UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

TECHNICAL REPORT – THE INDIAN BICYCLE SECTOR

Enhancing Productivity in the Indian Bicycle Sector

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TABLE OF CONTENTS

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Technical inputs for the assessment were sought from UNIDO expert Mr. Jeremy James Papadopoulos. The analyses and results in the report were drafted by Ms. Shraddha Srikant and have been reviewed and edited by Dr. Ritin Koria and Mr. Vikas Kumar.

Proofreading was undertaken by Ms. Lauren Cooke, and final layout and design was undertaken by Mr. Mauricio Mondragon.

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EXECUTIVE SUMMARY

The UNIDO bicycle project aimed to support the Indian bicycle industry by strengthening the capacity and capability of the Research and Development Centre for Bicycle and Sewing Machine (RDCBSM), and the two industry associations - the All India Cycle Manufacturers Association (AICMA) and the United Cycle & Parts Manufactures Association (UCPMA) - to provide better management and technical support to the Indian bicycle industry.

The activities under the UNIDO bicycle project included transfer of state-of-the-art technologies, technical capacity building and knowledge sharing activities (technical workshops, training of trainers, international study tours and fellowship training), twinning with international counterparts and upgrading of the RDCBSM’s testing facilities.

These training programmes were implemented based on an assessment of the baseline scenario, i.e. the needs of the Indian bicycle industry and the existing capacities and skills of RDCBSM and the industry associations.

Brief industry assessment:

At present, the Indian bicycle industry largely produces basic models of steel roadster bicycles (mostly for government tenders), single speed children’s bicycles and a very limited volume of premium bicycles (the parts for which are supplied by imports). The Indian bicycle manufacturers are currently unable to make the type of bicycles demanded in global markets, which are aesthetically and technically superior, are made from high-end materials, allow multiple speed settings and require several special components. Also, the domestic market is facing increasing competition from more cost-competitive imports. To make the transition from manufacturing basic bicycle models/ parts to manufacturing components for high-quality premium bicycles, some of the industry-wide critical needs include:

» Availability of correct grades of appropriate raw materials with a focus on aluminium)

» Marketing and sales channels for international markets

» Expert handholding for modern manufacturing processes

» Technology sharing mechanisms for adoption of superior raw materials (aluminium, plastic, etc.) and production of high-specialty components

» Design competence (aesthetic design; industrial design & componentry; supporting tooling/ machining)

» Robust testing and certification - testing for various international standards, raw material testing, environmental/chemical testing, component-specific tests and benchmarking of high-quality components for development of quality-based tests

» Technology development for new products (such as e-bikes, load bearing hybrid roadsters, carbon fibre/ titanium/ bamboo bicycles)

» Market research for industry trends, demand analysis & market scoping, futuristic trend projections, reporting/ exploration of emerging technologies and related developments

» Active advocacy mechanisms for key infrastructure/ policy-driven issues (import duties, freight charges, promotion of indigenous production, cycling infrastructure, promotion of cycling, etc.)

The main industry-wide recommendations include the establishment of a raw material bank (mainly aluminium in appropriate grades, forms, quantities and prices); technical guidance and hand-holding to adopt modern manufacturing processes and best available technologies to produce bicycles and components of exportable and consistent quality, aesthetic designs and economical pricing; focused marketing/common node for international sales to ensure the demand for Indian-produced bicycle components and appropriate government regulations and policy support relating to import duties, material pricing, infrastructure, required standards, domestic content and trade actions. The report then goes on to assess how the nodal technical institution, the RDCBSM, is positioned to deliver the identified avenues of support to the industry.

The associations are oriented towards playing a strong advocacy role for the dissemination of information to members, constant communication with relevant government entities and stakeholders, participation in trade fairs and engagement with schemes/ initiatives (such as the cycle valley/ request for special purpose vehicles). Thus, they are well-positioned to facilitate policy support for the industry-wide recommendations to materialize.

Research and Development Centre for Bicycle and Sewing Machine (RDCBSM):

The RDCBSM's service portfolio for the bicycle industry currently includes testing and certification (for ISO, IS and select international tests), tooling, production of special purpose machines (along with associated design & development), and training (including diploma and short-term courses). Industry actors, especially the SME components manufacturers, value the services currently provided by the R&D centre with respect to the testing and special purpose machines designed/ supplied. However, it has been observed that the RDCBSM faces several technical skill and knowledge gaps, and has largely stagnated in skill/ technologies development and transfer to the industry.

The R&D centre hasn't necessarily kept abreast with global market developments and the associated production practices, and is therefore not in a position to provide guidance to the industry for relatively newer products and technologies and facilitate the necessary technology sharing. There is very limited research activity at present, with considerable potential in product development, trouble-shooting services, and applied research for the adoption of emerging/ new technologies. Furthermore, there could also be a greater focus on activities for continuous technology development in partnership with the industry; the training areas should also be expanded, more in line with the industry's needs. This is also the case with the testing services, as industry requires increasing testing support for international and material/ component specific certifications. Overall, the skill levels of the staff must be enhanced for them to effectively assist the industry.

Based on the findings of the diagnostic assessment, several recommendations for a more robust service portfolio and areas in which capacity building initiatives would benefit the RDCBSM personnel have been identified. The recommendations are oriented towards strengthening the RDCBSM's expertise level and service offerings, and towards making it a dynamic nodal point to coordinate and facilitate the adoption of modern manufacturing practices to increase the competitiveness of the Indian bicycle industry.

1 INTRODUCTION

The United Nations Industrial Development Organization (UNIDO) has implemented a project titled '*Development and Adoption of Appropriate Technologies for Enhancing Productivity in the Indian Bicycle and Bicycle Parts Sector*', in collaboration with the Department for Promotion of Industry and Internal Trade (DPIIT) - formerly known as DIPP - Ministry of Commerce and Industry, Government of India.

The project aimed to support the Indian bicycle industry by strengthening the capacity and capability of the nodal technical institution for the sector, the Research and Development Centre for Bicycle and Sewing Machine (RDCBSM), and select industry associations - the All India Cycle Manufacturers' Association (AICMA) and the United Cycle and Parts Manufacturers' Association (UCPMA) - to provide better management and technical support to the industry to strengthen the global competitive position of the Indian bicycle sector.

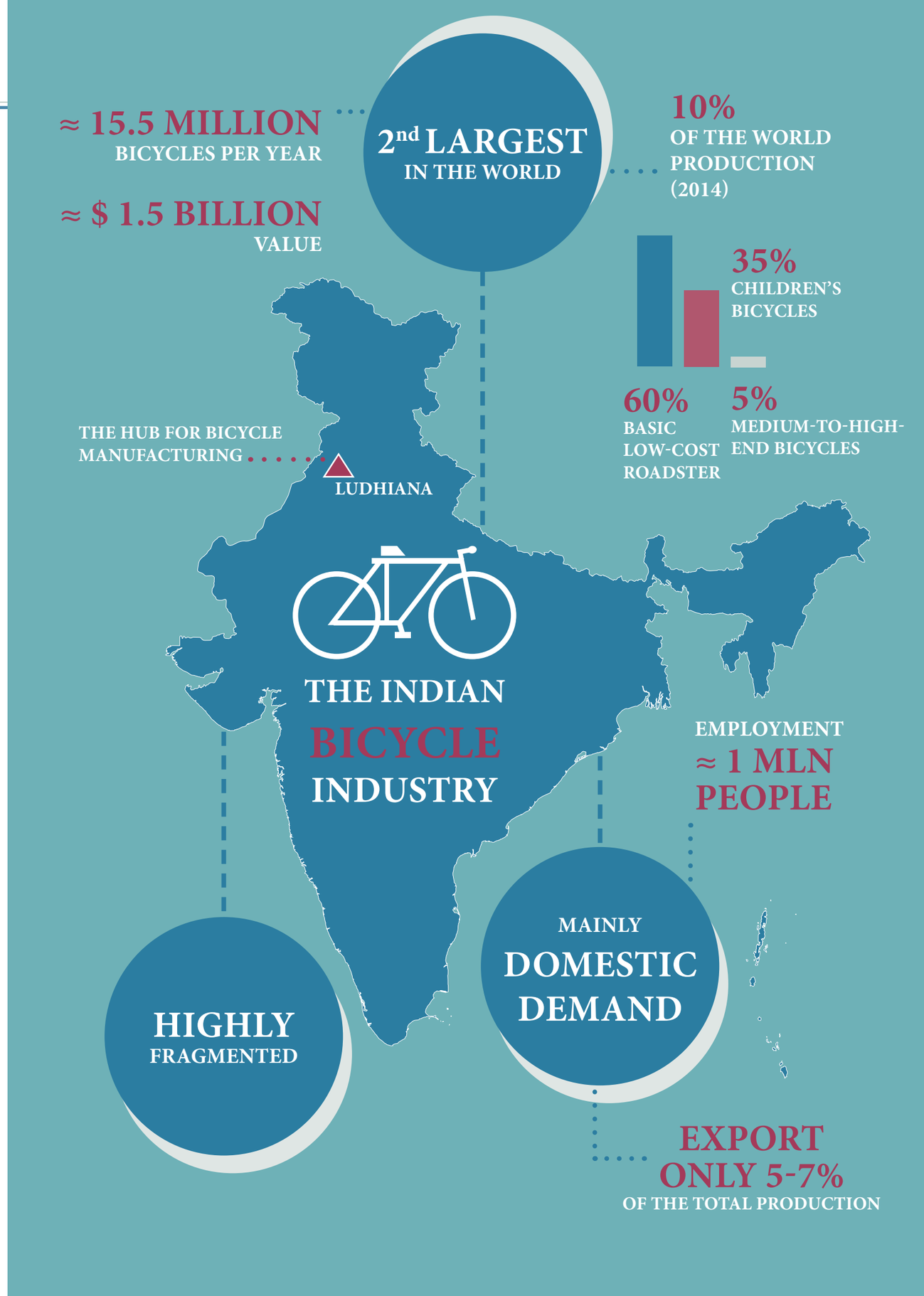
The project facilitated comprehensive technical capacity and capability upgrading for the RDCBSM and the associations through a series of soft interventions (including technology transfer; technical workshops, international study tours; fellowship training programmes; partnerships with international organizations; and hands-on training programmes) and hard interventions (procurement of equipment for the testing facility of the RDCBSM). The aim of this set of capacity building activities was to enable the beneficiary institutions to acquire the necessary exposure to, and knowledge of, best available technologies and best practices across the global bicycle industry, and to facilitate implementation of appropriate technologies and measures in the Indian context.

These programmes were implemented based on an assessment of the baseline scenario, i.e. the needs of the Indian bicycle industry and the existing capacities and skills of the RDCBSM and the industry associations. The industry diagnostic assessment was carried out to analyse the structure of the Indian bicycle industry, the main industry-wide critical needs and the main supply and demand-enabling factors required to build the competitive position of the industry. This analysis enabled the identification of gaps in the beneficiary institutions' service delivery and knowledge base and subsequently, effective orientation of the capacity building programmes of the project. The report presents these findings and recommended actions for improvement.

The assessment was based on information collected through:

- An initial assessment of the available background information, analyses, reports and market data.
- Interviews and interactions with a representative sample of employees at the RDCBSM, the AICMA and the UCPMA, sample bicycle and parts-manufacturing units and the Government of Punjab. These interviews were aided by supporting background documentation and data provided by the RDCBSM, the AICMA and the UCPMA.

> The project aimed to support the Indian bicycle industry by strengthening the capacity and capability of the nodal technical institution for the sector, the Research and Development Centre for Bicycle and Sewing Machine (RDCBSM), and select industry associations - the All India Cycle Manufacturers' Association (AICMA) and the United Cycle and Parts Manufacturers' Association (UCPMA) - to provide better management and technical support to the industry to strengthen the global competitive position of the Indian bicycle sector.



INDIAN BICYCLE INDUSTRY

2

2.1. Description of the Industry[1]

The global bicycle market is expected to reach an estimated $34.9 billion by 2022 and is forecast to grow at a CAGR of 2.7% from 2017 to 2022 (Research and Markets, 2017). The growth potential is said to arise from segments such as e-bikes, road, mountain terrain bike (MTB), and children's bicycles. The major drivers of growth for this market are: increasing fitness consciousness among people; environmental concerns; traffic congestion, and government programmes to promote cycling.

The Indian bicycle industry produces almost 15.5 million bicycles per annum, providing employment to almost 1 million people. Valued at approximately $ 1.5 billion, the industry is the second largest in the world, catering for 10% of the world's production (The Energy and Resources Institute (TERI), 2014). The Indian bicycle industry is growing at approximately 4% and the production of bicycles is mainly directed towards domestic markets, with exports representing approximately 5-7% of the total production. The product mix comprises basic roadster category bicycles (60%), children's bicycles (35%) and medium-to-high-end bicycles (about 5%). The nature of the domestic demand, therefore, is mainly from the low-income population, making it a price-sensitive industry (The Energy and Resources Institute (TERI), 2014). The exports are also monopolized by the basic roadster bicycle segment and are mostly directed towards developing countries in Africa and South Asia.

The value chain of the Indian bicycle industry operates at two levels - small and medium enterprises, produce bicycle components and accessories, whereas the larger manufacturing units/OEMs focus on bicycle assembly and production. The industry is dominated by 4 major bicycle-producing companies (controlling almost 85% of the market share), medium sized manufacturers (contributing 12% of the market share) and around 3500-4000 small and medium enterprises, producing bicycle components (AICMA). The SME component manufacturers provide the necessary supply to the large bicycle manufacturers.

The SMEs, which depend mainly on unskilled and semi-skilled workers, have grown over time but in an unorganised and informal manner and are engaged largely in producing bicycle components and parts. However, the bicycle/parts-manufacturing companies, particularly in the small-scale sector, are losing ground and competitiveness in terms of both price and quality. This is primarily due to increased competition from imports, poor manufacturing practices, the continued production of low-end ("traditional") bicycles, and the usage of dated technology. There has been an increasing trend of imported bicycles and parts, with imports growing much faster (25%) than the exports (10%) of Indian bicycles (The Energy and Resources Institute (TERI), 2014).

[1] Statistics from AICMA documents and TERI Report "Cycling towards a greener future' (2014)

The Indian bicycle industry has some key characteristics:

- The state of Punjab holds an 80% share in India's bicycle production. The city of Ludhiana is the hub for bicycle manufacturing in India, with over 3,500-4,000 MSMEs producing bicycle components, while the cluster produces almost 40,000-50,000 bicycles per day.
- Ludhiana is a landlocked city, a considerable distance from the nearest ports, resulting in substantial freight charges and transition time for the transportation of goods.
- Bicycle production is focused on basic, low-cost roadster bicycles, made of steel. Apart from these, mostly single speed (non-roadster) bicycles (including children's bicycles) are produced.
- Government tenders for bicycles constitute a major fraction of the domestic demand for bicycles. These tenders aim at procuring basic, low-cost bicycles for the distribution of free/subsidized bicycles to low-income sections of society, especially in rural areas. States like Bihar, Karnataka, Chhattisgarh, Tamil Nadu, Assam, West Bengal, and Kerala have taken up such schemes.
- The production of premium, high-quality bicycles (mountain bikes, racing bicycles of lightweight materials such as aluminium alloy) is limited, although bicycle manufacturers are increasingly venturing into this sector, given developing consumer demand in Indian markets. However, the required aluminium tubes and special components for such bicycles are sourced from other countries.
- The industry caters mainly to domestic demand, i.e. exports are limited. The absence of the production of premium, high-quality bicycles and components (in aluminium alloy, carbon and titanium) limits the Indian bicycle manufacturers' capacity to export and be internationally competitive. Simultaneously, the domestic market is also faced with growing competition from the import of good-quality, cheaper parts and bicycles from countries such as China.
- The industry is a two-tier industry- the component market comprises mainly (3500-4000) SMEs; whereas bicycle assembly/production is dominated by (mainly four) large-scale companies, controlling 85% of the market.
- The component-producing SMEs are largely informal and unorganised, using conventional and mostly manual technology. The technology level of the industry is considered largely basic (with the production of steel components/bicycles), there is also a lack of know-how for special components, limited automation, limited design abilities, limited exposure to best practices in production technology and the absence of an internationally accredited standards system.
- There seems to be limited backward integration in the domestic value chain between the component manufacturers and OEMs. The larger bicycle-manufacturing companies/OEMs look to procure good- quality, economically priced components from parts manufacturers, and often resort to imports if there is no indigenous supply available from domestic manufacturers. However, the OEMs are the main purchasers of the predominantly steel components produced by the manufacturers. Very few component manufacturers have ventured into alloy components, and very few have export channels.
- For the export of high-quality premium alloy bicycles and parts, there appear to be limited channels for marketing and sales in international markets. A few parts manufacturing companies have established one-to-one foreign collaborations, but such examples are limited.
- The bicycle industry is also largely wanting of substantial policy support to channel conditions affecting both demand and supply of bicycles, such as policies related to import duties for bicycles and parts, encouraging indigenous production for government tender bicycles, compliance-ensuring mechanisms for Indian bicycle standards, setting up channels for international sales, bilateral agreements for bicycle trade, cycling infrastructure and promoting cycling culture in the country.

Institutions:

- The industry is supported by the Research and Development Centre for Bicycle and Sewing Machine (RDCBSM) - the nodal technical agency for the industry, located in Ludhiana. Not many countries have a dedicated R&D centre for the bicycle industry, making this a distinctive characteristic for the Indian bicycle sector. The RDCBSM has been established as an institutional support centre to provide various facilities to the industrial units, especially the small and medium-scale bicycle and parts manufacturers, to enable them to upgrade themselves and adopt modern production and quality control practices.
- The industry also has two main industry associations – the All India Cycle Manufacturers' Association (AICMA) and the United Cycle and Parts Manufacturers (UCPMA).

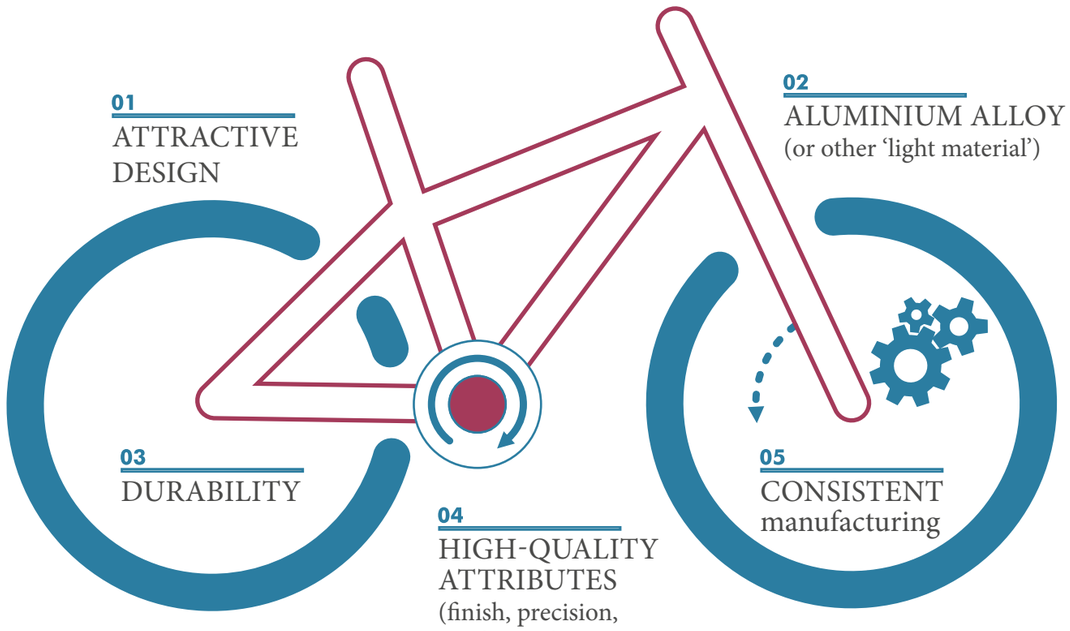
The Indian bicycle industry faces several challenges in terms of meeting the domestic demand and becoming competitive globally, especially vis-à-vis both cheaper and superior bicycles and parts from foreign producers. The Indian industry doesn't produce medium/high-quality premium bicycles from superior materials, which are demanded in international markets. In addition, the growing domestic demand for such bicycles is increasingly met by imports and established international brands. In order to become more competitive in domestic as well as export markets, Indian manufacturers must be able to **overcome certain key technology/skill gaps, produce bicycles in line with international trends and standards, effectively market and sell bicycles in global markets and facilitate backward and forward integration within the domestic value chain.**

2.2. Industry-wide Critical Needs

Over the last 20 years, the global bicycle industry has made substantial advances in materials technology (such as composite metal matrix (CMM), alloys, carbon fibre, plastics, titanium, injection moulding, magnesium), linked to sophisticated production methods (such as CNC milling coupled with computer aided design-based R&D, as in frame and component designing) and concepts imported from other technologies (such as hydraulic suspension and brake systems, disk brakes, auto and electric gear changing, microchip sensing systems, specialization in tyre technology, saddle manufacturing, gear changing devices, folding bicycle design and electric bicycles). These have added further value to higher-end modern bicycles (Oxer, 2000).

The pursuit of lightweight and high-strength bicycles in newer, superior materials, and advanced design, drives most upgrades in the bicycle industry. This has introduced a huge range of innovative equipment and processes in producing bicycles and parts, that the Indian bicycle industry has not necessarily kept up with. At present, the Indian bicycle industry largely produces basic models of steel roadster bicycles directed mostly to government tenders, children's bicycles and a very limited volume of premium bicycles. A majority of Indian bicycle manufacturers are currently unable to make and sell the type of bicycles demanded in global markets, which are aesthetically and technically superior, are made from high-end materials, allow multiple-speed settings and require several special components.

"THE MUSTs" for EXPORTABLE BICYCLES



Given the way the Indian bicycle industry is currently structured, there are both demand and supply-enabling factors that must be ensured for the adoption of such technology, equipment and processes. From the demand point of view, in order to initiate and sustain export-quality production, domestic manufacturers must not only be aware of global best practices adopted for technical, aesthetic and economic viability, but must also be able to establish consumer confidence in the quality of the products, and subsequently develop international sales channels. From the supply point of view, bicycle and parts manufacturers must bridge the gap in technical and production proficiency for the target medium/high-end quality bicycles demanded by export markets and more recently, domestically as well.

Therefore, the Indian bicycle industry must undergo a considerable improvement/shift in the type of bicycles/components currently being produced (soliciting a range of specific technical upgrading in the manufacturing), aided with robust sales and marketing initiatives to establish itself in international markets and gain credibility domestically. If Indian components become attractive to purchasers of these '*better*' bicycles, the industry can compete with countries like China and sustain, or even grow, its production. With such attractiveness and competitiveness, they will have a bulwark against imports, and with new products they can expand the domestic market.

To facilitate such a transition, the key industry-wide critical needs must be identified and addressed. While there are a number of industry requirements which, if met, would boost competitiveness, it is important to identify what is essential for industry survival, sustained competitiveness and quality improvements.

The main industry needs include:

1. The availability of raw material (mainly aluminium) in appropriate grades, forms, quantities and prices to make the shift to alternate materials viable.

2. Technical guidance and handholding to adopt modern manufacturing processes and best available technologies to produce bicycles and components of exportable and consistent quality, aesthetic designs and economical pricing.

3. An international marketing and selling channel, to ensure demand of Indian-produced bicycle components.

4. This could be aided with appropriate government regulations and policy support relating to import duties, material pricing, infrastructure, required standards, domestic content and trade actions.

Further elaborations of these requirements are given below[2]:

2.2.1. Availability of Raw Materials

One of the main challenges for the production of high-quality, premium bicycles in India is the availability of the correct specifications of required raw materials, at reasonable prices.

At present, most good-quality bicycles in the global markets have aluminium alloy components, which should therefore be the focus of the Indian bicycle industry. Indian component manufacturers mostly produce steel components and are unable to initiate

[2] This is not necessarily an exhaustive list, but provides an indication of the broad areas in which technical capacity building or institutional support would be valuable. This is based on the semi-structured interviews conducted as part of the diagnostic assessment

the production of alloy parts because a) they are unaware of the correct grades/specifications to be used, and b) the appropriate grades are not available, and/or are expensive to procure in small quantities, as per SMEs' scale of production. For Indian manufacturers to venture into the production of aluminium parts, they must have access to reasonably priced aluminium blanks, in relatively small quantities, until this is supported by corresponding demand/sales to justify major investment.

Typically, the fundamental component of bicycles, the frame, is made from either 6061 or 7005 aluminium alloy (Bike-advisor.com, 2012). These alloys display superior malleability, formability, resistance to corrosion and fatigue, and result in stronger, lighter frames. The grade of aluminium available in India is 6063 (among other types) aluminium alloy, which isn't considered to be as strong as the 6061 alloy[3].

The aluminium alloy tubes currently available are typically 1.6 mm thick and are thus not of the requisite thickness for the bicycle industry which is 1-1.2 mm thickness. The alloy tubes must subsequently be treated and/or shaped or butted to become usable by bicycle/parts manufacturers.

In addition to the frame, the bicycle is composed of many other aluminium parts such as the forged stem and hydroformed seat post, handlebars and shift/brake levers and crank sets. For these components, the provided material is also uneconomical to shape since it is not provided in appropriate grade and thickness, or in workably small pieces (thus soliciting further subtractive manufacturing of components with material wastage) and usually requires subsequent treatment (such as heat treatment, cooling either through liquid chemicals or air cooling) to become usable. A majority of manufacturers lack the facilities and the know-how to appropriately select such raw material and employ appropriate heat treating/extrusion processes to engage in the commercial production of alloy parts.

Given the nature/structure of the Indian aluminium industry, obtaining small quantities of the appropriate grades and shapes of aluminium has proven to be prohibitively expensive, especially for SMEs. This acts as a hurdle for Indian component manufacturers to initiate and sustain aluminium component production on a techno-economically viable scale. As a result, large bicycle companies either import the aluminium alloy parts they require, or the component manufacturers are forced to import raw material to venture into such production segments, which is expensive, especially in small quantities.

Thus, the bicycle industry requires the supply of the correct grades/specifications of raw material (with a special focus on 6061 equivalent aluminium) in the form of thin-walled tubes and appropriate production blanks. The availability of such raw material and blanks must also be aided with processing equipment/facilities to render the metals 'usable' in the industry. This involves heat-treatment facilities, hydroforming, forging, castings and extrusions to supply usable production blanks to component manufacturers.

In the longer term, the issue of access to raw materials extends to other modern materials, such as chromoly steel, carbon fibre and titanium, for manufacturers to venture into higher-end premium bicycle models.

[3] Based on inputs from industry actors during the diagnostic assessment.

2.2.2. Marketing and Selling Channel

Indian SME component manufacturers are predominantly suppliers for the Indian OEMs. These SMEs thus operate within the domestic value chain and do not have established export avenues, with only a few exceptions. For the Indian bicycle industry to hold ground in export markets for both, its bicycles and components, dedicated efforts towards sales and marketing are necessary. Assuming that the component manufacturers were to overcome their technology/skill gaps in producing aluminium alloy parts and other special components, establishing buyers from global markets (international OEMs) would be integral for export success. While the Indian OEMs are large enterprises with the necessary wherewithal to undertake sales and marketing functions, the multitude of SMEs producing bicycle components are largely unknown brands. These do not have the capacity to execute large-scale branding/marketing activities for themselves, the knowledge of points-of-sales in different countries or the necessary logistics. Such marketing efforts would also expand/diversify the buyer base for the component manufacturers. Thus, enhancing the selling ability through branding, quality assurance and tapping common sales channels is important for the industry. Examples of one-to-one foreign collaborations that enable exports do exist, however, for the industry as a whole, brand and image building would need to be developed for sustained international sales.

2.2.3. Technical Guidance/ Support for Production of High-quality Bicycle Components

Making an exportable bicycle (or component) has several aspects. The product must be attractive, durable, made of aluminium alloy (or other 'light material'), lightweight and manufactured consistently with attributes of a high-quality bicycle (finish, mechanical operation, durability, functioning, precision, etc.). Manufacturers must learn to process aluminium for the frame and other components and in the longer term this strategy would apply to other materials such as chromoly steel, titanium and carbon fibre. The current challenge for the Indian bicycle industry (apart from finding an economical source of usable aluminium and other materials and establishing export channels) is the ability to devise attractive designs, and create a consistent, demonstrably high-quality product. This would entail adopting modern manufacturing processes and product-specific production best practices to match international standards.

It appears that in order to achieve this goal, component manufacturers require technical guidance and dedicated expert support in the following areas (see following boxes for a description):

1. Advanced know-how in modern production techniques and technologies adopted in producing quality components and modern bicycles
2. Testing and certification guidance for export markets
3. Design

1 Advanced know-how in modern production techniques and technologies adopted in producing quality components and modern bicycles

The level of technology used in the Indian bicycle industry, specifically by the component-manufacturing SMEs, is considered to be basic and conventional. A lot of production processes are largely manual (such as welding and assembly), or operating with dated equipment. For component manufacturers to be able to undertake efficient production of higher-quality components, and in superior materials (such as aluminium alloy), the industry requires access to, and knowledge of, modern manufacturing methods and adaptation/optimization of equipment to such methods.

The manufacturing processes that are most relevant to upgrade the Indian industry at present broadly pertain to **a) processing/handling of aluminium to produce frames and other components, and b) quality and process optimization in current operations.** In such a context, the industry solicits technical handholding and guidance in these key production processes, as well as measures for production optimization.

Some of the production processes that are of key interest to manufacturers and of importance to the industry's competitiveness are[4]:

- TIG/MIG welding:
- Casting, forging, pressure die casting, extrusion, hydroforming
- Advanced coating methods/surface finishing/plating
- Injection moulding
- Painting (automated disc painting, effective manual painting, etc.)
- Wheel assembly
- Bicycle assembly
- Stickering process (automated/water-based, etc.)
- PLC automation in currently employed processes
- Raw material composition analysis and selection
- Total quality management
- Energy optimization
- Production layout; production planning
- Industrial engineering

Manufacturers are also keen to learn the process details of producing high-quality components of export quality, and the equipment required therein. Optimal production processes tie together in establishing production parameters for high-quality components. In the immediate future, Indian bicycle component manufacturers need to be able to produce major components (such as frames that are currently made of steel) in aluminium for export markets. In addition, they also need to be able to produce critical components for exportable bicycles. Thus, manufacturers need to learn the nuances of each component that must now be made in aluminium (and/or other materials), what the optimal configurations/specifications for each component are, how to adopt the necessary production processes, as well as quality checklists/benchmarks that the components must meet. Apart from the uptake of aluminium components, a proficiency in plastic components (for mud guards, fenders, back rests, etc.) is also required.

At present, Indian manufacturers do not have the capacity/capability to produce certain special/critical components such as derailleurs, multi-speed gear mechanisms, spokes, freewheels/cassettes, hubs, BB shells, etc. Global producers of such specialized components supply top-quality products in the market. Buyers specify the brand(s) of these special components and they therefore must be imported for domestic bicycle manufacturers to put together premium, high-end bicycles (thus driving up costs). The need of the hour is thus two-fold – firstly, there is a need to facilitate technology sharing between Indian component manufacturers and international producers of such components. Secondly, there is also a need to develop the abilities of local manufacturers to indigenously develop/produce parts for, and subsequently wholly produce at least some of these high-specialty components.

Indian manufacturers must be able to produce quality components not just for the widely used segments of bicycles, but also for a wider range of high-end bicycle models. Current know-how is limited vis-à-vis carbon fibre bicycles, Titanium components, e-bikes and bamboo bicycles.

In addition to the above, a majority of manufacturers have limited awareness regarding the different principles of product/process quality management, and the advantages of integrating such principles in their operations. Typical factories have operational characteristics such as high WIP (work-in-progress) and stock, long waiting periods of personnel during different tasks on the shop-floor, limited production-line monitoring for overall equipment effectiveness, planned vs. actual production, operator skills, etc.[5] This has a bearing on the overall quality of the components/bicycles produced.

[4] This is not an exhaustive list – these are indicative areas mentioned during the interviews conducted during the diagnostic assessment.

[5] Based on an assessment by Japanese experts during a diagnostic visit to the RDCBSM in February 2018.

2 Testing and certification guidance for export markets

To achieve export competitiveness and to meet the corresponding product standards, Indian components and bicycles must be rigorously tested and validated to assure customers of their quality and become integrated with global value chains. This implies that the industry must be supported by an exhaustive testing facility that provides testing and related services in keeping with dynamic industry trends. It is also worth noting that such services must be priced reasonably, keeping in mind the large number of SMEs availing such services, and must also be quick in delivery.

For exports to various countries, component manufacturers require testing services as per various international country-specific standards. The top priority, as expressed by the manufacturers interviewed, is the EN standard certification. Manufacturers require a testing facility to certify components and bicycles as per the qualifying standards for sale in the respective regions. Therefore, at present, the select bicycle and parts manufacturers who produce for export markets largely rely on international bicycle testing labs for country-specific product certification.

Manufacturers also require strong testing services and support in the testing of: components, most importantly now, made from aluminium alloy; plastic and rubber components; environmental and chemical testing associated with the different materials used, and the testing of material finish. Since the use of reflectors on bicycles was mandated by the Indian government, reflector testing has also become an important need, with industry actors currently taking support from automotive component testing labs for the same.

3 Design

Bicycle design is a multifaceted subject. The way in which the bicycle intends to be used determines the requirements of the design. Bicycle design takes into account certain overarching requirements such as speed, safety, comfort, weight, precision and endurance, as well as aesthetic appeal. These factors drive decisions related to material selection, interface between different components, appearance, additional accessories, geometrics and required tooling and jigs. Indian bicycle and parts manufacturers would thus benefit from developing the necessary expertise in developing aesthetically as well as technically proficient blueprints and the requisite design-sense.

In such a context, component manufacturers in India require upgrading with respect to:

- Aesthetic design: The production of bicycles is believed to largely be based on fashion-driven technology, especially for the premium segments. Indian bicycle manufacturers must be aware of the latest market trends, what type of bicycles are being produced and how to create products that consumers demand. This aspect pertains to the overall look and feel of the bicycle and responds to evolving consumer preferences. Indian bicycle manufacturers require exposure to the type of bicycles that are being demanded and sold worldwide and how to achieve those visual characteristics (surface finish, paint colours, frame shapes, etc.). There is also a need to enhance the packaging and presentation of the final products. As aesthetic design forms the basis of competitive advantage, the central idea is not necessarily the provision of design services to the manufacturers, but for the industry to be able to develop advanced design and development capabilities therein, in line with market trends and consumer preferences.
- Industrial/componentry design: Different bicycles/parts require a variety of component geometries, material selection, material behaviour analysis and component interface, thus also determining the required tooling, jigs and fixtures as well as special purpose machines to achieve the desired configurations. The increased application of design software and related tools (CAD, CNC machining, finite element analysis, etc.) and the know-how pertaining to the application of the software to bicycles and specific bicycle parts, form the foundation of technically sound designs and prototypes. The Indian bicycle industry requires such engineering design assistance whilst venturing into aluminium components, special components, plastic parts and the tools/machining needed therein.

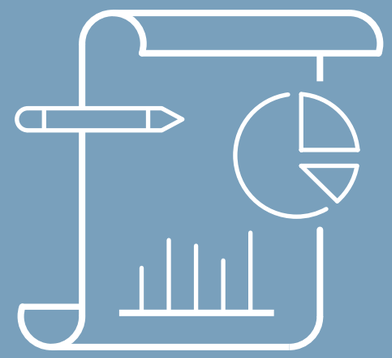
TOWARDS EXPORTABLE & HIGH-QUALITY BICYCLES

CURRENT PRODUCTION

- The industry caters mainly to domestic demand (mostly for government tenders)
- Bicycle production is focused on basic, low-cost roadster bicycles, made of steel.
- Lack of access to high-quality raw materials
- Poor manufacturing practices, and the usage of dated technology
- Limited automation, limited design abilities, limited exposure to best practices in production technology

- The availability of raw material (mainly aluminium) in appropriate grades, forms, quantities and prices
- Technical guidance and handholding to adopt modern manufacturing processes and best available technologies
- An international marketing and selling channel
- Appropriate government regulations and policy support relating to import duties, material pricing, infrastructure, required standards, etc.

CRITICAL NEEDS



DIAGNOSTIC ASSESSMENT OF THE RDCBSM AND THE INDUSTRY ASSOCIATIONS

3

The interventions of the UNIDO bicycle project aim to boost the global competitive position of the Indian bicycle sector. The project aimed to achieve this by strengthening the capacity and capability of the RDCBSM and the industry associations to better support and guide the industry, given the critical needs of the bicycle and parts manufacturers. Such capacity upgrades of the target institutions would include both soft interventions (skills development, training, capacity building, technical workshops, etc.) as well as hard interventions (procurement of equipment for the testing facility of the R&D centre).

The diagnostic assessment of the RDCBSM and the associations was conducted with the aim of correlating the needs, demands, expectations and challenges of the Indian bicycle industry (as identified in Chapter 2) and these organizations' responses to, and capabilities in, meeting these demands and expectations.

In context of the identified requirements of the industry, the technical diagnostic assessment mainly aims to evaluate the current service portfolio and expertise level of the RDCBSM, positioned as the nodal technical institute for the industry. In addition, the report also aims to identify how the current service portfolio can be strengthened, and the requisite capacity building efforts for the same. Therefore, this section provides an overview of the current institutional support system that the RDCBSM (and the associations, as applicable) provides to the industry in terms of technical guidance, as well as the main shortfalls in the provision of such support.

3.1. The Research and Development Centre for Bicycle and Sewing Machine (RDCBSM)

The RDCBSM was set up in 1983 by the Government of Punjab, with the assistance of UNDP/UNIDO, with the aim of assisting the industry to adopt innovative technologies for improvements in productivity and product quality. It was fitted with modern equipment for manufacturing, testing, calibration and training activities. The main objectives of the centre are to:

1. Create and provide facilities for increasing and diversifying production
2. Achieve the optimum productivity levels in the manufacturing centre
3. Upgrade quality compatible with international standards
4. Provide professional and job-specific training

The RDCBSM is meant to provide services such as: marketing and consultancy; product design and development; a precision tool room; testing and calibration; special purpose machine building; mass production machines, and relevant training to the industry. The focus of the centre is on SMEs in the bicycle industry that need a common facility for some of these services and require technical guidance for production.

A brief description and analysis of the centre's **service portfolio** is given in the boxes below.

Description and Analysis of the Centre's Service Portfolio

1 Product design and development

The RDCBSM is mandated to undertake the design and development of new or modified products, jigs, fixtures, tooling and gauges, prototypes, and complete tools for the adoption of innovative and latest manufacturing. To date, the R&D centre has introduced 60 special purpose machines (SPMs), 70 testing equipment and 35 cold forging tools. They have also filed 3 patents of designs developed at the centre.

The R&D centre has a CAD section with the latest software (AutoCAD, Solidworks, Delcam, Pro-E, MasterCam, Catia, etc.) to design engineering components and sub-assemblies, bicycle parts and hand tools testing equipment, special purpose mass production machines for bicycle components and inspection gauges, fixtures and tools. Over the years, the RDCBSM has developed a range of high-utility SPMs, special test rigs and cold forging tools for the industry. Bicycle and parts companies purchase the machines, test equipment and tools that are also manufactured at the centre.

The centre has a dedicated design and development team, comprising engineers proficient in CAD/CAM. Apart from the SPMs and tools developed at the R&D centre, the design and development team also provides tailor-made solutions for jigs and fixtures based on industry requests, as and when they arise.

However, the innovative development of new products and dedicated efforts towards independent prototype development seems to be limited. Apart from the designs/SPMs developed to date, the design and development vertical of the centre should be in a position to undertake more and continuous exploratory design deliberation-based projects, to investigate and create ingenious solutions to common industry problems and manufacturing processes. This would make design and development an ongoing process, and have a bearing on the nature and quantity of SPMs/tools/fixtures developed by the centre, in line with new materials being adopted, the corresponding production processes involved and the resulting requirement of tools to adopt those processes.

This process would be aided by an increased understanding of the applications of hydraulics and pneumatics, aerospace engineering the finite element analysis (and similar engineering principles) in system design. The design competencies must also be expanded to provide such tooling/machining support for plastic components.

In a broader sense, the design and development team must also be engaged in active research of the latest bicycles (i.e. frame designs, aesthetic characteristics of bicycles sold internationally), leading to deductions as to how these geometries can be best achieved, and guiding the industry to do the same.

While the design engineers are well-versed with the design software, the staff needs a greater orientation towards, and understanding of, the real-time implications of design specifications on bicycle component quality and overall product performance. The existing design focus at the R&D centre must be expanded to factor in optimal technical configurations for individual bicycle components, component interfaces, and metallurgy and material behaviour for bicycles/parts. This becomes increasingly relevant with the adoption of newer materials, and the associated adjustments to manufacturing processes (such as forging, casting, welding, etc.), while also keeping in mind aesthetic appeal/attractiveness of the final product. Thus, the staff would need to be able to develop superior skills in making accurate dies to provide the new varieties of required jigs and fixtures in keeping with the aesthetics/technical specifications of the final product.

Such an orientation of CAD/CAM skills would enable the RDCBSM's technology development competencies, as the staff would thus be equipped to engage with the specific challenges of bicycle/parts manufacturers and guide them through appropriate solutions. This would also enable the R&D centre to provide more well-rounded design support to SME clients.

2 Precision tool room and common facilities

The RDCBSM is equipped with high-precision CNC machines and general-purpose tool production machines. These include: a jig boring machine; cylindrical and internal grinders; surface grinders; a CNC vertical mill; a CNC lathe; tool and cutter grinders, among others. The tool room has developed 5 tools for cold forging of parts, manufacturing of 25 test equipment, 6 special purpose machines and 3 low cost automation equipment.

The workshop at the RDCBSM undertakes the manufacturing of press tools, dies, jigs, fixtures, inspection gauges, test rigs, and the reconditioning of dies for cold forging of components, not only for the bicycle industry, but predominantly for the automotive and other engineering sectors. Thus, the orientation of the tool room and the common facilities (that include CNC vertical/horizontal milling, lathes and forging machines) to the bicycle industry could be a function of increased explorative investigation into the requirements of adapting tools and machines for aluminium and other alloys, tooling for injection moulding, forging/casting/welding needs of specific components, adoption of low-cost automation equipment for specific processes – all with direct relation to the bicycle-manufacturing units.

In the context of the industry requiring appropriate forms/shapes of newer raw materials (mostly alloys), the tool room at the RDCBSM is not equipped or sufficiently skilled to act as a facility for processes such as hydroforming, heat treatment of alloys and extrusions for production blanks at present.

It must also be considered that a majority of the equipment stationed at the tool room/common facility is largely dated (some being in operation since the early 1980s) and requires urgent upgradation/replacement.[6] Upgrading the equipment and management would provide an ongoing valuable service for casting, forging, etc., as per the needs of the industry.

[6] As per the provided list of equipment (with date of installation of equipment stationed in the tool room)

3 Testing and calibration

The testing and calibration facilities of the RDCBSM are duly accredited by the National Accreditation Board for Testing and Calibration Labs (NABL; ISO/IEC-17025) and the Bureau of Indian Standards (BIS). As per the NABL accreditation, the RDCBSM labs carry out mechanical testing of metals and alloys, chemical analysis (Fe, Cu and Al, base metals and alloys), calibration of measuring instruments and gauges and the testing of bicycles/bicycle parts as per ISO:4210 (parts 1-9) and ISO 8098. Under the BIS certification, the RDCBSM provides testing for bicycles and bicycle parts, household and industrial sewing machines (IS:1610 and IS:12109 respectively), zig-zag sewing machines (IS:15449) and complete testing of steel as per IS:1875. In addition, the test labs at the R&D centre provide testing facilities for spectroscopic analysis of metals and alloys and mechanical testing of tor steels, structural steels, tubular products, cold and hot rolled steels, fasteners, fixtures and assemblies.

The RDCBSM's testing and calibration facilities are one of the key services provided to the industry. The mechanical test labs, the standards room and the coordinate measuring machine also cater to the needs of automotive and other engineering industries, as is the case with the chemical/spectro analysis-based testing, where clients from the other industries outnumber bicycle/parts manufacturers.

The bicycles supplied for the government tender-based orders (for steel bicycles and components) must be certified by a third party as per IS standards, a function that the RDCBSM fulfils for the industry. Thus, the IS testing facility is a common resource for the OEMs catering to these tenders adhering to IS standards. The IS standards comprise a wide range of tests for general-purpose bicycles, most of which are aligned with the corresponding ISO tests. From this list, the R&D centre is certified to execute tests such as those for: bicycle tube valves; frames; rims; handlebars; seat pillars; pedal assembly; hub assembly (R-type); spokes; axles; cranks and chainwheels; front forks; cycle/rickshaw pneumatic tyres; steering head assembly; mudguards; reflectors; specification for padlocks; luggage carriers; steel balls and chains. The RDCBSM has recently applied[7] to the BIS for an extension of scope to include more of the component-specific tests, to now form this more exhaustive coverage of tests. An exception to this list is the code of practice for the packaging of bicycles for export under IS, that is not currently available at the RDCBSM.

The R&D centre's bicycle test labs are accredited to perform parts 1-9 of ISO tests for bicycles. These tests largely cover safety requirements for city/trekking bicycles, young adult bicycles, and mountain and racing bicycles, and test methods for braking, steering, frames and forks, wheels and rims, pedal and drive systems and saddle and seat posts. The RDCBSM now has the facility to test for lighting and retro reflective devices[8] (ISO 6742; parts 1-5). It is important to note that the scope of the tests that fall under ISO certifications include a large number that are component-specific, currently not provided by the R&D centre.

For the tests that are available at the RDCBSM's testing labs, it appears that the personnel are well versed with the ISO standards and requirements. However, there is a need for further fine-tuning in the execution of these tests (including calibration of the equipment, measurement of results and avoidance of common mistakes in test execution) to make the R&D centre staff a commanding authority of certification and validation of bicycles and parts. This fine-tuning would cover aspects such as: appropriate force application for different fatigue tests; maintaining linear/rotational degrees of freedom; how to ensure load cells are free of radial loads/shear stress/torques; verification of indications on control units, etc.[9] In addition, there is also a lack of knowledge regarding endurance testing – to evaluate the strength of tested components, beyond the levels defined by the ISO standard.

The staff also requires guidance on how to execute these safety tests for bicycle components in different materials such as aluminium alloy, (and in the future, carbon fibre, titanium and other alloys). The ISO tests are not designed for any specific material, however, tests must be executed cognizant of material behaviour – a skill that must be developed at the RDCBSM.

A significant requirement of the industry actors looking to enter export markets, is a facility for testing and certification against major international country-specific standards (such as EN, ASTM, DIN, JIS, BS). Currently, the RDCBSM's bicycle testing labs only provide testing for select tests from these standards, equivalent to the corresponding ISO tests. However, the bicycle testing labs are not certified for the complete suite of tests under each of these international standards. It is worth noting that the standard documents (which are to be purchased) are not available at the RDCBSM for them to provide guidance to information-seeking industry clients. As the only bicycle-focused R&D centre providing test facilities, the bicycle testing lab must not only be accredited to carry out tests for various international standards, but also provide cross-comparative analyses for these various standards.

Another aspect in equipping the bicycle industry to meet export requirements is environmental/chemical testing. While the R&D centre's labs are equipped with safety/mechanical tests, manufacturers still require facilities to conduct validation of materials used vis-à-vis determination of heavy metals (lead, cadmium, chromium VI), morphology analysis, determination of phthalates (plasticized materials) and restriction of PAH, a set of services not currently available at the RDCBSM.

In addition to the above, there are several areas for improvement in the test labs that ought to be implemented by the RDCBSM[10]: for better repeatability of test results testing machines should be fixed on the ground to ensure minimum interference/distortion; the layout of the bicycle test laboratory could be modified in line with the sequence in which various tests are to be performed; wires and chords associated with test lab equipment should be secured/covered; jigs to be utilized for testing must be stored appropriately to avoid damage and consequent interference in accuracy; housekeeping of testing equipment/lab should be done on a regular basis, and SOPs for each equipment must be displayed.

[7] In September 2017

[8] The equipment for reflector testing has been installed under the UNIDO bicycle project (September 2017) and the application for such a certification has been submitted to NABL (May 2018).

[9] These examples are in line with the findings of the lab session conducted at the RDCBSM by Mr. Marcus Schroeder, MD – EFBE, Germany (June 23 2017).

[10] Based on an assessment by Japanese experts during a diagnostic visit to the RDCBSM in February 2018.

4 Training

The RDCBSM also provides engineering and management skills training programmes for the industry.

The centre runs an R&D polytechnic college offering diploma (certificate) courses for engineering industries. These courses are certified by the All India Council for Technical Education (AICTE). The courses offered are:

- A three-year, full-time regular diploma course in a) mechanical, b) automobile and c) computer engineering. These courses are also available in a part-time, four-year format.
- A one/two-year regular certificate course, for vocational training for a) machinists, b) machine maintenance and c) quality assurance inspector.

The diploma courses offered at the R&D polytechnic college are oriented as general engineering courses. There is limited bicycle industry orientation in the courses delivered, i.e. limited coverage on bicycle engineering, component geometrics, assembly, materials and design. To supplement the engineering principles covered in the existing courses, the graduate students would benefit from a greater orientation of the syllabus towards bicycle engineering, akin to the course for automobile engineering.

Apart from the diploma/certificate courses provided by the polytechnic college, the R&D centre also provides a range of short-term skill development courses. These are either CAD/CAM courses or industry-specific industrial training courses.

The CAD/CAM training courses include software-specific courses in the areas of: CNC milling and turning; advanced CAD/CAM and CNC machines; industrial training; tool design, and advanced manufacturing processes. These are areas in which technical personnel of bicycle/parts-manufacturing companies seek additional training, and thus match the industry requirements. Other industrial short-term courses cover: GAS welding; arc welding; MIG/MAG welding; TIG welding; quality and inspection; testing and calibration, and maintenance-fitter mechanic training.

The short-term courses offered at the RDCBSM, do not necessarily cover an exhaustive range of topics pertaining to various manufacturing processes, as required by the bicycle industry. In addition, there is immense utility of developing more specialized curricula for upgrading worker skills and overall production practices, in keeping with changing trends, different materials and best available technologies for these courses to be relevant to the industry. Increased support vis-à-vis design and development of specific bicycle components (which is currently not a part of the training portfolio) using these tools would provide superior utility of these courses for the industry.

In being able to deliver the necessary training to the industry, the trainers and lecturers delivering the training must also undergo a reorientation towards bicycle engineering and production, to prepare course content and curricula in line with the bicycle industry's needs, and be equipped to deliver these courses. The skill level requisite for trainers to effectively deliver such courses to the industry is currently lacking.

5 Consultancy

The consultancy function of the RDCBSM is meant to include guidance in the areas of productivity and quality improvement, low-cost automation, material selection and failure mode effect analysis (FMEA), identification of testing needs and resource identification for the industry. This function is carried out in some capacity at present, wherein the industry comes to the R&D centre for select trouble shooting assignments. However, the RDCBSM hasn't necessarily kept abreast with global market developments and the associated production practices, and is therefore not in a position to provide guidance to the industry for relatively new products and technologies and facilitate the necessary technology sharing. Thus, the current skill level, as per the current market requirements and developments is lacking. As a result, the consultancy function is not a dynamic service available to the industry for manufacturers to gain direction pertaining to suitable upgrades. Services such as providing feasibility reports and similar analyses are also not provided at present (or have been discontinued). As a technical knowledge resource for the industry, and in order to be able to provide expert guidance, the staff of the RDCBSM must first become proficient in best available technologies and production processes, to inspire confidence in the industry and produce valuable guidance.

3.2. Industry Associations

The bicycle industry is supported by two industry associations: The All India Cycle Manufacturers' Association (AICMA) and the United Cycle and Parts Manufacturers (UCPMA). Both the associations provide institutional/advocacy support to bicycles and bicycle parts manufacturers, and their interventions and support are inherently less 'technical' in nature, vis-à-vis the RDCBSM.

The **AICMA** represents large-scale Indian bicycle manufacturers, contributing to 85% of the bicycle production in the country. The aims and objectives of the association include a) protecting the interests of the member companies, b) promoting cycling in India, c) coordinating the overall growth and development of the Indian bicycle industry, d) acting as a think tank for spearheading innovation, transformation and a global outlook for the Indian bicycle industry, and e) supporting the building-up of a bicycle-friendly ecosystem in India. The association is structured into several committees that work towards policy-related issues in the following areas: taxation, demand, commerce and technical. Specifically, the Technical Committee essentially looks after advocacy-related actions pertaining to standards, any component-specific discussions with an industry-wide implication (e.g. the case of use of reflectors on bicycles being made mandatory by the Supreme Court of India), and related issues. The AICMA also has an IPR committee for the resolution of intellectual property-related disputes among its members. Since the AICMA members are the industry-leading OEMs, they are at the forefront of technology adoption, within the context of the Indian bicycle industry. Thus, with adequate technical consultation, the AICMA is positioned to facilitate the requisite industry-wide action as well as dialogue with various stakeholders.

The **United Cycle and Parts Manufacturers Association (UCPMA)** is among the largest associations worldwide in terms of the number of members (more than 2250 MSME members). Similar to the AICMA, the primary objective of the association is to bring about sustained growth of the Indian bicycle industry, with enhanced focus on the needs of component manufacturers. The association works to safeguard the common interests of the industry members, to communicate with the government regarding the main challenges and requirements, and also facilitate the participation of the Indian bicycle industry in international trade fairs for increased exposure. The activities of the association are largely advocacy and policy focused. The UCPMA also runs an Industrial Training Institute (ITI), under which basic computer courses are offered to young trainees.

4 RECOMMENDATIONS

4.1. Industry-wide Recommendations

The central need of the Indian bicycle industry is to be able to produce and sell technically and aesthetically superior bicycles and components that meet competitive quality standards. This increased competitiveness can come from several shifts in the type and quality of bicycles being made – medium to high-end bicycles that qualify for export markets and are thus demanded domestically as well, and to enhance the currently produced segment through innovative new products (such as electric assist hardware) and skills (e.g. advanced engineering) to optimize the basic bicycle models. For this, manufacturers must have the know-how/capability and support infrastructure to produce better-quality bicycles, and also ensure that this capacity upgrade occurs within a wider ecosystem that fosters innovation and entrepreneurial initiatives and has increased support and channels for domestic and international sales.

As highlighted earlier (Chapter 2), there are a range of identified industry-wide needs including availability of the requisite raw materials, vigorous sales and marketing mechanisms to enter global markets and technical assistance for the mastering of production techniques and knowledge of best available technologies (technology sharing) for: specific components and materials; design competence; robust testing and certification guidance, and technology development for new types of bicycles/products.

To supplement these supply-related needs, the bicycle industry also requires favourable infrastructural and policy support.

While a number of recommendations and market/capacity building initiatives would prove to be valuable for the industry, the essential recommendations for industry survival would include **a) the establishment of a raw material bank (mainly aluminium in appropriate grades, forms, quantities and prices), b) technical guidance and handholding to adopt modern manufacturing processes and best available technologies to produce bicycles and components of exportable and consistent quality, aesthetic designs and economical pricing and c) focused marketing/common node for international sales to ensure the demand for Indian-produced bicycle components.** This could be aided with **d) appropriate government regulations and policy support relating to import duties, material pricing, infrastructure, required standards, domestic content and trade actions.**

Thus, the key recommendations for rapid industry improvement fall into the categories of:

1. Material bank (and all associated services)
2. Technical assistance and training (production processes; tooling; component-specific best practices with an added focus on special components); bicycle engineering; exposure to new and emerging technologies; testing services; design, etc.)
3. Focused marketing functions and common node for sales
4. Enhanced advocacy to the government

1 Material bank for supply of appropriate grades of raw material

Given the challenges in accessing raw materials (with a special focus on aluminium) in the appropriate specifications and economical pricing, a **shared material bank and facility** to procure the necessary raw material and provide corresponding processing facilities, as appropriate for the materials provided, would be immensely useful for the Indian bicycle industry. The availability of appropriate 'blanks' for manufacturing is a major component of cost-effective production. Component manufacturers must have access to 'raw pieces' or desired tubes or sheets of the material in question, in the right size, shape and thickness, to be able to efficiently derive the required component out of the blank. This would minimize wastage in the production process, as the blanks would already be oriented towards the component being produced.

The material bank would broadly comprise:

a. **A purchasing agency**: To procure raw materials from various agencies and providers in large quantities, and supply the requisite small quantities demanded by component manufacturers. This directed procurement would ensure that manufacturers have access to the right specifications of the different raw materials required for various bicycle components, and at reasonable prices.

   The material bank could act as a sourcing agent for the various materials required by the bicycle industry such as aluminium, steel (especially high-strength steel such as chromoly steel, carbon fibre, titanium, etc.). However, in light of the required upgrade of a majority of component producers to aluminium, and given that obtaining it has been expressed as particularly prohibitive in terms of retail pricing, the material bank should be initiated with a focus on aluminium. This would entail conventional alloys like 6061 as well as modern compositions such as Duralcan. Entities such as NALCO and HINDALCO are possible source companies for this in India.

   Not only would this agency be able to procure large quantities of aluminium, allowing for the cost-competitive onward supply to bicycle component manufacturers, but it would also be able to ensure that the bicycle industry automatically has access to the correct grades and quality of aluminium.

b. **A warehouse**: To store the procured materials to be supplied to the industry.

c. **Processing facilities**: The material bank would also include a common facility to process the acquired raw material into usable forms for the industry.

   » This aluminium then has to be converted into production blanks, namely tubes for bicycle frames and handlebars, rim cross sections, and approximate shapes of hub shells, handlebar extensions, pedals, cranks, etc. in preparation for forging or machining by the manufacturers. Extrusion is the central need, because it can provide tubes for frames and rim sections, plus a great many other shapes suitable for pedals, possibly hubs and cranks, etc. Permanent mould casting is also highly valuable, providing parts for brakes, derailleurs, etc.

   » As the adoption of aluminium would be new for most component manufacturers, the in-house capabilities to process aluminium would be limited, and entail capital investments in machinery for the same. Depending on demand, the shared bank should provide the infrastructure for the conversion of the procured raw material/ingots into tubes, extrusions, castings or other appropriately shaped/sized blanks. This facility could consist of:

   - An extrusion press
   - Permanent mould foundry
   - Heat-treatment facility for aluminium
   - Hydroforming facility as necessary (or even procurement of hydroformed tubes which, as per industry units, are also available)

   The material bank would be a common resource pool/common facility for the industry. Manufacturers would be able to place orders for the quantities of whichever blanks they need, and initiate production accordingly. The material bank would overcome the major hurdles currently faced by the manufacturers, looking to enter aluminium component segments, or those who are currently importing expensive aluminium and losing out on cost competitiveness.

   To set up such a material bank, several options could be considered:

   » Contracting an external sourcing company: This would entail identifying and engaging an aluminium-producing and processing company to provide the necessary raw material supply to the bicycle industry. This effort would have to be coordinated by a neutral agency to procure the aluminium, in the large quantities required, by multiple manufacturers, and provide the supporting processing facilities (heat treatment, hydroforming) at prices that allow for SMEs to avail these services.

   » Alternatively, a collaborative unit could be set up to perform this function for the industry. This would mean that an entity is established, specifically for the operation of a material bank and versatile extruding and casting lines to serve the entire industry. Such an entity could be conceptualized in a number of ways – this could be a subsidiary of the RDCBSM with industry contribution and dedicated management; alternatively, it could be a government-funded facility for the industry, partnering with other public-sector enterprises that supply these raw materials; or, a special purpose vehicle (SPV) could be established with industry contributions dedicated towards collective raw material procurement and distribution.

2 Expert technical assistance, guidance and training

The Indian bicycle industry must be supported in upgrading its production. As highlighted in Section 2.2.3, manufacturers must be supported towards the uptake/adoption of the modern manufacturing processes and equipment that would enable them to produce components and bicycles that can compete in export markets (mostly related to the adoption of aluminium, achieving good appearance, and sustaining production consistency), and to develop new products and enter product segments with advanced engineering.

There are two goals to be pursued simultaneously:

a. To develop and produce bicycles and components in superior materials and desirable designs, as per exportable standards, as well as to achieve production efficiency.
b. Product development for domestic markets: This could involve using advanced bicycle engineering to reduce manufacturing costs, develop unique features for the basic roadster category or e-bikes and economical electric assist hardware for bicycles/tricycles and rickshaws.

In order to facilitate the achievement of these goals, bicycle and component manufacturers solicit support, i.e. there is a need for comprehensive technology and knowledge transfer to the industry. In terms of volume, the bicycle cluster in Ludhiana is dominated by component-manufacturing SMEs that do not necessarily have access to or knowledge of the latest industry developments and market trends, and thus solicit expert guidance in adopting modern production practices and technologies. In order to support the industry as a whole, there must be a centralized effort to facilitate the provision of the required services to the industry, be it technical consulting, expert handholding, testing facilities, market research, or any other such requirement.

This would entail:

» Deployment of experts for on-site guidance, consulting and problem-solving as support in production processes. The industry should be supported with experienced industrial experts offering relevant and affordable consulting support for production problem-solving and upgrading.[11]

» A centralized facility for the demonstration of modern manufacturing processes/techniques. This could be a pilot facility to produce and display sample components or even complete bicycles to the industry. This facility should also play a role in supporting the industry in design development. As a resource for the industry, this entity would play an important role in sensitizing manufacturers as to what aesthetic designs are popular globally, and how to achieve these looks and configurations.

» Dedicated efforts of a centralized agency towards R&D and product/technology development to disseminate technical and theoretical pre-requisites of the associated production processes.

» Focused support for companies to upgrade and certify their bicycle components and frames to world-class standards. That support should include rapid quality testing, product benchmarking and superior guidance for international product certifications.

» Provision of comprehensive training to the industry that not only includes bicycle engineering courses for young graduates, but also for technical personnel (management and worker levels) in modern manufacturing processes and handling of equipment. The training focus could also include business, sales and marketing courses.

» Facilitation of partnerships for technology sharing- various possible channels of technology sharing can be envisioned such as seeking foreign partners for joint ventures – international companies who know what the customer needs, who will give clear specifications for needed products, and possibly minor technical assistance, then provide a long run of recurring orders. Those partners will have taken on all the design, marketing and sales challenges. This will probably be the type of knowledge exchange that would take place under the proposed Cycle Valley in Ludhiana.[12]

» A competent and rapidly-responding tool room to supply production tooling, moulds and dies corresponding to the dynamic requirements of jigs and fixtures for different parts.

In the above context, the RDCBSM, as the nodal technical institution for the industry, is positioned to be the instrument for the delivery of a number of these recommendations. As is evident in the diagnostic assessment of the RDCBSM, there are several gaps in the skill, knowledge and facilities available at the R&D centre, however, with appropriate skill development, capacity upgrades and expert support, the RDCBSM could possibly play an important role in the delivery of technical assistance, guidance and training to Indian bicycle and parts manufacturers, especially the SMEs. Such potential upgrades for the RDCBSM are highlighted in Section 4.2.

[11] Some of the key interest areas include: TIG welding, weld inspection, PLC automation, advanced coating (painting) systems, low-pollution bright plating, polymer identification, injection moulding defects, die design (injection moulding, extrusion, hydroforming, permanent mould casting, forging), aluminum extrusion and permanent mould casting, heat treating, production layout, TQM, electric batteries, motors, and controllers.

[12] Ref: Cycle valley background documents.

3 Marketing/common node for selling

The Indian bicycle industry must not only undergo a considerable improvement/shift in the type of bicycles it produces (soliciting a range of specific technical/production upgradations), but must also be aided with robust marketing initiatives to establish itself in international markets.

Assuming Indian manufacturers can cost effectively produce a high-quality desirable product (supported by availability of affordable materials, process and engineering tweaks, and objective standards to ensure appropriate quality), appropriate market orientation and branding are an urgent and necessary change to enter export markets and establish consumer/buyer confidence.

The inclination of export customers (both individual bicycle customers, and the shops or distributors who serve them) to be drawn to relatively small, unknown/un-established brand names, with a limited guarantee of continued operation and quality verification would intuitively be limited. In addition, a single modest-sized company may only be able to supply a small fraction of the needs of a distributor or foreign OEM – and it is unlikely that these purchasers would be willing to undertake procurement of small amounts of differing origin.

In essence, an institution/entity must be able to provide component manufacturers with the export sales and marketing functions and support, similar to how Indian OEMs do it domestically. This would involve a nodal point of sales, warehousing facilities in various global locations to reduce transit/lead time, quality assurance to customers, and brand positioning and establishment. Foreign partners and individual collaborations might play a role for some companies, and Indian OEMs might take steps in those directions as well. However, a coordinated sales/marketing channel would significantly help the component manufacturers minimize ruinous competition amongst themselves, and collaboratively achieve the greatest efficiencies and brand credibility (therefore increasing sales and profits).

This could possibly be achieved by component manufacturers coming together into a single brand. This brand entity would undertake the work of: following trends; establishing presence at bicycle trade shows; marketing itself; building credibility; engaging Indian manufacturers to produce a consistent high-quality product and selling effectively. This voluntary arrangement would minimize duplicative efforts and expenses, catapult brand awareness of Indian products, provide negotiating and fulfilment power, and rigorously control quality standards of the participating units. In effect, it would have to play the role of a large bicycle company with outsourced manufacturing.

The unified brand proposal is a collaborative endeavour and can only be effective if many component manufacturers elect to participate and contribute to create such an entity. This initiative would operate in parallel to the existence and operation of the existing brand holdings of the participating manufacturers. The point of such collaboration would be to establish sales channels for the Indian industry as a whole, until brand value and quality assurance are established. The brand must incentivize individual manufacturers to qualify as brand suppliers, and develop an equitable formula for awarding orders. In the long run, this should develop into a self-sustaining non-profit operation that goes on as long as companies find it useful.

4 Advocacy and action for key issues

The Indian bicycle industry has the technical and production capacity to grow and diversify its product base and quality standards. For the bicycle industry to grow into its potential, it must be supported by several demand and supply enabling factors. Active advocacy efforts would be immensely useful for demand-related factors such as freight charges for operating from a dry port such as Ludhiana, appropriate import duties and minimum support prices for raw materials, cycling infrastructure support, promotion of cycling culture, bilateral trade understandings with various bicycle/parts-producing countries, government investment, trade practices, and consumer subsidies, to name a few.

With a focus on production/supply factors, increased advocacy for the norms for compliance to Indian standards in India, amending government tenders to include bicycle/component specifications not restricted to steel, supporting innovative concepts such as the e-assist hardware, would definitely help Indian manufacturers. With suitable technical guidance from the RDCBSM, the coordinated efforts of the AICMA and the UCPMA representatives would definitely go a long way to ensure that the appropriate enabling factors for bicycle/ components manufacturers to adopt modern manufacturing processes are in place to become globally competitive.

4.2. Recommendations for the RDCBSM

The Indian bicycle industry is uniquely positioned in that it has a nodal technical agency, the RDCBSM, dedicated to the sector and acting as an instrument for R&D as well as for the provision of the relevant support services required by the industry. Especially for the Ludhiana cluster, the centre acts as a centralized focal point to provide valued services such as testing, tooling and training. This is increasingly relevant for the segments of the industry that are not able to invest in independent exploratory R&D, large-scale equipment, or for industry-wide needs that solicit a common facility.

There are several shortfalls in the service portfolio of the RDCBSM, as well as several areas in which the technical knowledge and proficiency of the RDCBSM personnel require strengthening, to truly be considered a resource as per the changing needs of the industry. Such strengthened capacity, combined with appropriate collaborations with leading technical experts and international technical institutions will facilitate the requisite technology and knowledge transfer that manufacturers, especially the SMEs, need.

In such a context, there is a wide range of services that the R&D centre could provide, especially in the context of the industry-wide recommendations made in Section 4.1. This section lists recommendations to constitute a more robust service portfolio for the RDCBSM. The recommendations highlight the possible roles the RDCBSM could play, additional services the organization should be providing to effectively support the industry and the additional skills/capacities that will be required to effectively deliver these services.

Table 1: List of KPIs

	Audit Items	Evaluation Criteria	China	MANN
Quality	Defect rate level	» Assy defect rate ‹ 0.1% » Part defect rate ‹ 1%	5/6	1.0
	Inspection system level	Good inspection performed; Good inspection tool control	5/6	1.0
	Standardization level	Q-standard visualized and worker respects its standard	5/6	1.0
Cost (Productivity)	Machine utilization level	Main machine is running constantly	5/6	2.0
	Labor performance level	All workers are working hard without waiting time loss	4/6	2.0
	Layout	Straight Ine and no transportation wastes	5/6	1.0
Deliver	On time defivery level	OTD rate › 99%	4.5/6	2.5
	Stock level	» Product stock ‹ 3 days » Parts stock ‹ 7 days	4/6	0.5
	Synchronization level	WIP stock between processes is very smal	5/6	2.0
Technology	Automation level	Automation level to the main machine is good	4.5/6	0.5
	IT utilization level	Computer and IT equipment are used efficiently	4.5/6	0.5
	MC maintenance level	All machines are like new due to good maintenance	5/6	1.0
Work Site Management	5S level	» Sorting, » Set in order » Shining level is high	5/6	1.0
	Visualization level	Prod-progression status to the plan is visualzed	4.5/6	1.0
	Improve activity level	KAIZEN target and actions are visualized	4.5/6	1.0
Training Leadership	Discipline level	All workers put on safety uniform & greet visitors	4/6	1.5
	Work site atmosphere	Good atmosphere and active work site	4/6	1.5
			78.5/100	21

Strengthened consultancy services

1. Engagement of external experts

The R&D centre should be a knowledge resource to support the industry to develop and produce bicycles and components in superior materials, as per exportable standards and desirable designs, as well as to achieve production efficiency. In order to effectively provide such expert guidance and technical assistance to manufacturers, there is a need to **engage external, qualified experts with relevant manufacturing experience** in certain key areas at the RDCBSM, as the requisite expertise is currently lacking. These experts could be deployed at the centre for a fixed initial period (6 months - 1 year) to provide handholding and consultancy support to manufacturers, and the RDCSBM engineers would thus simultaneously receive on-the-job training from these experts. The required experts could be specialists in: TIG welding; weld inspection; PLC automation; advanced coating (painting) systems; low-pollution bright plating; polymer identification; injection moulding defects; die design (injection moulding, extrusion, hydroforming, permanent mould casting, forging); aluminium extrusion; permanent mould casting and heat treating; component interface; production layout and total quality management, among others.

2. Expertise building and knowledge transfer

For the centre to provide technical guidance to the industry, there is a need for capacity building and skills development of the RDCBSM's engineers, working across various departments. This training of trainers will enable the RDCBSM to effectively guide the industry and facilitate the necessary knowledge transfer. Some of the key areas in which the RDCBSM would require training are:

- Material behaviour of aluminium alloy and the requisite processing (e.g. extrusion, heat treatment, butting, hydroforming, permanent mould casting)
- Material identification, composition and behaviour analyses (applicable to high-strength steel, carbon fibre, titanium, etc.)
- Design of jigs, fixtures, dies and moulds, as applicable for different materials
- PLC automation in bicycle-manufacturing units
- Production efficiency and lean manufacturing
- Design competence and componentry design
- Manufacturing of critical components
- Efficient test execution and results analysis

Areas for general manufacturing support could include roll forming of new tubular cross sections, the interaction of a steel weld seam with tube forming, precipitation hardening of aluminium alloys, cold forging of higher-strength materials, quality of plastic injection moulding, quality of paint finishes, less-polluting bright plating, and the specification of motors and batteries for electric-cycle functionality.

3. Audits and quality-related performance assessment

The RDCBSM should be in a position to conduct on-site assessments of production operations of bicycle manufacturers and provide efficiency and production improvement guidelines. The RDCBSM's skills vis-à-vis 5S, total quality management, kaizen, etc. would have to be strengthened for it to subsequently support the industry. An indicative set of key performance indicators (KPIs)[13] that could be used for such services is given in Table 1.

[13] This list of quality/efficiency-related KPIs was provided by the two Japanese experts (From the Japan Management Association Consultants and O&M Inc. Ltd.) who visited the RDCBSM and select manufacturing units in the Ludhiana cluster in February 2018.

Testing

1. The Bicycle testing lab must be accredited to perform all tests as per various international standards. As discussed earlier, some of the important international (country-specific) certification systems include[14] JIS (Japan); EN (Europe); DIN (Germany); ASTM (United States); BS (England) and AS/NZS (Australia and New Zealand). As expressed by various industry representatives during the diagnostic assessment, certifications that would qualify them to enter export channels (with a special expressed focus on European markets) would enhance the RDCBSM's utility for local component manufacturers. Towards this, necessary steps would include:
   - » Purchase of country-specific standards documents
   - » Submission of applications for necessary accreditations as per international accreditations
   - » Cross comparison of requirements across each of the standards (for effective guidance to manufacturers)

2. The RDCBSM is equipped for parts 1-9 of ISO 4210 tests for bicycles. 'Part 10' (currently under development) for electrically power assisted cycles (EPACs) is to be included upon finalization. Thus, it is suggested that the RDCBSM facilities are equipped with the necessary electrical tests for such EPACs. These could include water/dust proof tests, electrical and battery safety, electromagnetic compatibility, etc.[15] In preparation for this addition, it is recommended that the bicycle test lab personnel undergo training in the inspection and testing of EPAC components.

3. While the RDCBSM is relatively well equipped for the mechanical/safety testing of bicycles, chemical and environment test facilities (mainly for tyres and tubes) must be established in order to assist manufacturers to meet product requirements for European/American markets. For the development of premium bicycles with rubber and plastic components, testing facilities for the ROHS (restriction of hazardous substances)/REACH (registration, evaluation, authorisation and restriction of chemicals) compliance is vital. This would involve detection of heavy metals (lead, cadmium, chromium VI), morphology analysis, determination of phthalates (plasticized materials) and restriction of polycyclic aromatic hydrocarbons (PAH). Competency in chemical testing for aluminium tube material characteristics would also enable manufacturers in identification and utilization of correct grades of alloys.

4. Reflector testing: Since the use of reflectors on bicycles has been mandated by the Indian government, establishing a reflector testing facility would be useful to the industry, that currently uses automotive research/testing labs. The R&D centre would be an ideal location for the establishment of a testing facility specific to configurations required for fixing reflectors on bicycles. It is recommended that the test lab staff undergo additional training in the photometric testing of bicycle reflectors, sheets and tapes. It is suggested that the RDCBSM establish a knowledge sharing partnership with other laboratories such as the International Centre for Automotive Technology (ICAT) that is already engaged in reflector testing.

5. In keeping with international trends, the specialized testing for certain accessories could improve the service offerings of the RDCBSM's test labs. An example of this is bicycle helmets, for which regulatory standards (as per the PPE Directive 89/686/EEC) exist in the USA, Australia, Canada, Japan, Europe and Great Britain.

6. The RDCBSM bicycle test lab personnel require expertise in conducting tests for specific components. The ISO system comprises a range of such tests that are currently not available at the RDCBSM. It is recommended that the RDCBSM bicycle test lab personnel undergo training at leading international test labs to observe the configuration and execution of such component-specific tests (e.g. cranks, handles and handlebars), as well as execution of tests for components of different materials.

7. In addition, test lab personnel require expert handholding for the optimal calibration of equipment, measurement of results and avoidance of common mistakes in test execution.

8. Non-destructive bicycle testing (such as ultrasonic testing, magnetic particle inspection, dye penetrant testing (DPT), radiography, fractography, etc.) is also an area in which the RDCBSM requires expert guidance.

[14] This is not an exhaustive list.

[15] ‹https://www.sgsgroup.us.com/-/media/local/usa/documents/flyers-and-leaflets/cts/sgsglobal-services-for-bicyclesa4en10v1.pdf›

Development of bicycle quality tests for benchmarking of high-quality parts and quality certification

1. The existing bicycle standards are largely related to the safety requirements of bicycles. The ISO (4210) System, for example, outlines a process for testing the fatigue strength of components. Its testing requirements are built on three pillars: fatigue (caused by recurring loads); overloading, and impacts (which are less frequent events) (Zedler, 2017). While such an approach ensures a certain level of operational safety, there are several aspects that fall outside the purview of these tests. These tests consider very specific conditions, and solicit extra testing for parts that don't fall within these defined categories. Aspects such as durability, functioning, precision or comfort are not measurable by safety tests.

   Therefore, while the safety tests provide a solid foundation, final product quality must be measured factoring in a bike's intended use. It is recommended that **new tests measuring functionality and durability are developed at the RDCBSM** so as to be able to benchmark top-quality bicycles and components, and subsequently define a novel set of quality standards as a notional target for Indian manufacturers.

   To illustrate, these could be conceptualized as roughly corresponding to:

   Level 1, the best Shimano[16] products (suited for $2000 bicycle);
   Level 2, medium Shimano products suited for $800 bicycle; and
   Level 3, the lower-end Shimano products suited to $250 bicycle; and so on.

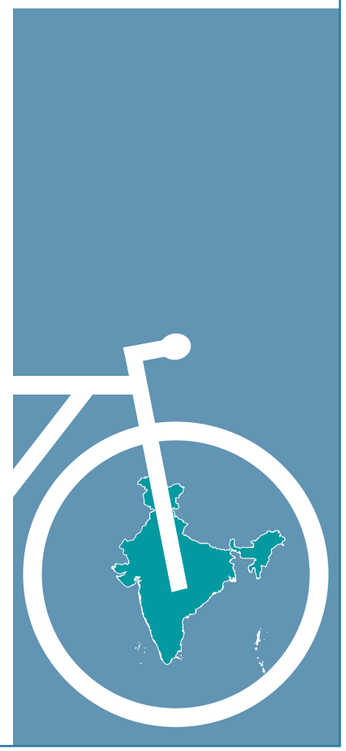
   Among the tests could be: tyre rolling resistance; seat and handle compliance; chain friction; ramp fatigue of load-bearing components; shifter repeatability; balancing ease; bearing life; spoke life; wheel buckling strength; wet braking, etc. Although this recommendation appears purely technical, it in fact should have a wider scope and impact. Quality tests and marks will only make a difference if the majority of the manufacturers employ them, if their application is rigorously controlled, and if all players publicize their significance internationally.

   The standards will first be used to provide feedback in product development, using appropriate cycle engineering skills. It would also allow display of rigorously controlled 'quality marks' on compliant Indian products, and support unified international marketing efforts to solidify faith in these markings. These quality tests would support Indian components and bicycles rapidly to develop an international reputation for quality (consistency), performance and attractiveness.

   In order to develop such tests, the need is for scientifically trained, qualified engineers (areas such as aerospace engineering would be desirable) to begin to learn the needs, using existing equipment in innovative ways in order to begin benchmarking the durability of world-class cycles. This consultative process could occur at the RDCBSM facilities, embedded within the needs of the manufacturers to meet export requirements.

2. Component-specific quality benchmarks: Based on the quality tests developed in the recommendation above, the RDCBSM should be able to determine and share the performance parameters of various top-quality components. This would provide manufacturers with the necessary benchmarks to reference the quality of their own products.

3. Subsequently, the developed tests would allow for the establishment of a **quality certification mark** (with appropriate legal and personnel structure) to administer a quality regime, allowing manufacturers to certify products as meeting strict standards, i.e. the quality standards established in the preceding recommendations. The requisite guidance to help manufacturers meet these standards must also be provided.



[16] This is an illustrative brand example; the benchmarking would be of several premium, high-quality brands.

Design

1. The design and development team must undergo comprehensive training in component geometries and interfaces. While the staff is proficient in the various software, the application of the software to bicycle design (frame building, wheel building), component design (production parameters, joining and combinations with other components, component interfaces) and overall bicycle performance must be enhanced.

2. It is advised that the design and development team undergoes further proficiency training in 3D CAD software to facilitate product development projects.

3. The RDCBSM should engage in prototype production services. This would involve prototyping bicycle parts, tooling mock-ups and related accessories such as helmets. The 3D printers deploy different types of technologies such as fused deposition modelling (FDM) or stereolithography (SLA), with different implications with respect to precision, finish, cost and final usage. It would be useful for the RDCBSM to house a rapid prototyping facility with such 3D printers, serving both experimental product development and mass production purposes.

4. The design and development staff must also develop expertise in analysing existing patent documents to establish production parameters for various components and advise manufacturers accordingly. The assistance of resource centres such as the Patent Information Centre, Punjab[17] could be sought in this direction.

[17] Under the Patent Facilitating Centre (Technology Information Forecasting and Assessment Centre), Government of India

Pilot facility

It is recommended that a small-scale **pilot-manufacturing facility** be established at the RDCBSM, to produce/assemble complete bicycles of various categories. The main goal of such a facility would be to provide the RDCBSM staff greater functional exposure to the bicycle production process and to better understand component interfaces, design implications, material behaviour, product performance as well as provide a practical understanding of different types of bicycle models. The facility could be housed at the RDCBSM premises and would also serve as a demonstration site for various modern production processes that the Indian bicycle industry is yet to adopt. This would also enable real-time demonstration of PLC automation measures applicable in the Indian context.

This proposed pilot facility could also be the test-bed for the production of certain critical components, the production of this has not taken place in India due to lack of technology or know-how. Components such as derailleurs and gear-shift levers are critical components for high-end bicycles, and the RDCBSM can use the pilot facility to demonstrate production techniques through appropriate technology sharing mechanisms with international companies, reverse engineering exercises, etc.

Training

1. The training function of the RDCBSM is a centralized resource for capacity building and knowledge transfer for the industry. While the centre currently delivers short-term training courses (as previously outlined) for the industry, it is recommended that a wider range of worker training courses be developed and delivered, in keeping with emerging processes and production methods such as:
   - » Advanced TIG/MIG welding:
   - » Advanced coating methods/ surface finishing/plating
   - » Injection moulding
   - » Painting (automated disc painting, effective manual painting?)
   - » Wheel assembly
   - » Bicycle assembly
   - » Stickering process (automated/water-based, etc.)
   - » Bicycle maintenance
2. It is also recommended that the RDCBSM work towards developing a diploma course tailored towards bicycle engineering.
3. The RDCBSM should also conduct component-specific training sessions for component manufacturers, i.e. knowledge dissemination forums for manufacturers of a particular component, to discuss global best practices, common hurdles and challenges and production processes. It is recommended that leading bicycle manufacturers and relevant technical experts conduct these sessions to maximize exposure.
4. For these proposed courses to be delivered to the industry, it is recommended that appropriate curricula be developed in consultation with leading R&D institutions (such as CHC Taiwan), international experts in each of the mentioned areas and relevant bicycle training academies from across the world.
5. It is also recommended that an industry-wide survey/poll be executed to understand the training requirements of the industry.

Upgrading of Common facilities/Mass production machines/tool room

1. To support the bicycle industry in adopting production in aluminium, the R&D centre's common facility should be upgraded to include facilities/equipment for producing production blanks and supporting services for the proposed material bank. Aluminium components go through the various shaping and joining processes which start with the extrusion process to make the tubes to construct the frame, butting to form the ends of the aluminium tubing, hydroforming to get the tubing into the required shapes of the frame, welding to assemble the frame, and then heat treatment to further change the physical properties of the aluminium. This would mean that the workshop at the RDCBSM should be expanded to include:
   - » An extrusion press
   - » Permanent mould foundry
   - » Heat-treatment facility
   - » Hydroforming facility

   Analogous to the current cold forging production facility at the RDCBSM, an extrusion/casting/heat-treatment facility for aluminium would position the R&D centre as a common facility for the industry, not necessitating major capital investments by the SMEs, at least as they initiate alloy-based production. This common facility could work in conjunction with the proposed material bank.
2. The general-purpose tool production machines and related equipment are a source of income for the R&D centre, but are dated and need to be upgraded/replaced. This applies specifically to the CNC machines such as the horizontal machining centre, cold forging machinery, etc.
3. The RDCBSM tool room personnel solicit training in how to make accurate dies for different moulds, jigs and fixtures for different materials, especially aluminium and plastic. This would entail training and expert guidance in tool design for the RDCBSM's design and development team.

Increased R&D function and Technology development

1. Applied research

Given the level of operation and technology of the Indian bicycle industry, R&D does not necessarily allude to the invention or origination of new, alternative, cutting edge technologies/methods, but more pertains to the adoption of globally adopted best practices, methods and processes into the Indian context. Most medium and small-scale manufacturers are largely unaware of what new methods are prevalent worldwide and how they can adopt them, without having the necessary resources/wherewithal to engage in such research themselves. This opens up an important service avenue for the R&D centre to investigate and analyse what the best available production processes are, what they entail and how they can be adopted in the industry. This could centre on material behaviour, component interface, stress analysis, optimal configurations for specific components, etc. Applied research would also be useful for trouble-shooting and fault correction in components and bicycle performance. When manufacturers bring testing samples to the R&D centre test labs and do not meet performance criteria, this would bring up pertinent topics and areas in which investigative research could be undertaken, in line with the applied research mentioned above.

» The R&D centre can explore the application of **advanced engineering processes** to provide feedback to any product development effort, using finite element analysis, structural dynamics, structural stability, fracture mechanics, service-load measurement, bearing life data, etc. While the bicycle-plus-rider system is complex, the engineering approach is the quickest route to sensible improvements, and will shortcut years of wasted development effort. The primary aim would be to provide rapid engineering services (stress calculation) and consulting (recommended dimension change) so companies can rapidly upgrade and certify their bicycle components and frames to world-class standards. It should be recognized that cycle engineering is not only applicable to premium products, the same advanced techniques will also lead to better and cheaper 'tender bikes' and cycle rickshaws. But another important goal would be to teach engineering methods to any manufacturer or employee who wants that expertise. It is recommended that engineers with an MS level background in fields such as aerospace engineering could be engaged at the R&D centre for such exploration.

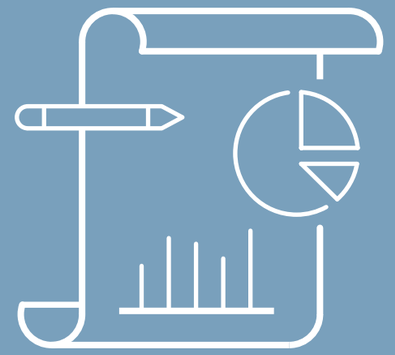
» **E-bikes and electric assist hardware**: According to Navigant Research, the global e-bike market is projected to grow at a 0.4% compound annual growth rate (CAGR) over the forecast period (2016-2025). Western Europe and the Asia Pacific, such as Japan and Vietnam, are expected to be major markets. In the coming years, e-bikes in Europe are expected to evolve from a specialty commuting or recreation device to a standard bicycle form that is accessible to nearly all bike consumers (Citro & Gartner, 2016). This is going to be a boom sector, which will allow the cycle industry to retain riders who might otherwise invest in motorbikes, and will assist cycle-transporters to travel faster with less effort.

Thus, the global e-bike market is well-positioned for continued growth, primarily in the Lithium-ion battery segment. Improving lithium ion (Li-ion) battery technology is resulting in e-bikes that are lighter, lower in cost, and remarkably similar to traditional bicycles. They are seen to have environmental and performance advantages over the traditional sealed lead-acid batteries (SLA).

There is tremendous potential in **economical electric assist hardware** that can be fitted onto any existing bicycle/tricycle/rickshaw, thus increasing the ease of it absorption in the market. It may include components such as a custom motor; a closed loop controller with power electronic drive elements for the motor; a battery pack with custom battery management circuitry, and torque and rotary position encoders (Petron, 2008). This is a relatively new product segment and can be explored for its applications to Indian-produced bicycles. Thus, this segment holds tremendous potential in developing a cost-competitive, environment-friendly product.

2. Market research

The R&D centre would be providing a valuable resource to the industry by investigating what types of bicycles/components are being produced in various parts of the world, what materials are being used necessitating what types of processing technologies, what designs are being targeted, and what new practices are emerging. With a more market-oriented view, such research could also be extended to industry sales trends, prospects and potential markets – applicable to both domestic and global bicycle-producing/purchasing regions - as a resource for manufacturers looking to venture into newer market segments.



5 CONCLUSION

The Indian bicycle industry is faced with several challenges in achieving export competitiveness. The industry largely produces basic models of steel roadster bicycles (mostly for government tenders), children's bicycles and a very limited volume of premium bicycles (the parts for which are supplied by imports). The bicycles demanded in global markets are aesthetically and technically superior than what is produced domestically, are made from high-end materials, are of multiple-speed settings and require several special components, often from specific brands.

Even though the Indian bicycle industry is the second largest in the world in terms of volume, manufacturers are faced with several demand and supply-related barriers in producing bicycles that are demanded globally, as explained in the course of this report. These include: a lack of access to appropriate grades and forms of raw materials at affordable prices, mainly aluminium alloy; the need for an international marketing and selling channel to access international markets and gain consumer confidence; the need for technical guidance and expert handholding to adopt modern manufacturing processes and best available technologies to produce bicycles and components of exportable and consistent quality, aesthetic designs and economical pricing; and appropriate policy support for the suitable enabling conditions for such production.

Thus, for an industry-wide transition towards producing and selling exportable bicycles and components, it is recommended that these aforementioned barriers are overcome through interventions such as (i) the establishment of a material bank to facilitate the economical supply of the requisite raw material to manufacturers; (ii) providing manufacturers, especially the component- manufacturing SMEs, technical guidance and handholding through a variety of modalities for efficient and competitive production. This could include deployment of technical experts for consulting/handholding services, technology sharing mechanisms, technology co-development and demonstration, focused testing support and quality testing services, etc.; (iii) the establishment of a common node/ entity for international sales and marketing, such as a common brand for the numerous, unrecognized brands of component-manufacturing Indian SMEs. These efforts could be aided with appropriate policy advocacy efforts to support the main needs of the industry.

In such a context, the RDCBSM, as the nodal technical institution for the Indian bicycle industry, could potentially be harnessed as the instrument for the delivery of a number of these recommendations, with special reference to the provision of technical support and guidance to manufacturers. With the identification of the main needs of the industry as well as the main areas in which manufacturers solicit production guidance,

the diagnostic assessment conducted under the UNIDO bicycle project aimed to evaluate how the RDCBSM is positioned to respond to these needs.

It was determined that the RDCBSM personnel have not necessarily kept abreast with global developments in the bicycle industry and the associated skills required to be adopted therein. Although the RDCBSM currently provides a range of valuable services to the industry, there are gaps in the current expertise available at the centre as well as the support offered to the industry. The centre is not in a position to pioneer the adoption of modern manufacturing processes in the Indian context, and thus requires expert assistance and skills/ capacity building support to absorb global best practices and disseminate the same to the industry. There are a number of ways in which the service portfolio of the R&D centre could be expanded and strengthened. For the RDCBSM to be able to better support the industry in line with global market requirements, there is a clear need to build capacity and expertise in areas such as: the material behaviour of aluminium alloy and the requisite processing (e.g. extrusion, heat treatment, butting, hydroforming, permanent mould casting, etc.); material identification; composition and behaviour analyses (applicable to high-strength steel, carbon fibre, titanium, etc.); design of jigs, fixtures, dyes and moulds, as applicable for different materials; PLC automation in bicycle-manufacturing units; production efficiency and lean manufacturing; design competence and componentry design; manufacturing of critical components; efficient test execution and result analysis, among others. The RDCBSM would then be in a position to deliver services such as applied R&D, product development, the operation of a pilot facility for high-end bicycles, quality testing and certification, worker training, critical consultancy services, etc. to the industry. However, in the short run, the R&D centre would need to be supported by a bank of external, international experts specializing in the identified production processes to simultaneously support the industry, as well as build proficiencies at the RDCBSM.

This report attempts to identify and highlight some of the critical needs of the industry, and corresponding measures that would enable bicycle and bicycle parts manufacturers to produce and sell as per international quality standards. In such a context, the RDCBSM and the industry associations should be positioned to play a key role in enabling manufacturers to become an active part of global value chains and markets. Addressing the industry-wide critical needs through collaborative industry action and equipping the RDCBSM and the industry associations to appropriately respond to these needs are thus crucial for export competitiveness and the survival of the Indian bicycle industry.

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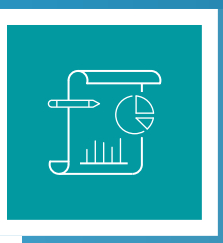

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