

JUNE 10th, 1915.

---

## CONSIDERATION IN THE DESIGN OF INDUSTRIAL MACHINES.

(By R. Sykes.)

---

Believing that we, here in Australia, will, as an outcome of the present European war, soon enter upon a new era of exceptional progress in the scope and extent of our manufactures, the author hopes the subject chosen to fulfil his obligation to this Association, though devoid of pure scientific detailed treatment, by reason of the large field it is necessary to embrace, will be of some interest, and especially so in view of the very material considerations involved.

The class of machines to which the matter of this paper more particularly refers are those machines which produce large quantities of material or articles, and require constant attention by skilled or semi-skilled operatives, such as textile looms, netting, hat, bottle, nail and other machines where commercial success depends upon a continuous high rate of production and a uniform predetermined quality of product—continuous not as measured by hours only, but also by days, weeks, months and years.

On the assumption that it is never wise to take a restricted view if it be desired to obtain and assimilate the whole truth, and in order to give the various factors that go to promote the ultimate success of industrial machine design their true perspective, it is as well to realise at the onset that many of the rather less complicated machines in use to-day do not essentially differ from those in use several generations ago, when engineer-

ing as the exact science as we know it was non-existent. Such machines are, therefore, not the product of any high order of engineering, and it is equally obvious they have been evolved by a process of trial and error plus natural aptitude for general arrangement, yet their survival is ample proof of the soundness of their principles. Theory has now practically eliminated the slow and costly process of trial and error, but there still remains the absolute necessity for a natural or acquired aptitude in general arrangement, a qualification largely independent of and often present where there is an entire absence of theoretical knowledge.

If an illustration is required of the machines just referred to, a notable example is found in the power loom as used in the cotton trade of Lancashire, and on which from ever since the middle of last century many hundreds of thousands of the population have been, and are now, solely and directly dependent for their livelihood, under conditions of unaided open competition in the world's markets.

The financial aspect is undoubtedly the key-note of the whole subject, and the engineer who relegates this view to a second place puts an irredeemable handicap upon his exertions and skill. Generally speaking, and especially under the high wage conditions ruling in Australia, the initial cost of machines plays only a very modest part in the net financial results of a factory; output, repairs, upkeep and consistent quality of product are the all-important factors that determine success or failure, and it is of the utmost advantage for the designer to be so thoroughly conversant with the relative bearing these three factors have on the financial aspect of the industry concerned, that subconsciously they permeate every motive in design in direct proportion to their importance as far as engineering requirements, pushed

very often to their uttermost limits, will permit. It is here that the purely scientific engineer is apt to go astray as compared to his less scientific, but more practical experienced brother, and it is here also where science and art merge into each other.

There is an important fundamental difference necessary in the method of approach in the design of pure engineering contrivances, as, for example, a steam engine or crane, and that of machines for manufacturing purposes. In the case of the former, comparatively few restrictions are imposed, limiting the adoption of conditions to obtain the best application of scientific principles; whereas, in the case of most industrial machines, hard and fast conditions of an exacting nature are imposed at the very onset without any reference to the engineering possibilities. To enumerate a few of the more general of these conditions, there are the requirements of the material and product, output, maintenance, accessibility for manipulation, visual considerations, and the very important question of the operative's convenience and standby position, involving health, posture, handiness and conservation of his energies.

Where the generally accepted engineering requirements can be readily reconciled with those imposed by the nature of the industry, all is, of course, straightforward work to any capable mechanical engineer, and needs no further comment here; but very frequently it is found seemingly impossible to so reconcile the two sets of conditions set down, and the question then arises as to whether the engineering or industrial side shall be sacrificed. Industrial limitations, however, make a hard taskmaster. It is generally found imperative to lay as much of the burden as possible on the engineering side, and scope is here provided for all the theory, practice, experience, ingenuity and keenness of perception it is

possible for man to acquire. There must be no pulling up short because this and that cannot be made to fit in with even only moderately fair practice. Where there is no liability to bodily injury, the engineer must be prepared to take license with any principle involved. It is not enough for him to know what is ordinarily safe practice; he must have a sound knowledge of the limits of failure, and know how near it is possible to work to these limits under any given set of circumstances, and also how to estimate the net result of his presumptions.

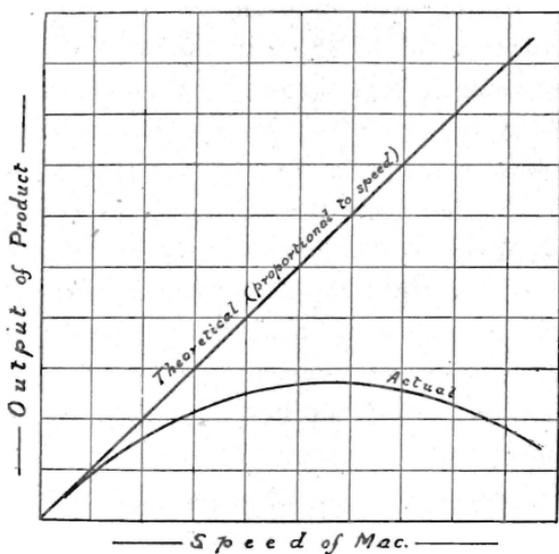


Fig. 1.

It is sometimes necessary to introduce methods and mechanisms that would denote sheer madness if used in a pure engineering contrivance, but in such cases it is often possible to largely compensate for the disadvantages by the exercise of a little ingenuity in arranging for cheap and rapid renewal of the parts affected most.

With few exceptions, industrial machines are more or less liable to occasional breakdown, but it does not by any means necessarily follow that a machine which breaks down more frequently than another is the least efficient

or least desirable of the two. On the contrary, a distinct advantage can be secured in some cases by introducing a design which, while increasing somewhat the liability to breakdown, more than compensates for this disability by the rapidity and small cost of repair or adjustment.

Another view of this speed question may be gleaned from a conversation the author had five years ago with a successful English cotton manufacturer, who said he had just been seriously approached by a firm of machine makers to adopt some looms designed to run at only

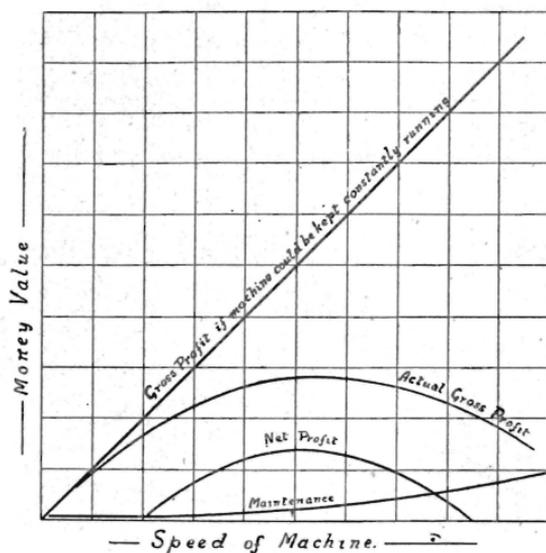


Fig. 2.

one-third the usual speed, and that the proposition as set out in detail looked commercially feasible, one of the ideas being that an operative could with equal ease look after four times the number of looms. This is of course an extreme case, and may never have come to fruition, but is cited here to impress upon the engineer that there are other way than increase of speed of increasing output per unit of labour and maintenance costs, and that very often to the benefit of the quality of the product.

One not infrequently hears adverse criticism of English-made machines in general by persons who evidently quite ignore the fact that they are attacking the main material source of strength upon which the greatest Empire that ever existed was built. Such persons would be far more profitably employed if, instead of trying to upset an obvious fact, they were to seek the cause of their divergent views, and they would not have far to seek. If financial considerations, as already stated, are the key-note of industrial machine design, how can it be

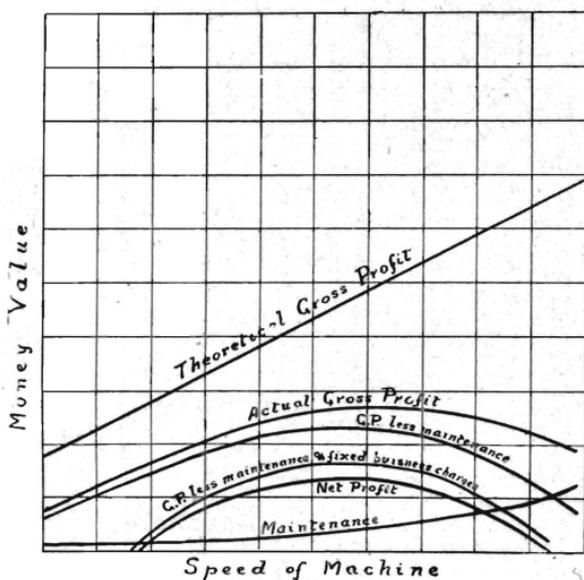


Fig. 3.

expected that machines designed to meet European conditions will be suitable in this country, where the financial and other conditions are so vastly different? The English machine maker cannot possibly know the Australian conditions as the Australian himself, and it therefore remains for the latter to work out his own salvation.

There is a strong tendency on the part of Australian manufacturers to run their machines at an excessive speed, which no doubt, under most circumstances, is the

best paying policy, since the manufacturers must be allowed to know their own business best, yet it results in exceedingly large repair staffs and maintenance charges as compared to English factories. This policy is independent of the producing efficiency of a machine, and the engineer must realise that if he designs an improved machine, whereby the original output is procured with reduced maintenance costs, it is quite likely the manufacturer will find it to his best interests to increase the speed until the increased maintenance makes it not worth his while increasing further. The net result of this is that the Australian engineer is faced with more frequent repairs than the English engineer, and must shape his design to compensate for the difference in the mechanical and financial ratio (Figs. 1, 2, and 3).

**Gearing.**—Quite apart from any consideration of the greater cost, accurate machine-cut gears in the class of machinery now under review, rather than always being an advantage, as against those cast from pattern gears, are often absolutely detrimental. One of the essential conditions necessary for the good running of cut gearing is, of course, the accurate paralleling or angular setting of the axes, the more accurate the gears the greater the demand for such accuracy, and the greater the accuracy of a machine the more necessary are proper conditions and attentive care, otherwise accuracy and its benefits soon cease to exist, and the original accuracy is not available for the purpose it was designed to serve.

The lines upon which factories must necessarily be worked make it very difficult to obtain conditions suitable for running machines of considerable precision. In the first place, the operative does not usually understand machinery, whereby trivial defects develop into breakdowns for want of the proverbial stitch in time; lubrication suffers by reason of his absorption in manufacturing

duties or thoughtlessness, and numerous small details which a mechanic, were he operating the machine, would almost unconsciously attend to, go entirely unheeded. Then there are often chippings, hard lumps, grit, scale, and many other undesirable substances of a more or less incompressible or otherwise objectionable nature, according to the industry, and from which the gears cannot be entirely protected. In many trades, of which the textile in some of its branches is an obvious instance, even the amount and kind of lubricant is determined not entirely by the requirements of the mechanics, but largely by those of the industry.

Gears accurately machined to a good fit, working under the foregoing conditions, are more susceptible to damage and deterioration than moulded gears; they entail more repairs and adjustments, which are individually more costly and take longer to effect, with a corresponding loss of output, entailing losses and annoyance to both employer and employee, to say nothing of the contingent losses in the way of late deliveries and irate buyers of the product.

It is better practice to rely more on proportions than on accuracy of workmanship, and from the manufacturer's standpoint it is in the long run cheaper to sacrifice some degree of power efficiency in favour of quick and less expensive repairs.

Australian engineers are considerably handicapped in the adoption of moulded gears on account of the indifferent attention the foundries in this country pay to this class of work, and probably due to the comparatively limited demand. There are many large foundries in England devoted entirely to the casting of moulded gears, and the results obtained approximate so closely the machine-cut gears that engineers there must have what would be considered here some exceptionally good reasons before they adopt cut gears. With well-moulded gears,