Modern Points of View in the Construction of Textile Machinery

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Textile machinery being part of the large group of works machinery is governed in its construction by the same technical and economical laws that apply to the group. But textile machines differ from other works machinery, especially from the machinery used for metal-working, in many very important respects. These differences are due to the nature of their field of application and to the raw materials which textile machinery has to work with.

Textile raw materials, both partially and completely worked up, which are subjected to the various processes of textile machines, are characterized by the relatively small size of their constituents, by low strength, both absolutely and relatively, by an elasticity not met with in other materials, and above all by the fact that they are very readily affected by external influences, such as atmospheric humidity, the temperature of their surroundings, their content of static electricity, and so on.

Since textile materials, whether raw or processed, are very readily affected by external influences, the working parts of textile machinery demand a much more rigorous observation of their basic principles and must be much more carefully adapted to the use to which the machines are to be put than is the case with other classes of machinery. For a long time, therefore, the construction of textile machines has been removed from the realm of empiricism and plays an important part in the science of working machinery, although indeed many textile machines are still built according to figures and rules that are purely empiric. The scientific treatment of the principles of the construction of textile machinery is in spite of this still in its infancy, just as the whole of our mechanical technology is still very far from being able to represent itself as a mature science. There is here wanting a generally applicable explanation of the various physical phenomena which go to form the nature and the characteristics of the construction and working of mechanical constructions. For instance we have not yet arrived at any generally accepted explanation of the theory of mechanical power.

Both verbally and in writing as well as in connection with explanations of the nature of electricity the author has since about 1916 given an explanation of the phenomena of mechanical power. He regards these as infinitely small vector whirling motions of the smallest particles of matter which in their totality form the macrocosmic phenomena which we can appreciate with our senses and our instruments. These explanations have proved themselves to be extremely fruitful for the understanding of all physical occurrences and will doubtless before long become common property in the science of physics, since they have proved that they can elucidate also all border phenomena. It has hereby been found that all physical forces, such as gravity, light, electricity, heat, chemical forces, and so on, are merely different aspects of one and the same original force. They are all subject to the same universal forces, whereby they influence one another, and the same laws, which are thus universal, always apply.

The most important fact for our present survey here shows itself with compelling lucidity. It is seen that the inertia of material mass particles is based upon the rotation of the vector whirling motion of the smallest particles of matter and that therefore the dynamic conditions in the construction of work machines are much more important than has hitherto been expressed in the practice of machinery building. This fundamental fact has most regrettably been neglected especially in the building of textile machinery, and to this is due the unsatisfactory constructions often encountered and their even more often unsatisfactory action both technically and economically.

We shall now consider in due order the raw materials for the construction of textile machinery, their construction and action from a modern point of view in reference to the most suitable construction and action technically and economically that can be attained. The space at disposal naturally permits of a treatment of the most important points only, but apart from this the present study makes no claim to treat fully and finally all the important modern points of view which appear in presentday constructions.

Cast-iron is one of the most important materials used in building textile machines. Thanks to refinements in the scientific and technical methods of research it has been possible to work out an efficient technique for smelting and casting all kinds of cast-iron quite independently of the various types of ore. The quality and uniformity have at the same time been raised and especially the strength of cast-iron prepared under strict chemical and technical control has been greatly perfected. Special raw iron from England is no longer used so much as it was after it had been found that the English cold-air iron could with advantage be replaced by careful mixture of good waste iron, such as steel and cast-iron chips or shavings. Cast-iron that is intended for vessels which have to work under high pressure is at present preferably made with the addition of manganese, and ferrosilicium is also used for this purpose.

Charcoal-iron possesses excellent properties due to the slight content of carbon and the absence of phosphorus and sulphur, as also the analogous silver-iron. The McLain process is much used in America for cast-iron for the construction of textile machinery because the content of silicon and especially of manganese is high. The original Martin process which produced steel by smelting waste steel and raw iron together has been extended in the last few decades by the use of pure chips using retort coal, carburit, etc. as the carbon carrier. Now that the electric smelting furnace has succeeded in preparing the so called synthetic cast-iron, it is probably destined to bring about an important improvement in all classes of foundry technique. The strength of cast-steel can be improved at only a slight extra cost. Malleable cast-iron, which many firms make themselves, is much used in the construction of textile machinery. American malleable cast-iron, characterized by its fracture showing a black core, should be a valuable addition to our foundries since it shows much increased extensibility and specific energy of shock. The types of steel which the presentday constructor of textile machinery has at his disposal may be grouped as follows: crucible steel, electro-steel (acid and basic), Siemensmartin steel (also acid and basic), Bessemer steel, and Thomas steel.

The uses to which these kinds of steel are put are determined by the nature of the qualities which are required of the various textile machines. The question whether in a given case cast-steel should be used instead of cast-iron must be decided by the strain which the machine has to stand and the saving in weight. In spite of the higher first cost, cast-steel will very often be found to be cheaper. As is well known cast-steel can also be forged and this quality can often be taken advantage of in the construction of textile machinery. Special kinds of steel produced by the addition of nickel-chromium, manganese, partly together with silicon etc., are of more or less importance for textile machinery, and very valuable case-hardened rollers, castings unaffected by acid, and so on, can be made by the use of such additions. Brass alloys with the addition of iron and aluminium have recently been tried out in foundries with success, and Babbitt metal for bearings has been created by the combination of lead, antimony and a little tin. Alloys with the addition of calcium and barium are also used nowadays. Monel metal, an aluminium alloy, has become of considerable importance for the construction of textile machinery abroad. Cast-aluminium with certain additions can be used to advantage for textile machines intended for export. Besides its low specific weight, this material has the further advantage of being a good conductor of heat, so that its use is to be recommended for equipment for equalizing heat, cooling apparatus, etc. Aluminium alloys can be made with the addition of copper, zinc, silicon, carbon, iron, phosphorus, manganese, lead, etc. and then possess specific properties, such as great hardness, good heat conductivity, not being affected by chemical action, and so on. Aluminium and its alloys can be looked on as the metal of the future for textile machinery and a general economical interest calls for every effort being made to develop the use of this material since it can replace other expensive metals which have to be imported from abroad, such as copper, with success. Its electrical conductivity is also comparatively good, so that it is excellently adapted for certain textile electrotechnical apparatus which are continually coming more into favour. Now that the nature of corrosion phenomena has been better comprehended and effective steps have been taken to combat it, brass has recently found more extended use in the textile industry, particularly for equipment which makes use of some chemical-technical principle or other. Brass piping is now being used more and more in America for water pipes after it had been found that material which was extremely well adapted for this purpose could be obtained by properly mixing the constituents and treating them suitably both thermally and mechanically. It should finally be mentioned that Krupp's "soft iron" is suited for many purposes in the construction of textile machinery instead of copper. It contains about 0.06% carbon and about from 0.12 to 0.14% manganese and is extraordinarily soft and tough both when heated (to about 200° C) and in the cold. Its strength at from 18° to 200° C is about 3200 to 4400 kilos per square centimetre.

Referring to the process for the production of cast-iron the spray casting process should also be mentioned. Its use is continually extending and it is applicable not only to pure metals, but just as well to alloys. For instance alloys with tin and lead, and then with zinc as basic material can be recommended for the construction of apparatus, as well as zinc alloys with the addition of copper and aluminium (Spandau alloy). Durolith metal is very strong and shows a strength of 30 kilos per square millimetre.

Foundry technique has reached a high pitch by the development of casting machines, and the use of an endless transport arrangement alongside form machines set up in a row for continuous working has recently been introduced in this country. Another novelty is the shaking casting machine which is much in vogue in America. Foundry technique has further been enriched by the clay casting process which avoids the use of a pattern, but makes high demands upon the skill of the technicians and workmen. If a skilled foreman watches the form carefully he can always make a success of the process. It is of course of the highest importance economically because it dispenses with all overhead costs for the preparation and storage of patterns.

It is fitting to close the above survey of the metals with a few observations upon the most important methods for testing metals as to their suitability for machinery construction. Recent investigations have shown that the ball pressure process, at any rate within the limits set by the technique, is quite as valuable as the static process as carried out according to Brinell's method. Also the notch shock test has found an important explanation through recent investigations. Important theoretical researches, full of significance for practical work, have been carried out upon the tensile bending test and especially upon the torsional stress of constructional parts. The well known formula of St. Venant has been expanded or partly supplanted by Föppl, Weber, and others. Euler's lateral flexure formula, which has lost much support since the collapse of the gasometer in Hamburg, has been successfully replaced by new formulae, in particular by that of Tetmeyer. Important investigations have also been published upon the bending of plates of varying thickness both singly and superposed, the results of which are of great significance for the construction of textile equipment, because just in this connection calculations were more or less empiric. The suitability of other materials used in the construction of textile machinery, such as wood, leather, fibre, have been further cleared up by valuable researches, and they can now be chosen very reliably for the most various purposes.

In recent years also the static and dynamic conditions which as a rule are of the highest importance for the construction and working of textile machinery have also been the subject of interesting and fruitful investigations. It is the bounden duty of every textile technical school nowadays which aims at imparting to the constructor of textile machinery rather more knowledge than usual of the nature of textile machines to pay more attention to applied kinematics and not merely to the arithmetical side of the science, but in particular to the problems of designing.

The author has more than once proposed to make dynamics the most important subject at higher schools and to treat statics as a special case of dynamics. Technicians of all ranks at the present day are face to face with dynamic problems without, as a rule, having the necessary equipment to solve them, because the necessary methods of treatment have not been imparted to them. Besides this it is a fact that power machines are generally treated rather broadly at the technical schools, so that little time remains for the statical and in particular for the dynamical problems. That is to say, it is considered sufficient to treat of the conditions relating to speed and strength in textile machines, but the problems of mass action, the forces of inertia, the phenomena of vibration, the forces of acceleration are, as rule, not gone into at all thoroughly. If these questions are explained and treated with the aid of diagrams, even not very skilled people can imbibe sufficient knowledge of kinematic laws and phenomena with little trouble, because this field of theoretical technics is particularly well adapted for treatment by this method. It must further be borne in mind that a great many conditions obtain in the construction of textile machinery which, far from being completely explained statically or dynamically, have not even been sufficiently investigated. This affords an excellent opportunity to a young textile technician or engineer for independent research and his labours in this field would be well rewarded. Besides this no great expense would be involved, because expensive experiments are not necessary. The following tabulation of the various drives of a general nature which serve to transmit motion will show the problems that await attack here:

a) for (preferably) uniform or irregular movements — spur gear, bevel gear, hyperbolic gear, worm gear, and so on;
b) for irregular movements — not round wheels, elliptic wheels, eccentric circle wheels, chains with and without cam and crank movement, pulley guide motions, eccentric crank mechanism, guide link motions, roller levers, etc.

All the systems of motion mechanism enumerated are to be found in the construction of textile machinery and can often be applied for new constructions with great advantage if their static and dynamic characteristics are well enough known. It is of the highest importance in building textile machines to pay attention to the static and dynamic laws which come into question, if constructions are to be attained which are technically irreproachable and especially economically suitable. Although the static forces as a rule are sufficiently considered in the calculations of strength and the determination of the speed conditions, the dynamic conditions are very far from being paid proper attention to. The noise of many textile machines, the oft-recurring breakages, occurrences which often remain unexplained, and the great waste of constructional material often met with could certainly be avoided if the magnitude and direction of the forces that here make their appearance were properly cleared up. To cite merely one case, the use of weights is very unsuited for mechanisms which must move rapidly, because the forces of inertia inseparably connected with the weights oppose powerful forces of acceleration to rapid motions. If, however, springs are used instead of weights, the forces of inertia are practically zero. Another instance concerns the loud noise which often accompanies the action of textile machines, such as looms, beaters, etc. The energy of vibration of the particles of air which produce the noise must naturally owe their origin to a source of energy. This proves to be the mechanical phenomena at the parts working which can be shown to be deformations and cause not merely a loss of heat, but also produce great loss by radiating free energy in the form of vibrations. If these can be suppressed, the sound waves cease and the consumption of power can be reduced.

It is an extremely important task for every builder of textile machinery to endeavour to find a cause for the often inexplicable fractures which occur. He must first endeavour to understand accurately and definitely the static and dynamic forces which make their appearance. If this principle applies to the improvement of existing machinery, it is still more applicable to the creation of new machines, although the conditions often are much more difficult here.

Of course the technological conditions which govern the nature, the measurements, the speed, the power, etc. of the construction of the textile machine in question are fully as important as the purely mechanical conditions which come into consideration and determine the construction. All phases of the physical operating conditions upon which the textile technological process is based must naturally be thoroughly known. Unfortunately there still remains much to be done in this direction in the textile industry. The practical operation of most textile machines and the conditions under which they are technically and economically successful are, it is true, well known, but there is often no clear comprehension of the important physical phenomena. The result is often that a state of affairs arises, when the operating conditions have to be changed, which causes difficulties that are hard to avoid. Even in new constructions it often happens that there is no guarantee of final success and satisfactory operation is, in fact, often reached after expensive trials.

In the construction of new textile machines the results of textile research, so far as applicable, will naturally be made use of, if need be first of all by trial to create the missing scientific basis. The present state of the art permits of saying definitely in advance how a new mechanism will act, but mistakes should be strictly avoided in view of the economic position of every business. It is further of great importance at the present time to pay attention to the physiological, partly also to the psychological conditions when constructing textile machinery. We cannot escape the conviction that a permanent economic recovery of our existence within the textile industry of the world is only possible by making the whole industry absolutely as automatic as possible and normalizing it. The rising costs of labour and the social burdens which rise with them, all of which appear as a function of the number of operatives in a factory, imperiously demand for every new mechanism a reduction of the number of persons required to operate it to the utmost. This can only be done when the whole process of manufacture is regarded technically and economically as a single unit, whereby the possibility of uniting certain phases of the manufacture readily follows from the technological conditions of the working process which then makes its appearance. In fact all modern constructions which seek to realize the continuous principle with more or less success have arisen from investigations of this kind. In order to carry out these investigations with necessary clarity, all the factors that exert an influence must be summarized graphically. Thus, for example, the quality which changes from process to process of manufacture, quantity, size, properties, power consumption, water consumption, operatives, raw materials, and so on, must be observed. From this can be seen at once with the aid of the present state of textile technique what technical means are necessary and the most appropriate arrangement of the construction can be settled with ease by means of such a tabulation. From the physiological characteristics of the human being also the most suitable forms can be found for attendance upon the mechanism, whereby the obviousness of the movements must be made as plain as can be done. By this is to be understood, for instance, that a switch motion for switching on and off a motor on a loom is arranged in the same way as the mechanical lever used on a belt-driven loom. In a lifting mechanism the upward movement of the control lever will be used for raising, and the horizontal position for indicating stoppage. If rolls of cloth are moved backwards and forwards, e. g. in measuring machines, the lever must be so arranged that the obvious correspondence of movement is clearly expressed.

An extremely wide field is open to the technique of textile machinery when the experience gained in other technical fields is brought to bear on its problems, and the still young electrotechnique in particular is destined to play a very prominent part. The success that can be achieved here both technically and economically is well shown by the spinning motors of recent construction, one individual electric drive being provided for each spinning spindle, so that all the advantages are made the most use of.

The application of electrotechnical laws to purely textile technical problems is also likely to prove fruitful as the points at which they meet are so universal. It may be recalled that it was only possible to clear up the difficult field of heat conduction and radiation after thermotechnics succeeded in operating with heating current just as the electric current is used in electrotechnics. When electrotechnical principles are applied in textile technique the prospects for the use of electricity would seem to be very promising.

In this way many auxiliary sciences, special subjects, and empiric sciences are united in the construction of textile machinery and of accessory equipment to make it appear as a branch of technology in general which is scientifically and technically well developed. A branch too which deserves all the more the attention of the technician and the political economist the more it succeeds in strengthening and extending the reputation of German labour, the German spirit of research, and the German instinct for the practical.