THE ROLE OF PLASTIC WORKING OF METALS IN NATIONAL DEVELOPMENT

Speech at the investiture of the National Chairman, Nigerian Institution of Metallurgical, Mining and Materials Engineering (A Division of the Nigerian Society of Engineers), Engr. Prof. D. O. N. Obikwelu, SPX, FNSE by Engr. Prof. Jacob S. Jatau, MNSE, FNMS, MNMGS.

PROTOCOL

It is a pleasure to be invited to present a speech at the investiture of the Chairman of our great Institution, the Institution of MMM (triple M), a division of Nigerian Society of Engineers, Engr. Prof. D. O. N. Obikwelu, FNSE. I have chosen to talk on the Role of Plastic Working of Metals in National Development, considering the impact it will have on the audience present today and the interest it will generate as we ponder over the state of our national development. I remember when I delivered my Professorial Inaugural Lecture on the topic: Iron and Steel the heart for technological development far back in 2005, I was convinced that without a developed iron and steel industry, the country cannot develop. Iron and steel was equaled to the heart or you can say the engine of any country that aspires to develop. My conviction has not just remained the same, but increased over these years. I believe also that a developed iron and steel industry must have a developed plastic working of metals which is one of the finishing processes in metal forming.

The overall usefulness of metals is due largely to the ease by which they can be formed into useful shapes.

Plastic working of metals, otherwise known as pressure shaping of metals or mechanical metallurgy is simply a metal forming process by the use of pressure instruments. This process includes processes as rolling, forging, extrusion and drawing. While the other metal forming process, casting, is very important, especially for metals that cannot undergo pressure shaping due to their poor plastic properties, it is necessary to note that majority of parts from metal are produced by plastic working processes since it is cheaper and more productive. In addition, objects of bigger sizes like wires, tubes (pipes), sheets, etc can be produced.

The beauty of these deformation processes, i.e. plastic working of metals is that they are designed to exploit a remarkable property of some engineering materials (most notably metals) known as plasticity, the ability to flow as solids without deterioration of their properties. Since all processing is done in the solid state, there is no need to handle molten metal or deal with the complexities of solidification as in casting process. Since the metal is simply moved (or rearranged) to produce the shape, as opposed to the cutting away of unwanted regions, the amount of waste is reduced substantially. The argument of not developing this industry can be that the forces required to deform the metals are often high and consequently, machinery and tooling can be quite expensive. But large production quantities can justify the approach and we have the resources in abundance.

And so now, let us look at these processes and see how they can affect our national development and economy. While Nigeria has good potential to exploit these processes based on the resources available, we see that we have not put to use even 5% of these processes. With very few rolling mill companies and may be a few drawing mills in Nigeria, we can see that we have a very long way to go. In fact our rolling mills have concentrated only on wire rolling, while there are quite a lot more in rolling than this.

Rolling is usually the first process that is used to convert metal into a finished wrought product. By rolling, cast ingots, strands, and slabs are reduced in size and converted into basic forms such as sheets, rods, and plates. These forms then undergo further deformation to produce wire, or the myriad of finished products formed by processes such as forging, extrusion, sheet metal forming, and others. By the shape of products, rolling can be divided into two broad forms, section rolling and flat rolling. The flat rolling produces finished products such as sheets, strips which are used in automobile industries as vehicle body parts and other construction industries, while section rolling produces products with wide range such as wires, angles, beams, rails, tubes, pipes, bars, etc.

Rolling can also be broadly divided into hot and cold rolling, depending on the temperature of work piece. In hot rolling, the heated metal is passed between two rolls that rotate in opposite directions, the gap between the rolls being somewhat less than the thickness of the entering metal. The metal is squeezed and elongates. Temperature control is a requirement for success. There are various roll configurations used in rolling operations. For the single stand mill, it includes the 2-high non-reversing mill, 2-high reversing mill, 3-high mill, 4-high mill and the cluster mill which has up to twelve rolls. In rolling of non-flat or shaped products, such as structural shapes and railroad rails, the set of rolls contain contoured grooves (passes) that sequentially form the desired shape and cross-section and control the metal flow. When the volume of a product justifies the investment, rolling may be performed on a continuous rolling. Billets, blooms, or slabs are heated and fed through an integrated series of non-reversing rolling mill stands. Continuous mills for the hot rolling of steel strip, for example, often consist of a roughing train of approximately four four-high mill stands and a finishing train of six or seven additional four-high stands. In the continuous structural mill, the rolls in each stand contain only one set of shaped grooves, in contrast to the multi-grooved rolls used when the product is produced by back-and-forth passes through a single stand. The control of speed and deformation parameters is very important in continuous rolling so as to avoid either the accumulation of metal or the tension of metal leading to rupture between the stands. The synchronization of six or seven mill stands is not an easy task, especially when key variables such as temperature and lubrication may vary during a single run, and the product may be exiting the final stand at speeds in excess of 110km/hr. Computer control is basic to successful rolling, and modern mills are equipped with numerous sensors to provide the needed information.

Because hot-rolled products are formed and finished above recrystalization temperature, they have little directionality in their properties and are relatively free of deformation-induced residual stress. As a result of the hot deformation and the good control that is maintained during processing, hot rolled products are normally of uniform and dependable quality, and considerable reliance can be placed on them.

I must mention here about the thermo-mechanical processing of metals. As with most deformation processes, rolling is generally viewed as being a means of changing the shape of a metal. While heat may be used to reduce forces and promote plasticity, the thermal processes that produce or control mechanical properties (heat treatments) are usually performed as subsequent operations. Thermo-mechanical processing, of which controlled rolling is an example, consists of integrating deformation and thermal processing into a single process that will produce not only the desired shape, but also the desired properties, such as strength and toughness. The heat for the property modification is the same heat used in the rolling operation, and subsequent heat treatment is unnecessary. Possible benefits of thermo-mechanical processing include improved product properties; substantial energy savings (by eliminating subsequent Heat Treatment); and the possible substitution of a cheaper, less-alloyed metal for a highly alloyed one that responds to heat treatment.

Cold rolling is clearly the dominant cold working process in terms of product tonnage. Sheets, strips, bars, and rods are cold-rolled into products that have smooth surfaces and accurate dimensions. Because of the smaller size and higher strength of the material (compared to hot rolling), most cold rolling is performed on four-high or cluster-type rolling mills.

If a product has a uniform (or nearly uniform) cross section and relatively small transverse dimensions (less than about 5cm), cold rolling of rod or bar may be an attractive alternative to extrusion or machining. Like the hot forming of structural shapes, the cold rolling of shapes generally requires a series of shaping operations. Separate passes (and roll grooves) may be required for sizing, breakdown, roughing, semi-roughing, semi-finishing, and finishing. A minimum order of several tons of products may be required to justify the cost of the required tooling.

Apart from rolling, forging is another important process of plastic working of metals. Forging is the term applied to a family of processes where the deformation is induced by localized compressive forces. The equipment can take the form of hammers, presses, or special forging machines. While the deformation can be done in the hot, cold, warm or isothermal mode, the term forging usually implies hot forging done above the recrystallization temperature.

Forging is the oldest known metal working process. From the days when prehistoric peoples discovered that they could heat sponge iron and beat it into a useful instrument by hammering with a stone, forging has been an effective method of producing many useful shapes. Of course, modern forging has developed from the ancient art practiced by the armour makers and the immortalized village blacksmith. High-powered hammers and mechanical presses have replaced the strong arm, the hammer, and the anvil, and modern metallurgical knowledge has supplemented the art and skill of the craftsmen in controlling the heating and handling of the metal. Parts can range in size from ones whose largest dimension is less than 2cm to others weighing more than 170 metric tons.

A variety of forging processes have been developed that offer a wide range of capabilities. A single piece can be economically fashioned by some methods, while others can mass produce thousand of identical parts. The metal may be:-

- drawn out to increase its length and decrease its cross-section;

- Upset to decrease the length and increase the cross-section;
- Squeezed in closed impression dies to produce multidirectional flow.

Common forging processes include:

- open-die drop-hammer forging
- impression – die drop – hammer forging
- press forging
- upset forging
- automatic hot forging
- roll forging
- swaging

In concept, open-die hammer forging is the same type of forging done by the blacksmith of old, but massive mechanical equipment is now used to impart the repeated blows. It is a simple and flexible process, but it is not practical for large scale production. It is a slow operation, and the size, shape and dimensional precision of resulting workpiece is dependent on the skill of the operator. Impression-die or closed-die forging overcomes these difficulties by using shaped dies to control the flow of metal.

For large pieces of thick products, press forging may be required in place of hammer or impact forging with high speeds. In this case, the deformation is now analyzed in terms of forces or pressures (rather than energy), and the slow squeezing action penetrates completely through the metal, producing a more uniform deformation and flow. New problems can arise, however, because of the longer time of contact between the dies and the work-piece. As the surface of the workpiece cools, it becomes stronger and less ductile and may crack if deformation is continued. Heated dies are generally used to reduce heat loss, promote surface flow, and enable the production of finer details and closer tolerances. Periodic reheating of the workpiece may also be required.

Other types of forging include upset forging which generally employs split dies that contain multiple positions or cavities; automatic hot forging; and roll forging where round or flat bar stock is reduced in thickness and increased in length to produce such products as axles, tapered levers, and leaf springs.

Another very interesting process of plastic working of metals is extrusion. In this process, metal is compressed and forced to flow through a suitably shaped die to form a product with reduced but constant cross section. Although extrusion may be performed either hot or cold, hot extrusion is commonly employed for many metals to reduce the forces required, eliminate cold working effects, and reduce directional properties. Basically, the extrusion process is like squeezing toothpaste out of a tube. Aluminium, magnesium, copper, lead, and alloys of these metals are commonly extruded, taking advantage of their relatively low yield strengths and low hot working temperatures.

Extrusion can be produced by various techniques and equipment configurations. Hot extrusion is usually done by either direct or indirect method. With either process, the speeds of hot extrusion are usually rather fast, so as to minimize the cooling of the billet within the chamber. In this process, lubrication is of high concern. An acceptable lubricant is expected to reduce friction and act as a barrier to heat transfer at all stages of the process. Impact extrusion, hydrostatic extrusion, and continuous extrusion are usually performed cold. Hollow shapes, and shapes with more than one longitudinal cavity, can also be extruded by several methods. In this case, the die forms the outer profile, while the mandrel shapes and sizes the interior.

Last of all, is the process of drawing which is a plastic deformation process in which a flat sheet or plate is formed into a recessed, three-dimensional part with a depth more than several times the thickness of the metal. The metal assumes the desired configuration as a punch descends into a mating die or the die moves upward over a punch. Hot drawing is used for forming relatively thick-walled parts of simple geometries, usually cylindrical. Because the material is hot, there is often considerable thinning as it passes through the dies. In contrast, cold drawing uses relatively thin metal, changes the thickness very little or not at all, and produces parts in a wide variety of shapes.

Ladies and gentlemen, having discussed the processes of plastic working of metals, at this stage, it important to tie it to the role it has in the national development. Chairman, fellow colleagues and invited guest, you will all agree with me that the development of this sector will definitely bring about the various activities in almost all sectors of economy. Take, for example, the products of rolling mills can be used in agriculture, power, transport, oil and gas, construction of infrastructures and roads, etc. This will in turn bring about multiplier effect in employment and a boost in economy. We can even venture into areas that are hitherto not in the country, for example, machine building industries where heavy equipments can be manufactured and also vehicle manufacturing industries.

Recently, I read in the News pages, the response of the richest African, Alhaji Aliko Dangote when it was reported that the PDP was wooing him to contest for president of the country. He rejected the offer and said he is not a politician, but an industrialist. He said he is more concerned with how to enrich the people by creating industries and providing employment for our many unemployed citizens. As a result, he is investing in agriculture (rice and sugar production) as well as building a refinery in Lagos. What a beautiful thing I thought. However, I have always wondered when we will have government or rich individuals who will invest in the industries that can affect the other industries ------ and that is the metal industry. How can you have mechanized farming without developing the metals industry?

Ladies and gentlemen, it is sad to see that our country is really not developing as it should, because we have misplaced priorities. We have neglected the main thing. It is the right time and very necessary for our society to create more awareness by publicity and I believe that one day those in authority will heed our warning and take advice. I am sad to see the wastage, for example, at Ajaokuta, a place that was meant to be the largest iron and steel plant in the South of Sahara. If Ajaokuta is fully put to use, it cannot be imagined how many jobs it would have created including the multiplier effect.

Chairman, ladies and gentlemen, from what we have discussed so far, I am sure you will agree with me that the metals industry and of course the investment in the Plastic Working of Metals has great role in the national development. And as we yet witness today, the investiture of the National Chairman of our great institution, the Institution of the Metallurgical, Mining and Materials Engineering, it is my prayer that he will add his own quota to bring to the attention of the government the importance of this sector to the growth of the economy.

Ladies and gentlemen, join me therefore in congratulating our able Chairman, Engr. Prof. D.O.N. Obikwelu SPX, FNSE on his investiture and wishing the Institution a good time under his leadership.