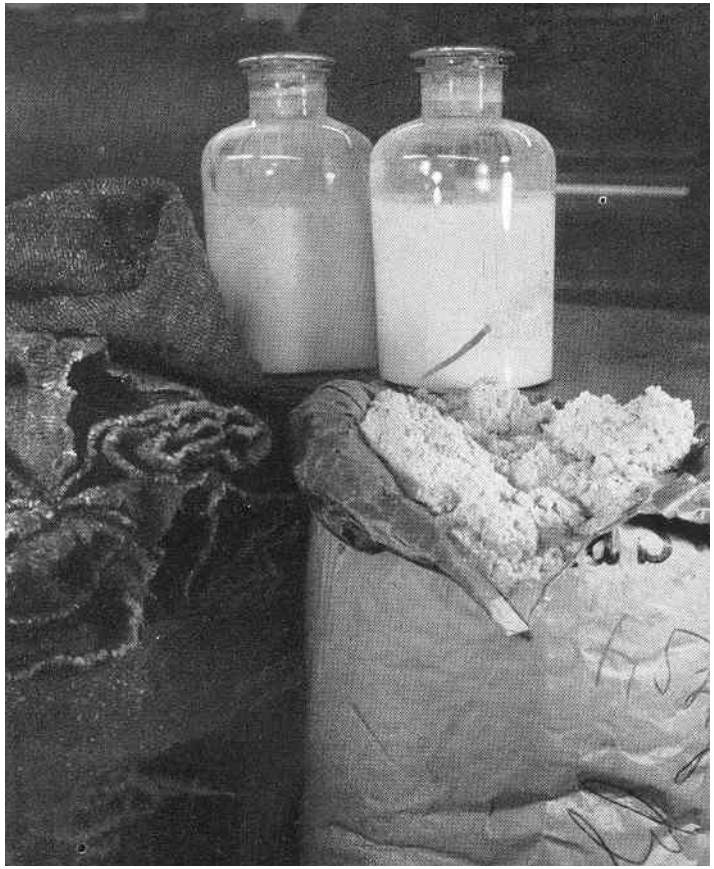
The Type of Rubber

In 1933, polybutadiene was still IG's "official" synthetic rubber and the Nazis would have been happy with this.

But IG was now keen to follow Du Pont's neoprene strategy and Buna N was found to be oil-resistant.

Could Buna N also be the general purpose synthetic rubber the Nazis wanted (but IG had little time for)?

By December 1935 it was clear that the answer was "no" because a mixed natural-synthetic tyre was now seen as essential and Buna N could not be blended with natural rubber.



Samples of Buna S latex, sheet and crumb

Push for Neoprene

If Buna N was unsuitable as a tyre rubber, neoprene did tick both boxes—this is often overlooked because Du Pont deliberately blocked any attempt to use neoprene as a tyre rubber to avoid any conflict with the powerful American rubber firms.

But clearly IG had to get a licence for neoprene. In October1934, IG's organic chemicals chief, Fritz ter Meer, visited Du Pont but returned empty-handed. Negotiations continued until 1938 but Du Point was never willing to give IG a comprehensive licence.

Why Du Pont Said No

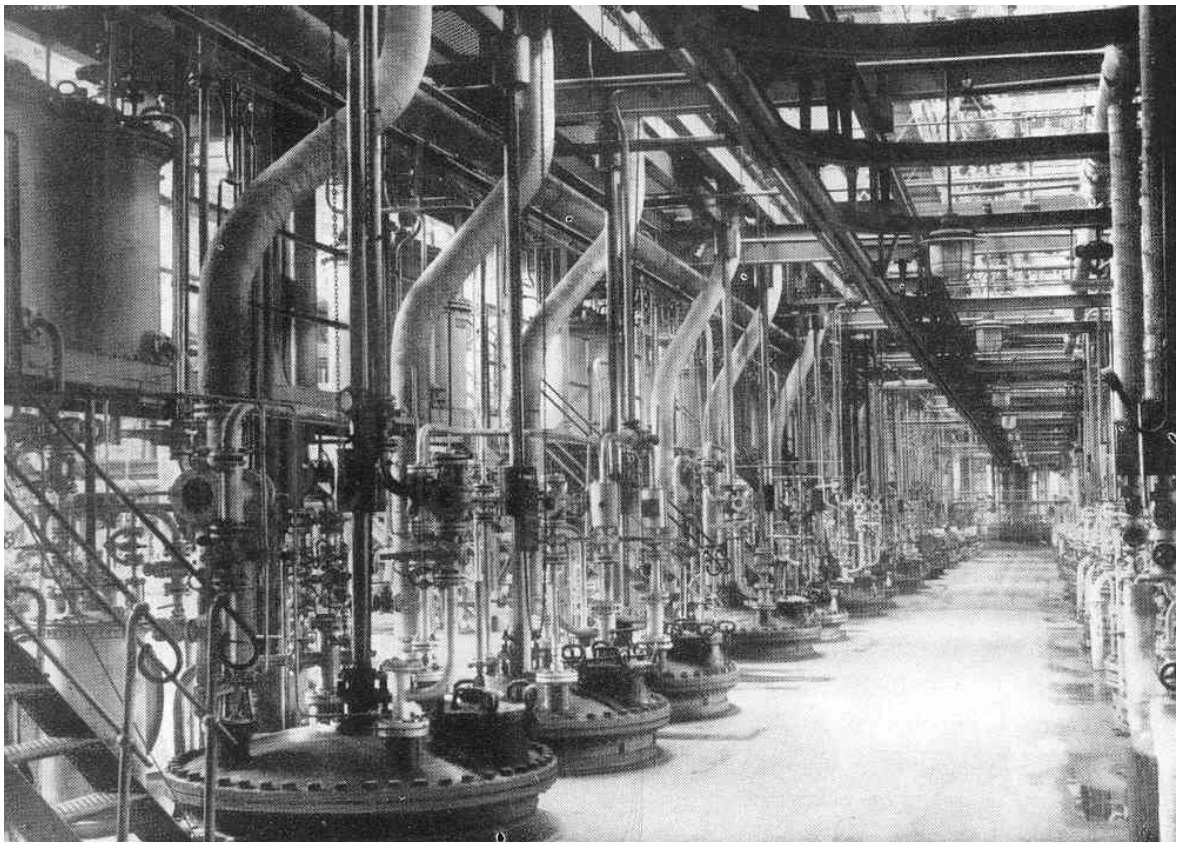
Why did Du Pont refuse to collaborate with IG?

- The top people at Du Pont loathed IG Farben as a firm, which they regarded as arrogant and over-powerful.
- IG Farben also had little to offer in return.
- Most of the technology it could have offered was tied to its agreement with Standard Oil and Du Pont was equally entangled with ICI.
- Du Pont were anxious not to annoy the American rubber industry and not to run foul of anti-trust laws.
- Du Pont may have also been worried about assisting Nazi Germany but this not appear to have been its prime reason for turning IG down.

The Rise of Buna S

Although Buna S had been the first co-polymer rubber to be patented, it had been largely neglected. However by late 1935—when the pressure was on to produce synthetic rubber and neoprene was not available—it became clear that Buna S was a good tyre rubber. It was wear-resistant and could be blended with natural rubber. But there was a major problem, it was too hard to be processed on the existing machinery.

This problem was solved in March 1937 when a crude method of softening the rubber by heating it ("thermisches Abbau") was patented. In the rush to solve the problem, a better method patented only 19 days earlier—the use of modifiers—was overlooked.



Buna S polymerisation

The Basic Feedstock

If one uses synthetic rubber to completely replace natural rubber as the Nazis wanted, you need a feedstock which is both cheap and available on a large scale. Not easy!

- Coal (via acetylene): readily available but expensive
- Coal tar (via benzene): needed elsewhere, not cheap
- Carbohydrates (via ethanol): not readily available in Germany and expensive
- Petroleum (via butylene): readily available but not in Germany and cheap, but requires new technology

IG Loved Acetylene

IG Farben chose acetylene even before 1933. It was an acetylene producer and saw it as a versatile starting material for many chemicals.

Acetylene chemistry was also “traditional” organic chemistry whereas both the petroleum and alcohol processes were a new type of chemistry.

But it was very expensive (required a lot of electricity) and new capacity would be needed to produce a general purpose rubber.

The Nazis and the Feedstock

Initially the Nazis (e.g. Wilhelm Keppler) were happy with acetylene, it was reassuringly “high-tech” for the period and consumed German coal.

But they also felt that IG was blinkered and often wondered if the firm was “missing a trick” or suppressing technologies it did have not patents for.

When chemists from the rival First Division of IG became the government’s advisors in 1936, the pressure to use petroleum increased.

The Problem with Petroleum

Although petroleum (or natural gas) was attractive in many ways, but was not readily available in Germany (but note synthetic oil plants) and the technology to convert it into butadiene was still being developed.

One of IG's processes (based on research by Perkin Jnr) was too complicated and the other one—the so-called "arc process" developed with Standard Oil—produced acetylene rather than butylene.

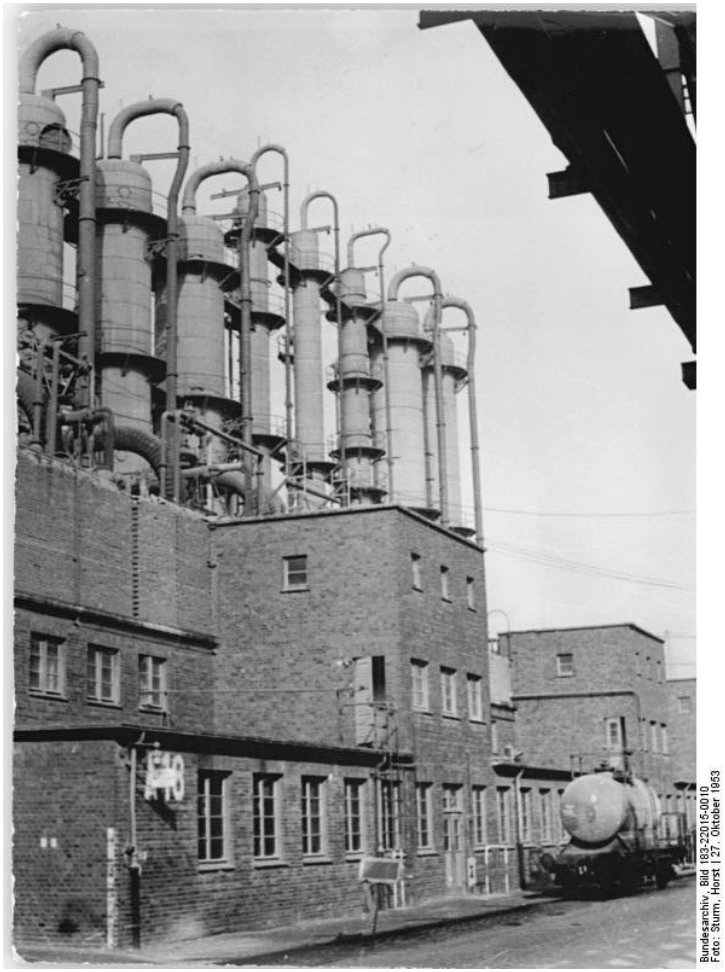
The Four Step Process

If acetylene was the only viable contender as a starting material (and alcohol was not taken seriously before 1942), how could it be converted into butadiene?

In the late 1920s, IG had developed the “classical” four-step process:

acetylene —> aldol —> butylene glycol —> butadiene

This was inefficient (overall yield was 60%) and hence expensive, but IG was comfortable with the technology and held the patents.



butylene glycol distillation towers, Schkopau

Effect of the Neoprene Shock

Du Pont's neoprene used a new type of acetylene chemistry developed by Julius Nieuwland (and Knute Rockne) at Notre Dame University in the 1920s.

The key breakthrough was the dimerisation of acetylene to monovinylacetylene (mova). Could this be converted into butadiene?

In theory this is possible but the only successful process would have required the world's total supply of palladium. Furthermore mova and its byproducts are explosive and there was a fatal explosion in 1935. This route was finally abandoned in 1938 when it was supplanted by the new Reppe process.

Enter Walter Reppe

At this point, IG found its own “acetylene star” Walter Reppe. Reppe had entered BASF at Ludwigshafen in 1921 and had made the key breakthrough in the four-step process in 1927—the so-called “key to Buna”—the dehydration of 1,3 butylene glycol to butadiene.

In the early 1930s he investigated the chemistry of acetylene under pressure, finding a new route to vinyl ethers.

He was rewarded for this new “Reppe chemistry” with the leadership of a new laboratory, the intermediates-plastics (ZK) laboratory at Ludwigshafen in 1934.

The Reppe Process

In 1937, Reppe used his high-pressure chemistry to add formaldehyde to acetylene to form butyndiol which could be reduced to 1,4 butylene glycol and hence butadiene:

acetylene —> butyndiol —> butylene glycol —> butadiene

IG was triumphant: its unique chemistry had produced a route to butadiene which used only one molecule of expensive acetylene rather than two. The firm's belief in its own R&D and in acetylene as the feedstock had—at least in its own view—been vindicated. But the process was still at the laboratory bench and the Nazis were demanding the introduction of synthetic rubber.

Get on with It!

Hitler had the building of the first factory announced at the Nuremberg rally in September 1935. He then kept the pressure up through his officials and by making another announcement at the Berlin Car Show in February 1936.

It is not clear if he did this because he wanted to put pressure on IG (and his officials), because he genuinely thought the firm was ready to go into production, or because he desperately needed to announce a breakthrough for political reasons. The effect was the same: IG were forced to announce the construction of its first synthetic rubber factory in December 1935.

Please be Patient

With the processing problems with Buna S still unresolved and the possibility of replacing the four-step process with a cheaper route on the horizon, IG was not anxious to rush into production.

By contrast Hitler was very anxious to begin the construction of factories. He needed a technological advance to equal Stalin's new factories and to show the superiority of German technology. He needed to show that German self-sufficiency was possible in at least one area. And he needed the synthetic rubber factories up and running before war broke out, whether it be a pre-emptive war on the part of the Allies or a war of aggression launched by Germany.

“The Hour of Peril”

Hitler’s frustration with IG and its obsession with getting the best process and the right rubber spilled onto the page when he wrote his secret memo on the Four Year Plan in August 1936:

The mass production of synthetic rubber must also be organised and achieved with the same urgency. From now on there must be no talk of processes not being fully determined and other such excuses. It is not a matter of discussing whether to we are to wait any longer; otherwise time will be lost, and the hour of peril will take us all by surprise. Above all, it is not the job of the economic institutions of Government to rack its brains over methods of production. This has nothing whatever to do with the Ministry of Economics. Either we possess today a private industry, in which case its job is to rack its brains about methods of production; or we believe that it is Government’s job to determine methods of production and in that case we have no further need of private industry.

The Fudge of Schkopau

The foundation stone of the new factory at Schkopau near Halle was laid with much fanfare in April 1936.But it was a fudge rather than a factory.

The original plant was only a pilot plant. It used a process which IG was hoping to abandon and initially produced Buna rather than Buna S.

It was sited at Schkopau because the government—concerned about bombing—would not allow it to be within the Leuna complex. But it was heavily dependant on Leuna for hydrogen as the Allied bombing in 1944 would demonstrate.

Forward to Hüls

IG also agreed in 1937 to set up a second factory at Hüls in the Ruhr, and in a concession to the First Division chemists working for the government, it used acetylene from natural gas. A coal-mining firm was also a minority partner. The Reppe process was still not ready and Hüls used the four-step process as well.

Schkopau finally started up as a full-scale factory in April 1939 (on Hitler's birthday) and Hüls followed in August 1940.

But IG beat off the government's attempts to build a third factory before the war and the Reppe process was not used until 1943.

Where’s the Rubber?

Because of the slow start to the industry and the failure to build a third factory in time, both largely the result of IG’s desire to postpone production, Germany entered the Second World War with a massive shortfall in synthetic rubber production. Instead of the planned 100,000 tonnes a year, production capacity was just 24,000t. Production only reached the desired levels in late 1942—which to be fair was the original target date—and this capacity was soon reduced by Allied bombing.

But was the impact of the Nazi regime on the synthetic rubber programme and on process development in particular?

Completed bales of Buna S

Buna without the Nazis 1

Can we work out how Buna would have been developed if the Third Reich had not existed? I believe we can:

- synthetic rubber would have still be produced but on a smaller scale and sold at a higher price
- it would have been Buna N, not Buna S
- it might have been neoprene, but this is less likely
- acetylene would have remained the feedstock
- being small-scale and sold at a higher price, the four-step process would have been acceptable
- but the Reppe process would probably still have been introduced, eventually.

Buna without the Nazis 2

The need to process Buna S would have not arisen so urgently and the use of modifiers in the polymerisation process might have been taken up sooner.

The pace of development would have been slower, but as production levels would have been lower, it might not have been much slower. I think production would have begun around mid-1937.

Production would have been based in the existing factories, probably Leverkusen and Ludwigshafen, and possibly Leuna if the arc process had still been introduced.

The Impact of the Nazis

Thus the impact of the Third Reich is easily summarised:

- the use of a general-purpose tyre rubber (Buna S) instead of a oil-resistant specialty rubber (Buna N)
- a much higher planned level of production
- an accelerated pace of development and industrialisation, hence…
- the use of the crude “thermisches Abbau” process for the working of Buna S instead of modifiers
- the use of the four-step process rather than the Reppe process (less clear-cut)
- the siting of the factories at Schkopau and Hüls

Carbide building, Schkopau

A Different World

This is counterfactual history on a large scale, but if the Third Reich had not existed and there had been no world war, it is unlikely that a mass-produced synthetic rubber industry would have existed anywhere outwith the Soviet Union.

Thus there would be no synthetic rubber industry today apart from a Russian one (which to be fair is still important) and most tyres would be made from natural rubber not the modern version of Buna S.

But most counterfactual history converges on the real present eventually, so perhaps synthetic rubber would have taken off after all.

But What's Nazi about It?

So we can delineate the impact on the Third Reich on the development of Buna, but what is specifically Nazi about it? The outcome would have much the same for any country trying to develop a general-purpose synthetic rubber regardless of the nature of the regime, be it Stalinist Russia or Rooseveltian America.

It is true that the drive to produce synthetic rubber was energised by Hitler's desire for self-sufficiency and his preparations for war. But that was true of other countries as well. No major country wanted to be a hostage of the British government.

The Real Impact of the Nazis

The Nazis' real impact was on the nature and siting of the factories. IG fought against the government's demands in this area, seeking to make the factories broadly based organic chemical complexes rather than solely synthetic rubber factories and even closed down one site before it was completed against the state's wishes.

But IG's need to fend off the SS in particular combined with its desire to build a major new complex in Eastern Europe converged with the founding of IG Auschwitz in the Spring of 1941. This was the ultimate conclusion of the Third Reich's involvement with Buna, but the site was chosen by IG Farben.

But what was Nazi about the *Process?*

But that is about the siting of the factories, which is clearly political/social/economic as well as technical.

The Nazis' impact on *process development* was one of pace and scope; there was nothing specific ideological about it. Hence I am rather sceptical about the idea of writing about Nazi science and technology apart from ideological constructs such as "Deutsche Physik".

Rather what is interesting—and important—is the way that chemical and technological issues (such as the shortage of palladium or the need for a flood-free plain for a factory) affected the plans of the all-powerful Nazi state.